

# Presentation Abstracts

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## Oral Presentations

### 001. Minimally Invasive Eyelid Incision Fronto-Orbital Craniotomy Approach to the Anterior Cranial Fossa: Lessons to Learn in Fifty-Eight Cases

Khaled Aziz, Alexander Yu (presenter), Erik Happ (Pittsburgh, USA)

**Introduction:** The concept of minimally invasive approaches for anterior crania fossa has been evolving during the past two decades. Supraorbital frontal mini-craniotomy with or without including orbital ridge is the commonly utilized approach. The eyelid incision fronto-orbital craniotomy has been recently introduced to neurosurgery skull base literature.

**Material and Methods:** We describe our experience with a transpalpebral “eyelid” incision, which utilizes the natural upper eyelid crease to obtain access to the anterior cranial fossa through the subfrontal-supraorbital corridor. This approach minimizes the cosmetic problems with the supraciliary or transciliary incisions. The eyelid approach reduces risk of injury to the frontalis branch of the facial nerve.

We will review our experience with 58 cases (40 anterior circulation aneurysms and 18 anterior skull base tumors). In all patients, eyelid layers incision and closure were performed by an oculoplastic neuro-ophthalmologist.

**Results:** Extracranial drilling of the greater sphenoid wing exposes the frontal dura, temporal dura, and periorbital “spheno-orbital keyhole,” which is the starting point for the one-piece eyelid fronto-orbital craniotomy. The bone flap performed in all cases was about 2.5 cm high. Anterior clinoidectomy and optic foraminotomy were performed, when indicated, without any difficulty or side effects. After the dura is opened, a panoramic view of the anterior cranial fossa floor is achieved, extending from the contralateral to the ipsilateral oculomotor nerve. Lumbar draining was encountered in all the 58 patients at the beginning of the procedure and was usually removed on postoperative day three. We will describe the approach and technique in step-by-step fashion, discussing the clinical and cosmetic results of our 58 cases, as well as the advantages of the transpalpebral approach. This is the largest series to be published in the literature utilizing the unique eyelid approach with excellent cosmetic outcome (no noticeable eyelid asymmetry with excellent healing and barely visible lateral edge of the incision, which gradually starts to fade after 3 months) in 56/58 patients. Seven complications were: one radiological stroke without deficit, one eyelid hematoma that required surgical evacuation, one superficial infection treated with systemic antibiotics, one deep infection that required surgical drainage, and three CSF leaks (two resolved with keeping the lumbar drain for total of 7 days postoperatively, and one required re-operation).

**Conclusion:** The transpalpebral “Eyelid” approach is an excellent option to approach lesions of the anterior skull base. The minimally invasive access through an eyelid incision involves dissection in normal tissue planes, preserves frontalis muscle fibers, avoids injury to the fronto-temporal facial nerve branches, and heals with excellent cosmetic results.

### 002. Surgery versus Watchful Waiting in Patients with Craniofacial Fibrous Dysplasia: A Meta-Analysis

Moran Amit (presenter), Michael T. Collins, Edmond J. FitzGibbon, John A. Butman, Dan M. Fliss, Ziv Gil (Tel Aviv, Israel)

**Background:** Fibrous dysplasia (FD) is a benign bone tumor that most commonly involves the craniofacial skeleton. The most devastating consequence of craniofacial FD (CFD) is loss of vision due to optic nerve compression (ONC). Radiological evidence of ONC is common; however, the management of this condition is not well established. Our objective was to compare the long-term outcome of patients with optic nerve compression (ONC) due to CFD who either underwent surgery or were managed expectantly.

**Methodology/Principal Findings:** We performed a meta-analysis of 27 studies, along with analysis of the records of a cohort of patients enrolled in National Institutes of Health (NIH) protocol 98-D-0145, entitled Screening and Natural History of Fibrous Dysplasia, with a diagnosis of CFD. The study group consisted of 241 patients; 122 were enrolled in the NIH study and 119 were extracted from cases published in the literature. The median follow-up period was 54 months (range, 6–228 months). A total of 368 optic nerves were investigated. All clinically impaired optic nerves ( $n = 86$ , 23.3%) underwent therapeutic decompression. Of the 282 clinically intact nerves, 41 (15%) were surgically decompressed and 241 (85%) were followed expectantly. Improvement in visual function was reported in 58 (67.4%) of the clinically impaired nerves after surgery. In the intact nerves group, long-term stable vision was achieved in 31/45 (75.6%) of the operated nerves, compared with 229/241 (95.1%) of the non-operated ones ( $P = 0.0003$ ). Surgery in asymptomatic patients was associated with visual deterioration (RR 4.89; 95% CI 2.26–10.59).

**Conclusions:** Most patients with CFD will remain asymptomatic during long-term follow-up. Expectant management is recommended in asymptomatic patients even in the presence of radiological evidence of ONC.

### 003. The Midline Biorbitofrontal Craniotomy Approach to Meningiomas of the Olfactory Groove and Planum Sphenoidale

William R. Miele (presenter), Carl B. Heilman (Boston, USA)

**Objective:** The evolution of endoscopic endonasal approaches to sellar, suprasellar, and clival lesions has

permanently changed management of these lesions. However, the role of the endoscopic endonasal approach to anterior skull base meningiomas remains controversial. We reviewed our operative management of meningiomas of the olfactory groove and planum sphenoidale. Attention was paid to rate of CSF leak, use of post-operative lumbar drains, and need for reoperation. Our approach to anterior skull base meningiomas was the midline biorbitofrontal craniotomy.

**Methods:** We reviewed our experience treating olfactory groove and planum sphenoidale meningiomas. Meningiomas of the tuberculum sellae, clinoid, and orbital roof were excluded. All cases were attended by a neurosurgeon (CBH) alone or with a second neurosurgeon or otolaryngologist. Technical aspects of the approach, microsurgical technique, radiographic and clinical perioperative, and follow-up data were reviewed.

**Results:** From 1994–2011, 27 patients were identified, 5 with planum sphenoidale and 22 with olfactory groove meningiomas. All patients underwent two-piece bifrontal craniotomy with biorbital-bar osteotomy (23/27) or one-piece biorbitofrontal craniotomy (4/27) with cranialization of the frontal sinus, and anterior fossa floor reconstruction where necessary. Complete resection was performed on 25/27 patients. Residual tumor was left in two cases where tumor encased the callosomarginal arteries. Excellent end cosmetic results were achieved in all cases. There were no new permanent neurologic deficits except for anosmia in some patients with functional smell preoperatively. CSF rhinorrhea was seen in 2/27 patients (7.4%); one was managed with a lumbar drain, and the second required endoscopic endonasal repair after failure of a lumbar drain. Two patients had lumbar drains placed for subgaleal effusions without CSF leak. There was one instance of meningitis (3.7%), no surgical site infections, no need for nasal irrigation, no need for repeated follow-up with the otolaryngologist, and no nasa complaints. There were no delayed CSF leaks. In 103 patient-years follow-up, one patient had tumor recurrence (3.7%), requiring reoperation on two occasions.

**Conclusions:** The midline biorbitofrontal craniotomy allows low rates of CSF leak, infection, and neurologic deficit. This approach affords excellent cosmetic outcomes when used to approach meningiomas of the olfactory groove and planum sphenoidale. Superior degrees of tumor resection and low recurrence rates are attainable.

#### 004. Quality-of-Life Improvements after Endoscopic Skull Base Surgery for Nonpituitary Tumors

Edward D. McCoul (presenter), Vijay K. Anand, Jeffrey C. Bedrosian, Theodore H. Schwartz (New York, USA)

**Objective:** Endoscopic skull base surgery (ESBS) is a minimal-access technique that provides an alternative to traditional approaches. Patient-reported outcomes are becoming increasingly important in measuring the success of surgical intervention. ESBS may lead to improvements in quality-of-life (QOL) because natural orifices are used to reach the pathology. The purpose of this study was to assess the impact of ESBS on site-specific and sinonasal-related QOL using two validated instruments, the Anterior Skull Base Questionnaire (ASBQ) and the Sinonasal Outcome Test (SNOT-22).

**Methods:** Consecutive patients undergoing ESBS for nonpituitary tumors were prospectively enrolled from a tertiary referral center. All patients completed the ASBQ

and SNOT-22 preoperatively and postoperatively at regular intervals. Patients younger than 18 years, those receiving concurrent craniotomy, and those who did not complete pre- and postoperative surveys were excluded from study.

**Results:** Of 223 consecutive patients, 51 met inclusion criteria for study, with a median follow-up time of 12 months. This cohort included 10 (19.2%) chordomas, 9 (17.3%) meningiomas, 7 (13.5%) craniopharyngiomas, 6 (11.5%) encephaloceles, 16 (30.8%) other benign tumors, and 3 (5.8%) malignant tumors. Nasoseptal flap closure was used in 31 (59.6%) cases, and a gasket-seal closure was used in 19 (36.5%) cases. Graft harvest from a second surgical field was performed in 30 (57.7%) patients. There was no decline in ASBQ score at 3 and 6 weeks postoperatively ( $P > 0.05$ ), and significant improvements at 12 weeks ( $p = 0.008$ ) and 6-months ( $P = 0.04$ ). No significant change in SNOT-22 score was seen at anytime point up to 6-months postoperatively ( $P > 0.05$ ), with significant improvement seen at 1 year postoperatively ( $P = 0.02$ ). The presence of a nasoseptal flap or a graft donor site did not contribute to decreased QOL on either scale. Postoperative CSF leaks occurred in 4 (7.7%), of which 2 (3.8%) required reoperation.

**Conclusions:** ESBS is associated with improvements in both sinonasal and site-specific QOL when assessed pre- and postoperatively with validated instruments. ESBS is a valuable tool in the surgical management of anterior skull base pathology with favorable implications for patient well-being and low morbidity.

#### 005. Comparison of Outcomes for Anterior Communicating Artery Aneurysms Clipped Via a Basal Interhemispheric Approach vs. a Pterional Approach

Ravi H. Gandhi (presenter), Alex Riccio, Constantine E. Plakas, Junichi Yamamoto, Alan S. Boulous (Albany, USA)

**Introduction:** Many approaches for clipping anterior communicating (ACoM) artery aneurysms are described in the literature, but controversy remains over the best technique. These techniques can be best divided into lateral (pterional) or interhemispheric. Although the interhemispheric technique has not gained generalized acceptance, we compare our experience between the basal interhemispheric approach and the pterional approach to clipping ACoM aneurysms.

**Methods:** Twenty ACoM aneurysms clipped from a basal interhemispheric (BIH) approach are reviewed and compared with 34 ACoM aneurysms contemporaneously treated via a pterional approach. The operative, perioperative complications and long-term outcomes are evaluated in a retrospective manner.

**Results:** Although there was a trend to a younger age in the BIH group (52 years) compared with the pterional group (56 years), there were no statistical differences in the demographics, comorbidities, or aneurysm characteristics. There was no statistical difference in the grade of patients being treated in both groups or in the projection of the aneurysms. Although not statistically significant, patients in the BIH group did tend to have higher Hunt Hess (1.7 vs. 1.2,  $P = 0.2$ ) and higher Fisher (1.7 vs. 1.2,  $P = 0.4$ ) scores. There was no statistical difference in the degree of postoperative spasm. In the pterional group, 18% of patients required postoperative ventriculoperitoneal shunts vs. 0% in the BIH group. In the BIH group, there were 2 wound infections, 1 CSF leak, 1 patient with hyposmia, and 1 intraoperative rupture. In the

pterional group, there was 1 wound infection, no CSF leak, no hyposmia, and 4 intraoperative ruptures. No patients within the BIH group have required any further aneurysm treatment, compared with 3 patients within the pterional group that have required retreatment due to residual aneurysm.

**Conclusion:** Although there are increased technical difficulties with the basal interhemispheric approach, we believe that this approach can be used to treat ACom aneurysms with good clinical results. The benefits of this approach include minimal retraction and decreased trauma to the frontal lobes and improved visualization of essential anatomical structures. Our results suggest that the BIH is a safe and feasible option in the treatment of ACom aneurysms and should be considered for all ACom aneurysms.

#### 006. Accessing the Parapharyngeal Space and Infratemporal Fossa Skull Base Using Robotic Surgery: An Anatomic Descriptions and Preliminary Clinical Series

Grace G. Kim (presenter), Adam M. Zanation (Chapel Hill, USA)

**Objectives:** The purposes of this study are to describe the parapharyngeal space and infratemporal fossa anatomy from a transoral perspective and discuss how robotic surgery may be applied to resect tumors within the infratemporal fossa.

**Study Design:** A retrospective case series at a tertiary academic center.

**Methods:** The da Vinci surgical robot (Si) was applied for off-label use to resect four skull base tumors. The pathological diagnosis was two pleomorphic adenomas in the parapharyngeal space—one pleomorphic adenoma in the infratemporal fossa, and one metastatic papillary thyroid cancer node in the high retropharyngeal nodal basin. A transpalatal approach was used to access the infratemporal fossa and retropharynx. Lateral pharyngotomies were performed to access the parapharyngeal spaces.

**Results:** Relevant anatomy related to the transoral robotic surgery (TORS) approach and dissection along the carotid into the infratemporal fossa are discussed. Our four cases are used to illustrate the clinical applicability of this anatomy and the TORS approach for skull base tumors. All four patients had complete resection of tumor confirmed by postoperative imaging. There were no intraoperative arterial injuries. One patient experienced a transient episode of 1-mm ptosis that resolved spontaneously. Patients had normal swallowing function within 5 days following surgery. There were no recurrences within short follow-up time (8–14 months).

**Conclusions:** Knowledge of the parapharyngeal space and infratemporal fossa anatomy allows for safe resection of tumors in these spaces using transoral robotic surgery. Future advances in technology will allow better access to additional portions of the skull base.

#### 007. Long-Term Outcome of Esthesioneuroblastoma: Hyams Grade Predicts Patient Survival

amie J. Van Gompel (presenter), Caterina Giannini, Kerry D. Olsen, Eric Moore, Manolo Piccirilli, Robert L. Foote, Jan C. Buckner, Michael J. Link (Rochester, USA)

**Object:** Esthesioneuroblastoma (ENB) is a rare malignant neuroendocrine tumor originating from the

olfactory neuroepithelium in the cribriform plate. Modified Kadish stage and nodal disease at presentation have proven to predict outcome; however, controversy still exists regarding the role of pathologic grading (Hyams) in prognostication. This study was undertaken to describe our experience with ENB and assess the role of pathologic grading in patient outcome.

**Methods:** This was a retrospective single institutional experience. The study included 109 patients with pathologically proven ENB treated within our institution from 1960 to 2009. Hyams grade was confirmed on all cases available ( $n = 87$ ) by pathology interpretation blinded to outcomes. Multivariate analysis was performed utilizing Cox regression analysis models built utilizing age, gender, modified Kadish stage, and Hyams grade.

**Results:** Mean age was  $49 \pm 16$  (median 50) years at presentation. Forty-four percent in this series. Mean overall survival was  $7.2 \pm 0.7$  years and median survival was 5.1 years. Mean progression-free survival was  $4.8 \pm 0.7$  years. All causes of mortality were significantly influenced by Hyams grading in univariate ( $P = 0.045$ ) and multivariate ( $p = 0.019$ ) analysis. This was in addition to proven prognostic factors, Kadish staging, lymph node metastasis, and age. Median survival was 9.8 years compared with 6.9 years with low versus high Hyams grade. Median follow-up was 5.1 years.

**Conclusion:** ENB has a variable outcome that is primarily prognosticated by the extent of involvement at presentation (Kadish stage and lymph nodes metastasis). However, it appears that higher Hyams grade pathology at diagnosis influences patient survival.

#### 008. Functional Outcomes of Individuals Undergoing Surgery of the Infratemporal Fossa, a 14-Year Experience

Rohit Garg (presenter), David B. Keschner, Jivianne Lee, Joseph Brunworth, Eugene Chu, Marc Vanefsky, Kenneth Krantz, Sooho Choi, Terry Shibuya (Irvine, CA, USA)

**Objective:** To assess the functional outcomes of individuals undergoing surgery of the infratemporal fossa for tumor removal.

**Study Design:** Case series with chart review.

**Setting:** Community hospital and tertiary referral center.

**Methods:** Fifty-nine individuals were identified as having undergone infratemporal fossa surgery over the past 14 years. Of these individuals, 45 had clinical data available for analysis. Patient clinical outcomes were measured assessing nine areas: (1) mastication, (2) speech, (3) swallowing, (4) cranial nerve VII function, (5) V2 and V3 sensation, (6) vision, (7) cosmesis, (8) pain, and (9) pre- and postoperative scores. The results of the assessments were: Mastication graded as normal (1), mildly impaired (2), moderately impaired (3), severely impaired, and NPO (4). Speech graded as normal (1), mildly impaired (2), moderately impaired (3), severely impaired, aphonia (4). Swallowing graded as normal (1), mildly impaired (2), moderately impaired (3), severely impaired, NPO (4). Cranial nerve VII function graded as House-Brackmann scale (1–6). V2 and V3 sensation graded as present (1), impaired (2), absent (3). Vision graded as normal (1), impaired (2), absent (3). Cosmesis graded as normal (1), minimal change (2), moderated change (3), severe change (4). Pain graded as none (1), mild (2), moderate (3), severe (4). Pre- and postoperative scores were compared using the Wilcoxon Signed Rank test.

**Results:** There were 31 malignancies and 14 benign tumors studied. There were no significant differences in pre- and postoperative function with regard to mastication, speech, swallowing, cosmesis, and V3 function. There was significant reduction in pain, V2 sensation, and vision postoperatively. Individuals with malignancies had a significantly higher incidence of loss of vision and V2 and VII function due to surgical sacrifice. They also had a significantly higher reduction in pain.

**Conclusion:** Functional outcomes of individuals undergoing surgery of the ITF were not significantly different with regard to mastication, speech, and swallowing. There was a significantly higher reduction in pain postoperatively for all cases. Individuals with malignancy had a higher incidence in loss of vision, V2, and VII function due to surgical resection.

#### 009. Paranasal Sinus and Skull Base Fibro-Osseous Lesions: When Is Biopsy Indicated for Diagnosis?

Pete Batra (presenter), Guy Efune, Carlos L. Perez, Liyue Tong (Dallas, USA)

**Introduction:** Paranasal sinus fibro-osseous (FO) lesions represent a heterogeneous group, often sharing overlapping radiographic and pathologic features posing a dilemma in accurate diagnosis. The objective of this study was to correlate preoperative radiologic and postoperative histologic diagnosis to help guide a diagnostic algorithm.

**Methods:** Retrospective analysis was performed of 60 FO lesions between 1994 and 2010.

**Results:** The mean age was 42.3 years with average follow-up of 12.5 months. The preliminary radiologic diagnosis was osteoma in 22 (36.7%), fibrous dysplasia (FD) in 9 (15%), ossifying fibroma (OF) vs. FD in 5 (8.3%), and OF in 3 (5%) cases. The diagnosis was indeterminate in 21 (35%) cases. Management consisted of excision in 29 (48.3%), observation in 17 (28.3%), and biopsy in 14 (23.3%) patients. For patients undergoing resection or biopsy, positive predictive value of preoperative radiology was 100% (10/10) for osteoma, 86.7% (6/7) for FD, and 33.3% (1/3) for OF cases. For the indeterminate lesions, most common pathologic diagnoses for 21 patients included osteoma in 4 (17.4%), arrested pneumatization in 3 (14.3%), OF in 3 (14.3%), and FD in 2 (9.5%). For FD vs. OF cases, 3 underwent surgery revealing osteoma, FD, and OF in 1 patient each.

**Conclusion:** In this series, radiologic-histopathologic correlation was high for osteoma and FD and low for OF and OF vs. FD. This data suggest that patients with classic radiologic characteristics of osteoma and FD may be observed, unless resection is warranted based on clinical symptomatology. Preoperative diagnosis of OF, OF vs. FD, or indeterminate lesions may warrant a biopsy to establish firm diagnosis to guide definitive management.

#### 010. Aberrant Motor Regulation in Chordoma

Anthony C. Wang, David B. Altshuler (presenter), Shawn L. Hervey-Jumper, Khoi D. Than, Xing Fan, Karin M. Muraszko, Erin L. McKean, Stephen E. Sullivan (Ann Arbor, USA)

One of the most challenging aspects of chordoma treatment is adequate control of primary disease. Recurrence is com-

mon, metastases occur in as many as 40% of treated patients, and survival has been estimated to be only 40% at 10 years. Chordoma has proven relatively insensitive in chemotherapeutic and radiation trials. High-dose fractionated radiotherapy has been shown to improve overall survival, but it is often limited due to highly radio-sensitive adjacent nervous structures.

Recent advances in targeted molecular therapeutics, however, offer promising new avenues by which novel treatments for chordoma could be developed. To better understand molecular mechanisms involved in the origin and perpetuity of chordoma after treatment, we are studying the canonical signaling pathways that have been shown to be involved in chordoma, including PI3K/AKT, PTEN, and mTOR signaling. In particular, mTOR signaling is an attractive target to study, given that tuberous sclerosis proteins tuberin and hamartin function to inhibit the mTOR pathway. Tuberous sclerosis is the only known genetic syndrome with an increased incidence of chordoma. We examined mTOR genes that act upon the tuberous sclerosis complex at the transcriptional and translational levels using quantitative real-time PCR, western immunoblot, and immunofluorescence.

In our western immunoblot analysis, we found elevated p70 S6K protein expression in two primary human chordoma samples. p70 S6K is a serine/threonine kinase that is activated through phosphorylation by mTOR complex 1 to regulate translation. p70 S6K plays an important role in G1 cell cycle progression and cell growth. Interestingly, p70 S6K is tightly suppressed in human embryonic stem cells, and increased levels of expression induce differentiation in these cells. We are currently examining the role of p70 S6K in the tumorigenesis of chordoma.

We are also examining other potential mechanisms of dysregulation of the mTOR complex 1. Several microRNAs have been predicted to be involved in p70S6K regulation. We performed a microRNA microarray on primary patient samples to examine microRNA expression levels in primary human chordoma samples. In particular, microRNA 539 was overexpressed in chordoma samples compared with normal levels of expression. In vitro studies of microRNA overexpression in chordoma cell lines are ongoing.

#### 011. Establishment and Initial Characterization of a Primary Human Chordoma Xenograft Model

I-Mei Siu, Vafi Salmasi, Brent A. Orr, Qi Zhao, Zev A. Binder, Douglas D. Reh, Masaru Ishii, Christine L. Hann, Gary L. Gallia (presenter), (Baltimore, USA)

Chordomas are rare tumors arising from remnants of the notochord. Because of the challenges in achieving a complete surgical resection, the radioresistant nature of these tumors, and the lack of effective chemotherapeutics, the median survival for patients with chordomas is approximately 6 years. Reproducible preclinical model systems that closely mimic the original patient's tumor are essential for the development and evaluation of effective therapeutics. Currently, there are only a few established chordoma cell lines and no primary xenograft model. In this study, we aimed to develop a primary chordoma xenograft model and implanted four independent patient tumor samples into athymic nude mice. A serially transplantable xenograft was established from one of these patient samples. Histopathological analysis and immunohistochemical staining for S-100, EMA, and cytokeratin

AE1/AE3 of the primary patient sample and the xenografts confirmed the xenografts were identical to the original patient chordoma. Immunohistochemical staining and western analysis confirmed the presence of Brachyury, a marker of chordomas, in the patient tumor and each of the xenografts. Genome-wide variation was assessed between the patient's tumor and the xenografts and found to be > 99.9% concordant. We have established, to the best of our knowledge, the first primary chordoma xenograft that will provide a useful pre-clinical model for this disease and a platform for therapeutic development.

#### 012. Chondroid Chordoma: Is It Really a Chondrosarcoma and Does It Matter?

Christopher H. Rassekh (presenter), Courtney B. Shires, Virginia A. Livolsi, Laurie A. Loevner, Sean M. Grady, Bert W. O'Malley (Lafayette Hill, PA, USA)

**Background:** Chondroid tumors of the head and neck continue to be a unique challenge to manage. A large subset of chondroid tumors arise in the skull base region. Most challenging of all are the chondrosarcomas and chordomas of the clivus. An entity called chondroid chordoma was first described in 1973 but has remained controversial. Immunohistochemical studies have shown that these lesions are more consistent with a low-grade chondrosarcoma. The imaging features of chordoma and chondrosarcoma overlap, but chondrosarcoma frequently has virtually pathognomonic radiographic features. However, in the clivus both entities may be particularly difficult to differentiate from one another and sometimes from other entities as well.

**Objectives:** The objectives of this study are to (1) determine the degree of discordance between imaging and pathology in chondroid tumors and (2) identify patients with chondroid tumors of the clivus whose radiographic features suggested chondrosarcoma but histologically were diagnosed as chordoma.

**Methods:** The database of the Department of Pathology and Laboratory Medicine from 1991–2011 was searched for the diagnoses of chordoma, chondrosarcoma, and chondroid chordoma of the head and neck to identify chondrosarcomas and chordomas of the clivus. The pathology reports and radiology were reviewed to identify discordance or a failure of radiology or pathology to make a definitive diagnosis. In addition, all cases diagnosed as chondroid chordoma were retrieved for further detailed evaluation.

**Results:** We identified 75 patients with chondroid tumors histologically diagnosed as chondrosarcoma or chordoma. To date, we have identified 26 lesions that involved the clivus for whom we have sufficient data, and virtually all of these appeared to at least theoretically have the clivus as the epicenter. Among the 26 cases, 18 had radiographic features that suggested both chondrosarcoma and chordoma within the differential diagnosis. Eleven patients had classic chordoma and nine patients had chondrosarcoma histologically, and six patients had chondroid chordoma diagnosed histologically. However, radiographic features were more consistent with chondrosarcoma in the latter group. The discordance of radiographic features in the classic chordoma and chondrosarcoma groups was rare. At least two of the patients in the chondrosarcoma group had some histological features, which resembled the chondroid chordoma group.

**Conclusions:** Chondroid chordoma is a rare entity, and its existence is further questioned by the fact that radiographic features of these tumors are more suggestive of chondrosarcoma. This data combined with the known calcification patterns of chondrosarcoma and the immunohistochemical profile of chondroid chordomas have prompted us to extend our study to evaluate the calcification patterns of all chondroid tumors in an ongoing subsequent study. Careful imaging evaluation is of great importance. Pathologic diagnosis of chondroid chordoma may suggest a different prognosis than classic chordoma and a tendency to be lower grade and resemble a low-grade chondrosarcoma radiographically and clinically.

#### 013. Skull Base Chordoma: Results and Outcomes of Minimally Invasive Approaches in a Single Institution

Waleed M. Abuzeid (presenter), Nadeem Akbar, Stephen E. Sullivan, Lawrence J. Marentette, Erin L. McKean (Ann Arbor, USA)

**Objectives:** The purpose of this study is to provide analysis of early outcomes of patients with skull base chordoma treated with a minimally invasive surgical approach.

**Methods:** A retrospective cohort analysis was performed based on consecutive patients presenting with chordoma to a tertiary care academic medical center from 2009 to 2011.

**Results:** Seven patients were included with a median follow-up time of 12 months (range, 2–27 months). The mean age at diagnosis was 56 years (range, 40–76 yrs). Facial pain and/or headache were presenting symptoms in six patients (86%). Preoperative cranial nerve palsies were seen in four patients (57%). The tumor epicenter was the sellar/suprasellar region in two patients (29%) and clivus in five patients (71%), with intradural extension noted in four patients (57%).

Six patients (86%) underwent an expanded endoscopic endonasal approach (EEA), and one patient underwent a transoral-transpalatal approach. Mean preoperative tumor volume based on MR imaging was 40.5 cc (range, 1.3–145 cc). Post-resection, the mean tumor volume was 5.8 cc (range, 0–15.8 cc), representing a mean volume reduction of 86% (range, 47–100%). Gross total resection was achieved in two patients (29%). Tumor volume reduction was most limited with the transoral-transpalatal approach.

Two patients (29%) required intraoperative placement of a lumbar drain. One patient with a suprasellar cisternal tumor developed a persistent CSF leak requiring CSF diversion and three revision endoscopic surgeries, complicated by pneumocephalus and meningitis. No other postoperative complications were observed.

Six patients (86%) received adjuvant proton or photon therapy. One patient refused adjuvant therapy and was the only patient to experience an early disease recurrence.

**Conclusions:** Tumor volume can be effectively and accurately calculated using MR imaging, and resection efficacy derived from these data. The EEA can safely be used to effectively resect skull base chordoma, including lesions with limited intradural extension. This surgical resection should be combined with adjuvant radiation. Long-term follow-up will be needed to determine disease-free survival.

#### 014. Clivus Chordoma Ibrahim Sbeih (presenter), (Amman, Jordan)

Chordomas are rare lesions comprising 0.1–0.2% of primary intracranial tumors. Most authors still differ as to whether

these tumors are histologically benign or malignant. However, they are characterized by local aggressiveness and tendency to recur.

We are presenting our experience in 32 cases of clival chordomas, treated surgically. There were 22 females with age ranging from 19–57 years (mean, 35 years) and 10 males ranging in age from 18–61 years (average, 41 years). Mean presentation features were increased intracranial pressure and diplopia, and the abducent nerve was the most common affected nerve.

We achieved gross total resection in 20 patients and subtotal resection in 10 patients. We used transnasal approach in 6 cases, maxillotomy in 8 cases, transbasal subfrontal in 3 cases, transpetrosal in 3 cases, and retrosigmoid approach in 12 cases. Perioperative mortality was encountered in one patient who developed respiratory arrest 12 hours after surgery. Morbidity was encountered in four patients who experienced increased neurological deficits and in one patient with CSF leak.

Following surgery, 24 patients received fractionated radiotherapy and 8 patients received Gamma radiosurgery.

Follow-up period ranged from 19 months to 120 months (mean of 67.4 months). Eight cases recurred after surgery and radiotherapy; four of these died 2–5 years after second surgery. Two patients refused further surgery. One case recurred after Gamma radiosurgery requiring a second operation. The overall result of the 32 patients was: 20 patients are still alive and well, 10 are in fair condition, 4 are in poor condition, and 6 died in the long follow-up period.

We believe that radical surgery has an important role to play in almost all cases. Postoperatively, the residual tumor should receive complementary treatment by external beam radiation, radiosurgery, or proton beam.

#### 015. Micro-Neurosurgical Management of Cavernous Sinus Meningioma: Single-Surgeon Experience from Louisiana State University, Shreveport.

Jai D. Thakur (presenter), Vijaykumar Javalkar, Shashikant Patil, Imad S. Khan, Mathew Burton, Anil Nanda (Shreveport, USA)

**Introduction:** Cavernous sinus meningiomas (CSM) continue to represent a cohort of challenging skull base tumors where the technical success of surgery may not parallel good outcomes. Because different levels of expertise may be a potential confounding factor in assessing outcomes, this study focuses on long-term outcomes of patients operated on for CSM by the senior author (AN).

**Methods:** A total of 43 CSM (primary + secondary) patients underwent microsurgical removal by the senior author from 1996 to 2010. Retrospective analysis to elucidate perioperative complications and long-term clinicoradiological outcomes was done. Sekhar classification, Modified Kobayashi grading, and GOS were used to define tumor extension, tumor removal and clinical outcomes, respectively.

**Results:** The mean age of the predominantly female (78%) patients in our study was 55 years. Mean follow-up time was 54.5 months (range, 6–187 months). The most common presenting symptom was headache (74%). Preoperative cranial nerve dysfunction (CND) was evident in 67% of the patients, of which the most common was second CN deficit. Complete or partial recovery of CN was significantly better in patients with CND inflicted postoperatively compared with those having CND preoperatively (89% vs.

63%,  $P = 0.037$ ). Overall, 35% of the patients showed radiological recurrence after their initial surgery. No significant difference in recurrence was found among grades of Sekhar classification. The mean time of recurrence in the patients treated by surgery alone vs. surgery plus adjuvant SRS was 49 months vs. 50 months, and recurrence rate among the two groups was not significant (21% vs. 53%,  $P = 0.23$ ). On linear regression analysis, preoperative CND was predictive of tumor recurrence after surgery ( $P = 0.006$ ). At their latest follow-up, 74% of patients had good outcomes (GOS 4 or 5). Extent of tumor removal and extension were not predictive of good outcomes.

**Conclusion:** Although fraught with unavoidable postoperative morbidity, long-term good outcomes and tumor control is possible in CSM with microsurgery and appropriate use of SRS. In our study, preoperative CND improved in majority of patients and was predictive of tumor recurrence after surgery.

#### 016. Surgical Results of 32 Foramen Magnum Meningiomas with a Special Reference to Vascular Complications

Soichi Oya, Burak Sade, Bjorn Lobo (presenter), Joung H. Lee (Cleveland, USA)

**Objective:** Surgical treatment for foramen magnum meningiomas (FMMs) is fraught with challenges. In this study, we aimed to review our surgical technique and operative results of FMMs with an emphasis on vascular complications.

**Methods:** Thirty patients harboring FMMs underwent surgery by the senior author (JHL) at the Cleveland Clinic between 1993 and July 2011. Clinical data on age, gender, pre- and postoperative neurological deficits, surgical approach, complications, and the follow-up results were reviewed.

**Results:** Mean age was 50.3 years (range, 27–87 years), and male/female ratio was 11/21. The most common clinical symptoms were headache and neck ache (46.9%), numbness/paresthesia (31.3%), unstable gait (18.8%), weakness (18.8%). Seven patients (21.9%) were asymptomatic. Preoperative neurological examination showed decreased sensation (31.3%), motor weakness (18.8%), ataxic gait (18.8%), and cranial nerve (IV, VI, VII, XI–XII) dysfunction (18.8%). The neurological examination was unremarkable in 18 patients (56.3%). The average tumor size was 3.4 cm (range, 1.5–6.0 cm). In 22 patients (69.0%), the tumor was anterolateral. Transcondylar approach was used in 89.2% of anterior, lateral, or anterolateral FMMs. Transposition of the vertebral artery was not performed in any case. Gross total resection was achieved in 75% of all cases. Cranial nerve injury was observed in eight patients (25.0%). Three patients had neurological deficits due to brainstem ischemia (9.4%). Mean follow-up was 48 months, and 90% of patients have been free from recurrence or regrowth.

**Conclusions:** Although a satisfactory resection can be achieved for FMMs utilizing meticulous skull base techniques, anterior or anterolateral FMMs carry significant surgical risks of cranial nerve injury and brainstem ischemia. The likelihood of cranial nerve recovery is favorable in time even when multiple lower cranial nerves are involved. However, ischemic injury of the brainstem due to occlusion of the vertebral, anterior spinal arteries, and/or medullary perforators may lead to fatal medical complications and unfavorable outcome.

### 017. Long-Term Clinical and Surgical Outcomes of Patients with Intracranial Meningiomas

Winward Choy (presenter), Won Kim, Ashley Osborne, Marko Spasic, Nicole Cremer, Isaac Yang (Los Angeles, USA)

**Introduction:** Meningiomas are the second most common primary CNS neoplasm and are commonly benign and slow growing. While gross total resection has been associated with improved survival, complete surgical resection can be difficult given poor tumor accessibility and proximity to sensitive structures. We review our institution's long-term experience with meningiomas to compare outcomes and complications associated with gross (GTR) and subtotal resection (STR).

**Methods:** We reviewed all patients with meningiomas treated at Ronald Reagan UCLA Medical Center from 1996 to 2009. Inclusion criteria included (1) histopathologically confirmed primary intracranial meningioma, (2) GTR or STR performed at UCLA, and (3) follow-up  $\geq 2$  years. Surgical and clinical outcomes of GTR vs. STR were analyzed.

**Results:** Of 203 patients receiving surgical resection, 106 met our inclusion criteria. There were 41 males and 65 females, and the average age was 54 years at presentation. There were 84 WHO grade I (79%), 19 WHO grade II (18%), and 3 WHO grade III (3%) meningiomas. Average follow-up was 61.2 months (range: 24 to 172 months). Of the 72 patients undergoing GTR, 5 (7%) received radiotherapy. Of the 34 patients with STR, 19 (56%) received radiotherapy. Overall survival for both groups was 100%. Compared with STR, GTR was associated with improved 3-yr PFS (92.5% vs. 75%,  $P = 0.062$ ) and 5-yr PFS (92.5% vs. 62.5%,  $P = 0.002$ ). However, GTR was correlated with increased complications (11% vs. 2.9%,  $P = 0.26$ ). This difference was not statistically significant. Reported complications included hematoma (2), surgical site infections (2), CSF leak (2), venous infarcts (2), and venous thrombosis (1).

**Conclusion:** Overall, meningiomas are slow growing tumors with a good prognosis, and surgical resection can offer excellent rates of tumor control. Although GTR is associated with longer PFS and should be the goal when feasible, these findings suggest that a more aggressive surgical approach is correlated with increased risk for surgical complications.

### 018. Surgical Management of Jugular Foramen Meningioma

Junting Zhang, Jie Tang (presenter), Zhen Wu, Liwei Zhang, Guijun Jia, Xinru Xiao, Sumin Geng, Dabiao Zhou (Beijing, China)

**Background and Objective:** Jugular foramen meningioma (JFM) presents a challenge for intraoperative protection of neural and vessel structures and for postoperative nursing, which are important outcomes for patients with JFM.

**Methods:** The data of consecutive patients with JFM, surgically treated in Beijing Titan Hospital from January 1, 2004 to April 30, 2010, were analyzed retrospectively. The medical data were reviewed, including medical charts, operation notes, intraoperative neurophysiological monitoring, neuroimaging, pre- and postoperative (follow-up) neurological assessments, and other factors.

**Results:** A total of 21 patients with JFM were included, 10 male and 11 female, with average age of 39.6 years (range, 14–57 years). Ten cases were type A intracranial style,

and 11 cases were type D dumbbell style (intra-extracranial communicating style). Hoarseness was found in 6 patients, dysphagia in 9, hearing disorder in 7, diplopia in 2, lingual atrophy in 2, hydrocephalus in 1, and limb weakness in 6. For type A cases, the retrosigmoid approach was used in 6 cases, and the posterior suboccipital horseshoe incision far lateral approach was used in 4 cases; gross total resection was achieved in 9, with 1 recurrence. For the 11 type D cases, a postauricular C shaped incision with the far lateral approach was used to achieve adequate exposure of the extracranial part of the tumor—GTR was achieved in 6 with 4 recurrences. Intraoperative monitoring is very important for neural structure protection. Gentle manipulation and removal of the tumor without injuring the brainstem and lower cranial nerve are the keys of the operation. Avoiding injury of the sigmoid sinus is a very important part of the surgery. Lower cranial nerves dysfunction was presented in all cases immediately after surgery; tracheotomies were performed in 3 cases for prevention of asphyxia. Neural function was recovered in 13 cases, and the rest were stable. The pathology revealed 1 malignant (WHO 3) and 3 atypical (WHO 2) tumors in this group, which recurred postoperatively. The high ratio of malignant pathology is quite unique compared with other intracranial meningiomas. No patients needed a permanent feeding tube. No patients died postoperatively. All patients lived independent lives.

**Conclusion:** Although overall outcome of patients with JFM was significantly favorable after microsurgical treatment, the neurological deficits remain challenging for skull base surgeons. It requires multidisciplinary teamwork to improve exposure and protect neural and vessel structures.

### 019. Endonasal Endoscopic Approaches to Lesions Invading the Cavernous Sinus: Reaching Equipose

Graeme F. Woodworth, Edward McCoul, Vijay Anand, Theodore H. Schwartz (presenter), (Baltimore, USA)

**Background:** Lesions involving the cavernous sinus (CS) have proven to be surgically challenging due to the deep, complex neurovascular anatomy in this region. Traditional approaches have focused on transcranial "lateral to medial" routes. In this study, we detail our series using an endoscopic endonasal "medial to lateral" route to treat tumors invading the cavernous sinus and evaluate the outcomes of this approach.

**Methods:** We reviewed a prospective surgical database of patients with invasive cavernous sinus lesions who underwent endoscopic endonasal surgery. Outcomes were compared based on the Knosp-Steiner (KS) classification, and histopathological categories.

**Results:** This review identified 41 consecutive patients with lesions either arising within or extending into the CS. The mean follow-up was 16 (range, 12–37) months. Pathology included pituitary macroadenoma (57%), meningioma/hemangiopericytoma (17%), chordoma/chondrosarcoma (13%), and miscellaneous other lesions (metastatic adenocarcinoma, lymphoma, etc.) (13%). The surgical approach was transsphenoidal transsellar in 31 patients (76%), transthemoidal parasellar in 4 (10%), and transmaxillary transpterygoid in 6 (14%). Average degree of CS resection varied significantly by KS class (KS1-2, 62% vs. KS3-4, 41%;  $P = 0.04$ ). Gross total CS resection was achieved in 47% of medial (KS1-2) as opposed to 21% of lateral (KS3-4) lesions ( $P = 0.05$ ). The recurrence rate for KS 1-2 lesions was also

significantly lower than those with KS 3–4 status (10% vs. 43%,  $P = 0.02$ ). Extent of resection was highest for chordoma/chondrosarcoma (72%) followed by pituitary adenoma (55%) and meningioma (40%). Two patients with preoperative cranial neuropathy improved, and one remained stable. Complications included new postoperative cranial neuropathy (2.5%) and CSF leak (2.5%).

**Conclusions:** The endoscopic endonasal approach provides a useful and safe medial to lateral approach particularly to the medial compartment of the CS. Although certain tumors can also be removed from the lateral CS, based on the consistency, site of origin of the tumor, and the risk to the patient, lateral to medial approaches or radiosurgery may be required to control tumor growth in the lateral CS.

#### 020. Direct Healthcare Cost Analysis of Endoscopic Compared with Sublabial Transseptal Pituitary Surgery Candace A. Mitchell (presenter), Adam M. Zanation, Brent A. Senior, Matthew G. Ewend, Charles S. Ebert, Jr. (Carrboro, NC, USA)

**Background and Methods:** Completely endoscopic endonasal approaches to skull base pathology have rapidly gained popularity in recent years. Evidence of their safety and efficacy has begun to appear in the literature, and quality of life (QOL) data available to date also suggest comparable or improved outcomes compared with traditional approaches. However, data comparing costs of endoscopic skull base procedures and classic approaches are scarce. We considered the cost of minimally invasive pituitary surgery (MIPS) versus classic sublabial transseptal (SLTS) approaches. Expanded endonasal approaches were not included. Using real costs (rather than billed costs) associated with each surgery, cost effectiveness and sensitivity analyses were performed in conjunction with our School of Public Health.

**Results:** Total cost for MIPS was \$11,438, and total cost for SLTS was \$21,005. If narrower variability ranges are employed, the costs changed to \$12,513 and \$18,095, respectively. Thus, cost differences favor MIPS over SLTS by as much as \$9,567 and a minimum of \$5,582. Additionally, factors identified that contributed most to cost of the MIPS approach included length of stay, nursing cost, nursing time, and total number of complications. Monte Carlo simulation of 1000 case scenarios indicated that under a variety of conditions, MIPS remains less costly than SLTS 94–98% of the time.

**Discussion:** In the current healthcare milieu, cost analyses to justify the use of new techniques are paramount. Our data suggest that, at least in the case of pituitary resections, endoscopic procedures are cost effective as compared with traditional approaches. We discuss the difficulties of comparing expanded approaches given the inability to measure specific CPT codes and the variability in practice and pathologies treated. Further analysis must be done to compare endoscopic procedures for these highly heterogeneous non-pituitary skull base pathologies, but our data provide reassurance that endoscopic approaches have the potential to save valuable healthcare dollars.

#### 021. Endoscopic Nasoseptal Flap Repair of Skull Base Defects: Is Addition of a Dural Sealant Necessary?

Jean Anderson Eloy (presenter), Arjuna B. Kuperan, Mark E. Friedel, Chirag D. Patel, Pratik A. Shukla, Osama J. Choudhry, James K. Liu (Newark, USA)

**Background:** We compared the incidence of postoperative cerebrospinal fluid (CSF) leaks in patients undergoing

endoscopic skull base repair with a pedicled nasoseptal flap (PNSF), with or without the addition of a dural sealant.

**Methods:** A retrospective analysis of a prospective database was performed on patients who underwent endoscopic repair of high-flow CSF leaks using a PNSF between December 2008 and August 2011. Repair materials, incidence of postoperative CSF leaks, and demographic data were collected.

**Results:** Thirty-two high-flow CSF leaks were repaired with a PNSF alone without dural sealant (Group I), and 42 were repaired with a PNSF with the addition of a dural sealant (Group II). In Group I, there were no postoperative CSF leaks (0%), whereas in Group II, there was one delayed postoperative CSF leak, resulting in a 2.4% leak rate. The incidence of postoperative CSF leakage was not significantly different between the two groups ( $P > 0.05$ ). The overall postoperative CSF leak rate was 1.4% in this cohort.

**Conclusions:** The use of dural sealants when performing endoscopic PNSF repair of high-flow CSF leaks is not supported by our data. In addition, this practice may significantly increase surgical cost. We encountered no postoperative CSF leaks in patients with high-flow CSF leaks treated with PNSF alone without dural sealants. Meticulous surgical technique and proper positioning of the PNSF seem to obviate the need for dural sealants during endoscopic skull base reconstruction of high-flow CSF leaks.

#### 022. Pedicled Nasoseptal Flap Preservation for Endoscopic Reconstruction of the Cranial Base: Technique and Approach

Seth E. Kaplan (presenter), Donald D. Beahm, Tyler J. Kenning, Christopher J. Farrell, James J. Evans, Marc R. Rosen (Philadelphia, USA)

**Introduction:** The pedicled nasoseptal flap is an excellent option for repair of skull base defects. Popularized by Hadad and Bassagasteguy, this neurovascular flap is based on the septal branch of the sphenopalatine artery and utilizes tissue from septal mucoperiosteum and mucoperichondrium. The flap provides reliable reconstruction of cranial base defects from the frontal sinus to the clivus and is now considered the “workhorse” of anterior skull base reconstruction. Unfortunately, there are instances during endoscopic skull base surgery in which the pedicle is injured or sacrificed, eliminating its use for reconstruction. The objective of this paper is to offer surgical techniques and approaches to the skull base to better preserve this valuable tissue for skull base reconstruction.

**Methods and Results:** We describe five approaches that allow an appropriate level of exposure during endoscopic skull base surgery while preserving the nasoseptal pedicle and flap. All approaches provide protection for at least one pedicled nasoseptal flap to be used as a rescue flap if needed. Approaches include: (1) strictly unilateral approach; (2) limited unilateral septectomy, or the “1.5 Approach”; (3) hemitransfixion incision with development of a septal mucoperichondrial/mucoperiosteal flap (without making superior/inferior nasoseptal flap incisions); (4) septal mobilization and transposition; and (5) standard harvest of the nasal septal flap, storage in the nasopharynx, and sutured back in place. Relevant anatomy and surgical technique are discussed.

**Conclusion:** The nasoseptal flap is an important reconstruction option for skull base defects. We identify five approaches to endoscopic skull base surgery that better protect both the pedicle and flap while allowing adequate



exposure of the sella and skull base for tumor resection. Using our methods, skull base surgeons should be able to have at least one nasoseptal flap at their disposal as a means of repairing unanticipated skull base defects.

### 023. Endoscopic Endonasal versus Microscopic Transsphenoidal and Open Transcranial Approaches for Giant Pituitary Adenomas

Daniel M. Raper, Ricardo J. Komotar, Robert M. Starke (presenter), Vijay K. Anand, Theodore H. Schwartz (St. Leonards, Australia)

**Objective:** Giant (> 4 cm) pituitary macroadenomas often require surgery to decompress the optic nerves. Compared with traditional open or transsphenoidal microscopic methods, the extended endoscopic endonasal transsphenoidal approach offers the potential for aggressive resection via a minimal access corridor. We conducted a systematic review of the literature to further our understanding of the role of endoscopy in the management of these challenging lesions.

**Methods:** MEDLINE search of the modern literature (1995–2010) was conducted to identify surgical series for pediatric and adult pituitary adenomas > 4 cm in maximal diameter. Patient and tumor characteristics, resection, morbidity, and visual outcome were compared by approach. Chi-square and Fisher's exact tests with post-hoc Bonferroni analysis were used for statistical analyses.

**Results:** Sixteen studies (478 patients) were included. Compared with the open cohort, the endoscopic cohort had higher rates of gross total resection (47.2% vs. 9.6%;  $P < .003$ ) and improved visual outcome (91.1% vs. 45.7%;  $P < .003$ ). The microscopic transsphenoidal cohort had lower rates of total resection and worse visual outcomes than the endoscopic group. There were no instances of postoperative CSF leak reported in the endoscopic group. The transcranial group had a higher rate of perioperative mortality compared with the transsphenoidal group ( $P = .004$ ).

**Conclusion:** In select cases, the endoscopic endonasal approach is safe and effective for the treatment of giant pituitary adenomas, with the potential for gross total resection and improved visual outcome. CSF leak, which is a major limitation of the endonasal approach, may be avoided using meticulous multi-layer closure and vascularized nasoseptal flaps.

### 024. The Role of Endoscopic Endonasal Approach in the Treatment of Cavernous Sinus Meningioma

Daniel M. Prevedello, Ammar Shaikhouni (presenter), Rodrigo Mafaldo, Leo Ditzel Filho, Daniele de Lara, Brad Otto, Ricardo Carrau (Columbus, USA)

**Objective:** Treatment of cavernous sinus (CS) meningioma remains controversial. Radical resection of these lesions through the transcranial route is associated with significant morbidity. Studies have suggested surgical decompression followed by radiotherapy to treat these lesions. This approach is further favored with the development of endoscopic skull base surgery. Prior studies described the use of transsphenoidal decompression of CS meningiomas. Here we outline a role for an endoscopic endonasal approach in treating CS meningioma by decompression or radical resection. We provide four case illustrations of this approach.

**Method:** We illustrate our philosophy with four symptomatic patients with CS meningiomas. Three of these patients presented with newly diagnosed symptomatic CS meningioma. Two patients presented with unilateral CN 6 palsy. One patient had unilateral CN 3 and 6 palsies. The fourth patient had a recurrent tumor and complete right CN 3, 4, and 6 palsies as well as partial cranial nerve 7 palsy and complete hearing loss on that side. As part of her prior surgeries, her right ICA was sacrificed. She presented with radiologic tumor progression causing brainstem compression.

**Results:** The three patients with new diagnoses underwent endoscopic endonasal cavernous sinus decompression with postoperative cranial nerve improvement, while the patient with recurrence had a radical endoscopic endonasal resection of the tumor followed by gamma-knife focused on the minimal residual on the seventh cranial nerve. None of the patients experienced endocrine dysfunction. None of the patients had new neurological deficits.

**Conclusion:** CS meningiomas can be successfully managed via a purely endoscopic endonasal approach. Our experience shows that both decompression and radical resection can be safely performed with this approach. The choice of resection vs. decompression is guided by patient factors, medical history, and symptoms. We recommend EEA decompression for new symptomatic CS meningioma with incomplete loss of CN functions. In patients with total loss of CN functions, a radical resection of the CS meningioma can be achieved with EEA.

### 025. Decision Analysis: Endoscopic Versus Open Resection of Tuberculum Sellae Meningiomas

Leif-Erik Bohman, Sherman Stein, Jason G. Newman, James Palmer, Nithin Adappa, Aamir Khan, T. T. Sitterley, Diana Chang, John Y. Lee (presenter), (Philadelphia, USA)

**Introduction:** Tuberculum sellae meningiomas (TSMs) are challenging tumors for neurosurgical resection. Open microsurgical approaches pose significant risk to the optic apparatus, which may be obviated by endoscopic approaches. However, endoscopic endonasal surgical resection is a relatively new procedure with its own Achilles heel—CSF leak.

**Materials and Methods:** MEDLINE and Embase online databases were searched for English-language articles containing key words related to tuberculum sellae meningiomas. Data were pooled, including five of our own patients. Meta-regression and a decision-analytical model was constructed to compare 3-year outcomes between open microsurgery and endoscopic endonasal approaches.

**Results:** The 3-year recurrence rates were not statistically different between the two approaches ( $P = 0.529$ ). Meta-regression of 28 reports of open craniotomy suggested a 3-year recurrence rate of 4.6% (SD = 0.699, R<sup>2</sup> = 35.5%,  $P = 0.005$ ), and meta-regression of eight publications on endoscopy suggested a 3-year recurrence rate of 9.9% (SD = 0.396, R<sup>2</sup> = 2.6%,  $P = 0.231$ ). In addition, the overall quality of life (QOL) was not significant between the two surgical approaches ( $P = 0.410$ ), despite significant differences in individual complication rates. The Monte Carlo simulation yielded an overall average QOL in craniotomy patients of 0.915 (SD = 0.020) and in endoscopic patients of 0.952 (SD = 0.019). Endoscopy had a higher CSF leak rate (26.8 vs. 3.5%,  $P < 0.001$ ) but a lower rate of injury to the optic apparatus (1.4% vs. 9.2%,  $P < 0.001$ ) compared with craniotomy.

**Conclusion:** Endoscopic endonasal resection of TSMS appears to be a comparable alternative to traditional open microsurgical resection. Rates of CSF leak appear to be higher than open resection, but visual complications are less common than in open resection. The data are insufficient to provide a meaningful comparison of recurrence rates; however, this issue may be resolved as longer follow-up is obtained.

#### 026. A Plausible Mechanism for Optic Nerve Damage: A Comparative Study of Heat Transfer during Optic Canal Decompression

Brian C. Kelley (presenter), MyLe Shaw, Jason Sokol, Paul J. Camarata (Kansas City, USA)

**Introduction:** Multiple articles have described vision loss after neurosurgical intervention from heat-induced injury to the optic nerve during exposure to the optic canal. This project's objective was to determine factors associated with heat transfer during drilling of the optic canal that could lead to possible optic nerve injury.

**Methods:** On a non-embalmed cadaver, the optic canal was approached through a standard pterional craniotomy. A thermocouple was placed within the optic canal, and the temperature was recorded during 30-second continuous drill sessions using both CUSA NXT and Anspach eMax 2 with a 3-mm diamond burr. The drill power and irrigation rate were varied for comparison of heat transfer.

**Results:** There was an incremental increase in optic canal temperature with both Diamond burr and ultrasonic aspirator over time (10-, 20-, and 30-second time points). Stepwise elevations in temperature occurred with increasing sonication amplitudes. Decreases in thermal conduction were noted in both diamond burr with continuous irrigation (mean, 3.3°C reduction) and sonication with increased irrigation (from 2 to 4 mL/min) at 50% amplitude (mean, 1.1°C reduction), but was insufficient to combat the heat generation at 80% amplitude, and may result in a slight increase in heat conduction (5.5°C increase from baseline at 2 mL/min vs. 6.8°C at 80% with 4 mL/min). Thermal transfer was comparable between diamond burr with continuous irrigation and sonication at 50% amplitude with 4 mL/min irrigation (avg. increase from baseline 1.3°C drill vs. 1.1°C ultrasonic aspirator).

**Conclusions:** Increased drilling times correlated with increase in temperature from baseline using both bone removal devices. Elevations in sonication amplitude resulted in incremental increases in optic canal temperature. These temperature changes can be mediated by irrigation, although the effect of increasing irrigation rate to suppress the rise in temperature decreases with increasing sonication amplitude. Thermal transfer was similar between the diamond burr with continuous irrigation and sonication at low power and high irrigation. This pilot study has revealed critical information for the development of further projects with the aim of determining if thermal transfer from optic canal decompression could contribute to optic nerve damage, and what techniques could be applied to prevent it.

#### 027. Transsphenoidal Surgery for Acromegaly: Methods of Surgical Resection, Remission Using Modern Criteria, and Predictors of Outcome

Robert M. Starke (presenter), Sebastian Koga, Carrie L. Pledger, Spencer C. Payne, Edward H. Oldfield, John J. Jane, Jr. (Charlottesville, USA)

**Introduction:** Whether endoscopic or microscopic surgical approaches are superior for patients with acromegaly

remains unclear. Recent consensus requires use of more stringent endocrine remission criteria than were previously used. We reviewed our experience with endoscopic transsphenoidal surgery (ETSS) and microsurgical transsphenoidal surgery (MTS) to assess outcomes and predictors of remission according to the 2010 consensus criteria.

**Methods:** The prospectively recorded outcomes of 110 acromegalic patients undergoing surgical therapy were reviewed. Remission was defined as a normal IGF-I and either a suppressed growth hormone (GH) less than 0.4 ng/mL during an oral glucose tolerance test or a random GH less than 1.0 ng/mL.

**Results:** Remission was achieved in 19 of 24 microadenomas (79%) and 53 of 86 macroadenomas (62%). Baseline characteristics, remission rates, and complications were not significantly different between patients undergoing ETSS and MTS. A postoperative GH level of less than 1.0 ng/mL provided the best predictor of remission (OR = 45.6, 95% CI 9.9–210.9,  $P < 0.001$ ). Preoperative variables predictive of remission in univariate analysis included age ( $P = 0.004$ ), preoperative GH level ( $P = 0.006$ ), preoperative IGF-1 ( $P = 0.009$ ), tumor size ( $P < 0.001$ ), and Knosp score ( $P < 0.001$ ). Preoperative variables predictive in multivariate analysis included GH > 25 ng/mL (OR = 4.9, 95% CI 1.5–16.5,  $P = 0.01$ ) and Knosp score of 3 or 4 (OR = 25.0, 95% CI 5.0–125.8,  $P < 0.001$ ).

**Conclusions:** ETSS and MTS provide high rates of remission according to the updated guidelines for surgery for acromegaly. Patients with high preoperative GH levels and Knosp scores are less likely to achieve remission, and the 2010 census guidelines provide excellent postoperative prediction of remission.

#### 028. Surgical Treatment of Trigeminal Neuralgia without Vascular Compression: 20 Years of Experience

Rogelio Revuelta-Gutierrez, Miguel A. Lopez-Gonzalez (presenter), Jose L. Soto-Hernandez (Beachwood, OH, USA)

**Background:** There are few reports on the outcome of surgical treatment of TGN without vascular compression.

**Methods:** Between 1984 and 2004, 668 patients underwent MVD for TGN. In 21 patients (3.1%), vascular compression was absent. The surgical strategy in these cases involved the following: (1) dissection and exposure of the entire trigeminal nerve root, (2) slight neurapraxia with bipolar tips at the trigeminal nerve root, and (3) isolation of trigeminal nerve with Teflon sponge fragments.

**Results:** The patients' (female/male, 20/1) ages ranged from 33 to 77 years. Their right side was the most frequently involved (61.9%). Their mean duration of pain before treatment was 7.6 years (range = 1–20 years). At surgical exploration, vascular compression or anatomical abnormalities were absent in 15 patients (71.4%), arachnoid thickening was present in 5 (23.8%), and fiber dissociation of the trigeminal nerve was present in 1 (4.8%). Mean follow-up after surgery was 17.7 months (range = 4–65 months). Immediate relief from pain occurred in all 21 patients. On Kaplan-Meier analysis, recurrence was maintained at 14.8% for 12, 24, and 36 months, increasing to 43.2% at 48 months. Permanent hypoesthesia was present in 6 patients (28.6%), whereas loss of corneal reflex was observed transiently in 1 (4.8%). Motor function of the trigeminal nerve was intact in all patients. No other complication was found.

**Conclusion:** The proposed surgical plan of standard MVD plus slight trigeminal nerve root neurapraxia is a safe and effective management option for TGN without vascular compression.

### 029. Comparative Outcome Analysis of Surgical Procedures Performed in Acute and Intermediate Facial Paralysis

Yury A. Shulev (presenter), Alexander V. Trashin, Vladimir L. Rychkov (St. Petersburg, Russia)

**Objective:** The purpose of this study was to analyze outcomes after different surgical procedures for facial nerve (FN) restoration and facial muscles reanimation. Reviewed procedures included: free nerve graft, FN decompression in temporal bone, and spinal accessory nerve–facial nerve anastomosis (AFA).

**Methods:** Thirty-nine patients with total FN loss were included in the study. They were divided in two groups. The first group contained 20 patients with an intermediate facial paralysis. The interval between FN loss and the operation was from 1 to 6 months (mean, 4.7 months). All patients in the series had total FN function loss after acoustic neuroma surgery. In 12 patients, FN was anatomically intact but showed no function recovery due to stretch injury. Patients in the first group underwent AFA. The second group consisted of 19 patients with acute facial paralysis due to FN intratemporal injury. The interval between FN injury and surgery ranged from 2 to 30 days (mean, 17.4 days). Seventeen patients underwent FN exploration in the labyrinthine segment of the facial canal through a middle cranial fossa approach. FN was decompressed in mastoid bone in 2 patients. Therefore, FN decompression was performed in 14 patients. Surgical exploration was combined with free nerve graft in 5 patients with total disruption of FN continuity. House-Brackmann (HB) grading scale was used to evaluate FN functions in both groups. Preoperative electrophysiological testing demonstrated total facial muscle degeneration. The mean duration of follow-up was 4.65 years (range, 1–10 yrs).

**Results:** Overall, in the group after AFA, 4 patients (20 %) recovered from facial palsy with final HB grade II; 11 (55 %) patients had HB III and 5 patients (25 %) had HB IV–V. There were following intraoperative findings in the second group: FN injury in labyrinthine segment was observed in 17 cases. Two patients had FN injury in the mastoid segment. FN transection was performed in 5 patients, and we used nerve graft for FN repair. We found bone impingement and hematoma in 11 cases, and FN edema was identified in 3 patients. Among patients with FN decompression and nerve graft according to HB scale, 2 patients (10.5%) achieved HB I, 5 (26%) had HB II, 10 (53%) had HB III, and 2 (10.5 %) had HB IV–V.

**Conclusion:** AFA is a good option for facial muscles reanimation in intermediate facial paralysis. In total loss of FN function, early decompression is indicated for the best functional result in acute facial paralysis. Early nerve graft for nerve repair gives good results.

### 030. Extracranial to Intracranial Bypass for Treatment of Complex, Large and Giant Aneurysms of the Middle Cerebral Artery: An Analysis of 27 Years of Experience in 26 Patients

Yashar Kalani (presenter), Peter Nakaji, Yin Hu, Azam Ahmed, Robert Spetzler (Phoenix, USA)

Complex, large, and giant aneurysms of the middle cerebral artery are challenging lesions that are not usually amenable

to endovascular therapy, and may require extracranial to intracranial or in-situ bypasses with hunterian ligation of the parent vessel or excision of the aneurysm. We retrospectively reviewed our experience between 1983 and 2011 with the microsurgical treatment of 26 complex, large, or giant middle cerebral artery aneurysms, where an extracranial to intracranial bypass was used in conjunction with clipping of the aneurysm. Our series consisted of 9 females (34.6%) and 17 males (65.4%) with a mean age of 35.6 years (range, 4–62 years; median, 39.5 years). Three of the patients in our series presented with subarachnoid hemorrhage ( $n = 3$ ; 11.5%). Twenty-one of the aneurysms in our series were giant (69.1%), the remainder were large and complex lesions. At a median follow-up of 63.6 months (range, 1–240 months; median, 36 months), the majority of the patients (81%) made an excellent recovery (modified Rankin scores 0–2) from the bypass and microsurgical clipping of their middle cerebral artery aneurysm. The mean modified Rankin score for the patients in our series was 1.5 (range, 0–3; median, 1). We advocate the use of an extracranial to intracranial bypass in the treatment of complex, large, or giant aneurysms of the middle cerebral artery.

### 031. Endoscopic Endonasal Pituitary Surgery: Patient and Societal Costs of Surgical Education

Raj C. Dedhia (presenter), Christopher Lord, Carlos Pinheiro-Neto, Juan C. Fernandez-Miranda, Eric W. Wang, Paul A. Gardner, Carl H. Snyderman (Pittsburgh, USA)

**Introduction:** Endoscopic endonasal surgery for pituitary lesions is a well-established skull base procedure. Endoscopic skull base surgery requires a learning curve, similar to other learned procedures. Simulators are gaining popularity as tools for developing surgical proficiency without placing the patient at risk. Given the increased morbidity and costs associated with longer operative times, we sought to determine the difference in operative times and associated complications for cases performed solely by attending-level surgeons versus cases assisted by surgeons-in-training for standardized skull base procedures.

**Methods:** After IRB approval was obtained, 51 cases of endoscopic endonasal pituitary surgery from 2005–2011 were identified. Inclusion criteria included operative dictation report from two surgeons (otolaryngology and neurosurgery) and primary pathology of the pituitary gland. Exclusion criteria included intraoperative lumbar drain placement in combination with other procedures. Information was garnered from dictated operative reports, intraoperative records, and discharge summaries.

**Results:** Thirteen of 51 cases were identified as attending only (AO) surgeries, and the remaining 38 had trainee involvement (TI). Operative times (minutes) for the AO group were significantly shorter than the TI group ( $156.5 \pm 42.9$  vs.  $198.0 \pm 54.6$ ,  $P = 0.02$ ). No major intraoperative complications were reported in either group. The AO group had fewer minor intraoperative complications (15% vs. 39%) and shorter length of stay (2.9 vs. 6.0 days).

**Conclusion:** This study is the first to compare operative times and outcomes for attending only versus trainee-involved cases at a single academic institution. Cases performed solely by attendings decrease both operative times and patient morbidity. These results have important implications for the growing impetus to incorporate endoscopic simulation technology into the core curricula of residency and fellowship training programs.

### 032. Early Morning Cortisol Levels as Predictors of Short- and Long-Term Adrenal Function after Endonasal Transsphenoidal Surgery for Pituitary Adenomas and Rathke's Cleft Cysts

Nancy McLaughlin (presenter), Pejman Cohan, Philip Barnett, Amy Eisenberg, Charlene Chaloner, Daniel F. Kelly (Santa Monica, USA)

**Introduction:** Patients undergoing pituitary adenoma or Rathke's cleft cyst (RCC) removal are often administered perioperative glucocorticoids regardless of lesion size and preoperative ACTH/cortisol levels. To minimize unnecessary glucocorticoid therapy, we describe a protocol in which patients with normal preoperative serum cortisol and ACTH levels are given glucocorticoids only if postoperative day 1 or 2 (POD1 or POD2) cortisol levels fall below normal.

**Methods:** A total of 207 consecutive patients undergoing endonasal surgery for an adenoma or RCC were considered for study. Of these, 68 patients with preoperative adrenal insufficiency or Cushing's disease were excluded. Glucocorticoids were withheld unless POD1/POD2 morning cortisol values were below normal ( $\leq 4$   $\mu\text{g/dL}$ ). Subsequent adrenal status was assessed through follow-up biochemical and clinical evaluations.

**Results:** The 139 patients included 119 with macroadenomas, 14 microadenomas and 6 RCCs (follow-up, 3–41 months; median, 10 months). Nine (6.5%) patients, all with macroadenomas (mean diameter  $26 \pm 10$  mm) had low POD1/POD2 cortisol values and received glucocorticoids; of these, 5 were weaned off within 3–28 weeks of surgery. Overall, 12/139 (8.6%) patients were treated for early ( $n = 9$ ) or delayed ( $n = 3$ ) adrenal insufficiency, but only 5 (3.6%) remain on glucocorticoid replacement. No patients experienced an adrenal crisis.

**Conclusion:** In patients with normal preoperative cortisol levels undergoing endonasal removal of a pituitary adenoma or RCC, normal morning cortisol values on POD1/POD2 reliably predicts adequate and safe adrenal function in over 96% of patients. This simple protocol of withholding postoperative glucocorticoids avoids unnecessary steroid exposure and poses minimal risk to the well-informed, closely monitored patient.

### 033. Endoscopic Endonasal Transpterygoid Nasopharyngectomy

S. Al-Sheibani, A. Zanation, R. L. Carrau (presenter), D. M. Prevedello, C. H. Snyderman, B. A. Otto, M. Old (Columbus, USA)

**Objective:** To describe our technique for endoscopic transpterygoid nasopharyngectomy and support its effectiveness with our early clinical outcomes.

**Methods:** Our endoscopic endonasal technique comprises an extended inferomedial maxillectomy, mobilization of the pterygopalatine fossa, and removal of the pterygoid plates and Eustachian tube to access the posterolateral nasopharynx. Control of the para-pharyngeal and petrous segments of the internal carotid artery is the keystone of the approach.

**Results:** Various histopathologies were treated, including epidermoid carcinomas ( $N = 9$ ), lymphoepithelioma ( $N = 1$ ), adenoid cystic carcinoma ( $N = 7$ ), adenocarcinoma ( $N = 2$ ), mucoepidermoid carcinoma ( $N = 2$ ), and sarcoma

( $N = 1$ ). Negative microscopic margins were obtained in 86% (19/22) of patients. No perioperative mortality, cerebrospinal fluid (CSF) leak, meningitis, or cerebrovascular accident was encountered; however, one patient suffered an internal carotid artery (ICA) injury that was controlled without permanent sequelae. All but one patient received adjuvant therapy (IMRT, proton and/or stereotactic radiotherapy with or without chemotherapy). Follow-up ranged from 12 to 78 months (mean = 36 months). Overall survival was 59% (13/22), and local control was 68% (15/22).

**Conclusions:** Endoscopic transpterygoid nasopharyngectomy for primary and recurrent nasopharyngeal malignancies is feasible and safe in properly selected patients. Our preliminary outcomes compare to that of conventional techniques. Endoscopic resections, however, are demanding; they require specialized equipment and a team versed in endoscopic oncologic surgery. Long-term follow-up and reproducibility remain undefined.

### 034. Proton Therapy of Cancers of the Nasal Cavity and Paranasal Sinuses—the UFPTI Experience

Robert S. Malyapa (presenter), William M. Mendenhall, Daniel Yeung, Craig McKenzie, Zuofeng Li, Chris G. Morris, Nancy P. Mendenhall, Paul Okunieff (Jacksonville, USA)

**Aim:** Sixty-eight patients with cancers of the nasal cavity and paranasal sinuses have completed treatment with proton therapy at UFPTI since January of 2007. The disease characteristics, treatment planning, delivery techniques, and follow-up results of 49 patients who have completed treatment more than 1 year ago are presented.

**Method:** Of 49 patients, 43 had prior surgery, 23 with close/positive margins. Six patients had biopsy only. Skull base invasion was noted in 34 of 49 patients, (69%). Ages ranged from 16 to 82 years with a median of 58 years. Histology included sinonasal undifferentiated carcinoma, adenoid cystic carcinoma, esthesioneuroblastoma, mucosal melanoma, spindle-cell carcinoma, and osteogenic sarcoma. Prescribed doses ranged from 64.8 GyE to 69.6 GyE for postoperative negative margins, to 74.4 GyE for presence of positive margins or presence of gross unresectable tumor at 1.2 GyE twice a day. Proton treatments were delivered with orthogonal kV x-ray imaging guidance to achieve 1-mm set-up accuracy for each fraction.

**Results:** All patients completed their prescribed treatment. Follow-ups ranged from 0.4 to 4.1 years (median 2 years). Brisk skin reactions developed in all patients, and resolved within 4 weeks after completion. Medial retinopathy occurred within the treated volume in 1 patient at 11 months after completion without negative impact on vision. Complete local disease control was noted in 43 of 49 patients (88%). In-field recurrent disease was noted in 2 postoperative patients at 9 and 12 months; one of them is free of disease after surgical salvage. Progressive meningeal seeding was identified in 1 patient within 2 months after radiation and was salvaged by additional therapy. Six patients who at initial diagnosis were inoperable and received 74.4 GyE had varying local response, succumbed to disease progression in 6 months to 20 months. Five patients who received postoperative proton radiation died of distant metastasis between 12 and 15 months without any evidence of local recurrence. The overall survival at 1 year and 2 years was 94% and 73%, respectively.

**Conclusion:** Our experience suggests that patients with cancers involving the nasal cavity and paranasal

sinuses with skull base invasion will benefit from high-dose conformal proton therapy.

### 035. Chondrosarcomas of the Head and Neck: A 50-Year Review

James P. O'Neill (presenter), Justin Elder, Jeffrey C. Liu, Ian Ganly, Snehel Patel, Mark Bilsky, Dennis Kraus, Jatin P. Shah (New York, USA)

**Summary:** Chondrosarcomas of the head and neck are rare heterogeneous malignant tumors of cartilaginous lineage. The objectives of our study were to report our experience in the surgical management and to identify factors predictive of outcome.

**Methods:** Sixty-six patients with head and neck chondrosarcomas treated at Memorial Sloan Kettering Cancer Center were divided in two cohorts from 1955 to 1985 and 1985 to 2005. Overall survival (OS), disease-specific survival (DSS), and recurrence-free survival (RFS) were determined for each cohort by the Kaplan-Meier method.

**Findings:** Five-year OS was superior in the 1985–2005 cohort compared with the 1955–1985 cohort (86.5% vs. 54%). In the 1985–2005 group, 5-year DSS and RFS were 89.5% and 51%, respectively. For RFS, grade, margin status, and postoperative radiation (PORT) were predictors of outcome. High- and intermediate-grade tumors had poorer RFS compared to low grade tumors (22.6% vs 70%,  $P = 0.02$ ). RFS was worse with positive margins compared with negative margins (30.5% vs. 81.5%,  $P = 0.004$ ). Patients with positive margins, patients treated with PORT had better RFS (45.7% vs. 18.2%). Sinus and skull base tumors had poorer RFS (43.4% vs. 70%,  $P = 0.35$ ).

For DSS, margin status, anatomical site, and grade were not predictive. Despite poorer RFS, patients with high-grade tumors and/or positive margins were salvaged by surgery and/or radiation therapy (RT) such that DSS was similar to that of patients with low-grade tumors and negative margins (DSS for high-grade vs. low-grade was 84% and 93%, respectively,  $P = 0.1$ ; DSS for positive vs. negative margins was 90% vs. 89%).

**Interpretation:** Survival of head and neck chondrosarcomas has improved over the past 25 years largely due to the use of adjuvant PORT. Despite high rates of recurrence in high-grade tumors, positive margins, and skull base locations, DSS is improved by successful salvage with further surgery and radiation therapy.

### 036. Small Molecule Inhibitor of CBP/Beta-Catenin Signaling Enhanced Radiation Sensitivity in Head and Neck Squamous Cell Carcinoma

Vicky Yamamoto (presenter), Rohit Khanna, Michael Kahn, Vijay Kalra, Uttam Sinha (Los Angeles, USA)

**Background:** Survivin is highly expressed in many types of cancers, including head and neck carcinoma (HNC). HNC is the sixth most common cancer in the world, and its 5-year survival rate is less than 50%. An increased survivin expression level in cancers is correlated with increased proliferative index, reduced apoptosis levels, and resistance to chemotherapy and radiation therapy. ICG-001, developed by Michael Kahn, Ph.D., is a novel small molecule inhibitor of Wnt signaling. Previous studies have shown that ICG-001 selectively blocks CBP/beta-catenin interaction and thus

inhibits its downstream target gene expressions, which includes survivin. The main objective of this study is to examine the therapeutic effect of this small molecule inhibitor in head and neck squamous cell carcinoma (HNSCC), which constitutes more than 90% of all HNC.

**Experimental Methods:** Three HNSCC cell lines (USC-001, SCC-71, and SCC-15) were used in the study. Expression levels of survivin, and other CBP/beta-catenin downstream target genes, such as cyclin-D1 and S100A4, were determined by real-time qRT-PCR. In addition, survivin expression was analyzed by western blotting and immunohistochemistry. Survivin and Wnt and beta-catenin promoter activities were analyzed by survivin luciferase and TOPflash assays, respectively. Viable cells were determined by trypan blue exclusion assay and WST-1 assay. Dead cells were determined by Sytox Green/Hoechst staining. Caspase activity was determined by Caspase-Glo assays.

**Results:** Our in vitro data showed that ICG-001 treatment (at 5, 10, and 25  $\mu$ M) significantly reduced viable HNSCC cells and Ki67-positive cells as much as 50%, in a dose-dependent manner. Western blotting, RT-PCR, immunohistochemistry, and survivin-promoter analysis showed that survivin expression level was significantly reduced by ICG-001 treatment. Wnt/beta-catenin promoter activity was also reduced by ICG-001 treatment. Pretreatment with ICG-001 enhanced radiation-induced cell death in vitro, determined by WST-1 and Sytox Green/Hoechst assays. Our preliminary results showed that caspase-6 activity, but not caspase-3/7 activity, was enhanced in ICG-001 pretreated, radiation-treated cells.

**Conclusion:** Inhibiting CBP/beta-catenin signaling by ICG-001-induced antiproliferative effect in HNSCC. Inhibiting CBP/beta-catenin signaling could also enhance radiation sensitivity in vitro by causing more cell death, which could be caspase-dependent.

### 037. Incidence and Timing of Neck Metastases in Esthesioneuroblastoma

Victoria E. Banuchi (presenter), Luc Morris, Mark H. Bilsky, Jatin P. Shah, Dennis H. Kraus (New York, USA)

**Purpose:** To assess the incidence of cervical lymph node metastases, at presentation and after treatment, as well as the effectiveness of salvage therapy for neck failure, in patients with esthesioneuroblastoma.

**Methods and Materials:** This was a retrospective analysis of 59 patients with esthesioneuroblastoma treated at Memorial Sloan Kettering Cancer Center between 1979 and 2009, with median follow-up of 69 months. Cumulative incidence of neck failure and survival was assessed using the Kaplan-Meier method.

**Results:** Most patients (41; 69%) were male. Tumor stage at presentation was Kadish A in 11 patients, B in 22, C in 22, and D in 4. Resection via open approaches was performed in 51 patients, 4 patients had endoscopic resection, and 4 were treated with chemoradiation alone. Overall survival at 5 years was 85.2%; at 10 years, 76.4%. At presentation, 4 patients (7%) had neck metastases and 13 patients (22%) developed neck failure subsequently, for a cumulative incidence of 30.8%. Median time to neck failure was 76 months (range, 17–107 months). The rate was higher in Kadish stage D (50%) patients than in Kadish A (33.3%,  $P = 0.012$ ), Kadish B (46.6%,  $P = 0.027$ ), and Kadish C (24.5%,  $P = 0.014$ ) patients. After neck failure, 2 patients were treated with neck dissection and

radiation, 9 with surgery followed by chemoradiation, and 2 with chemoradiation. After neck failure, the probability of survival was 57.1% at 5 years and 42.9% at 10 years. There was a trend toward poorer survival compared to patients not experiencing neck failure ( $P = 0.07$ ).

**Conclusion:** The rate of regional failure in patients with esthesioneuroblastoma is significant for all Kadish stages, generally occurs in a delayed fashion, and negatively impacts survival.

### 038. The Use of Radiofrequency Ablation for the Removal of Juvenile Nasopharyngeal Angiofibroma in Children

Matthew Whitley (presenter), Brian Dunham, Ken Kazahaya (Philadelphia, USA)

Juvenile nasopharyngeal angiofibroma (JNA) is an uncommon, highly vascular, benign, but locally aggressive neoplasm that occurs almost exclusively in adolescent boys. The treatment of choice is complete surgical extirpation. Over the past decade, open surgical approaches have been replaced with endoscopic transnasal resection of these tumors. The advantages of endoscopic resection include better cosmesis, decreased operative time, decreased hospital stay, and more rapid return to normal activity. Because of their vascular origin, the resection of these tumors can be complicated by excessive bleeding. Numerous techniques have been developed and utilized in an attempt to circumvent this issue, the most common of which is preoperative embolization. Despite this, bleeding continues to pose a challenge during resection, and several new techniques are being explored to reduce blood loss at the point of resection. The radiofrequency ablation (Coblation, ArthroCare ENT, Austin, TX) device is a new instrument that uses bipolar radiofrequency energy and electrolytes to create a low temperature plasma field, which disrupts molecular bonds and dissolves tissue. In this report, we describe our experience over the preceding 5 years in 16 patients that underwent endoscopic transnasal resection of JNA at the Children's Hospital of Philadelphia. Seven of these patients underwent resection utilizing the radiofrequency ablation device. Patients were analyzed retrospectively and groups compared in terms of adequacy of resection, estimated blood loss, complication incidence, length of hospital stay, and recurrence. In addition, we describe the technical aspects of the use of this device in the limited space of the pediatric nasal cavity and nasopharynx.

### 039. Loss of PTEN Expression in Sinonasal Squamous Cell Carcinoma

Michelle D. Williams (presenter), Diana Bell, Ehab Y. Hanna (Houston, USA)

**Background:** Squamous cell carcinoma (SCC) arising in the sinonasal and paranasal regions arises from the surface Schneiderian mucosa and may have biologically distinct molecular alterations. Identifying altered pathways for targeted therapy and markers to aid in predicting outcome and response to therapy are needed. Phosphatase and tensin homolog deleted from chromosome-10 (PTEN), a tumor suppressor gene associated with regulation of the PI3K pathway, is altered in many tumor types, including SCC in other head and neck sites. We sought to determine the incidence and potential correlation of PTEN expression with clinical parameters in sinonasal SCC.

**Methods:** Tumor tissue from 48 patients with primary sinonasal SCC who underwent a surgical procedure from 2001–2008 were included in a paraffin tissue microarray. Immunohistochemical analysis was performed for PTEN expression using standard techniques (PTEN 6H2.1, 1:100, Dako, Carpinteria, CA). Each tumor was evaluated for expression in duplicate cores as negative (loss of PTEN expression) or positive (staining in the cytoplasm and/or nucleus in any tumor cells).

**Results:** Five of 48 (10.4%) sinonasal SCC showed complete loss of PTEN expression by immunohistochemical analysis. Internal controls were positive in each case. All five tumors arose in the maxilla in three males and two females. Patients were treated with surgery with or without radiation therapy. One of the five patients developed local recurrence and was treated with salvage surgery. Three patients are alive with no evidence of disease (49–105 months follow-up), and two patients died of other causes with no evidence of disease at 33 months. Survival curves were not statistically significant between PTEN expressing tumor and those with PTEN expression loss.

**Conclusions:** PTEN expression is altered in a subset of sinonasal SCC with 10% showing complete loss by immunohistochemical evaluation. The significance of this alteration in sinonasal SCC is unclear, secondary to limited number of events. Studies are ongoing to delineate the molecular basis for this alteration.

### 040. Endoscopic Endonasal Transcribriform Approach for Anterior Skull Base Tumors Involving the Cribriform Plate: Indications, Techniques, and Results in 13 Patients

Smruti K. Patel (presenter), Mickey L. Smith, Osamah J. Choudhry, Jean Anderson Eloy, James K. Liu (Newark, USA)

**Introduction:** Tumors involving the anterior skull base have traditionally been treated with a transcranial or craniofacial approach. The endoscopic endonasal transcribriform approach (EEA-TC) is an extracranial approach that provides direct visualization and exposure of the ventral anterior skull base without brain retraction or manipulation of neurovascular structures. In this study, we reviewed our experience with EEA-TC for surgical removal of anterior skull base tumors.

**Methods:** Retrospective review of a prospective database of endoscopic skull base procedures performed within a 2-year period revealed 13 patients that underwent EEA-TC for ASB tumors involving the cribriform plate. Nine underwent a pure endonasal approach. Four underwent a combined cranio-nasal approach (EEA-TC plus transbasal craniotomy) because of significant intracranial tumor extension. The pathologies included olfactory groove meningioma ( $n = 4$ ), esthesioneuroblastoma ( $n = 3$ ), sinonasal teratocarcinosarcoma ( $n = 1$ ), olfactory schwannoma ( $n = 1$ ), osteoblastoma ( $n = 1$ ), melanoma ( $n = 1$ ), sinonasal small cell neuroendocrine carcinoma ( $n = 1$ ), and adenoid cystic carcinoma ( $n = 1$ ). All patients underwent multilayer reconstruction of large cribriform skull base defects using autologous fascia lata and AlloDerm graft followed by a vascularized pedicled nasoseptal flap.

**Results:** Gross-total resection was achieved in 84.6% (11 cases), and near-total resection was achieved in 15.4% (2 cases). Postoperative complications occurred in two patients, including a postoperative hematoma and delayed

brain abscess in one patient in the pure EEA-TC group, and pneumocephalus and subsequent bone flap infection in another patient in the combined cranionasal group. There were no postoperative CSF leaks. Mean follow-up was 10 months (range: 1 to 23 months).

**Conclusion:** The EEA-TC is a safe and viable approach for resection of benign and malignant ASB tumors involving the cribriform plate. This can be combined with a transcranial approach in cases with significant intracranial extension. Meticulous multilayer reconstruction of these large skull base defects with nasoseptal flap repair can minimize the risk of postoperative CSF leakage.

#### 041. Navigated Transconjunctival Endoscopic Approaches to the Orbit

Guenther C. Feigl (presenter), Boris Krischek, Rainer Ritz, Kristofer Ramina, Andreas Korn, Marcos Tatagiba (Tübingen, Germany)

**Introduction:** Because the orbit is relatively small yet densely packed with important and delicate anatomical structures surrounding the eyeball, great surgical skill is required in order to avoid injury during surgical approaches. Standard approaches to the orbit involve, in most cases, large skin incisions and also a craniotomy. In order to evaluate less invasive surgical approaches to the orbit, a study was designed assessing endoscopic transconjunctival approaches.

**Methods:** Using 30°/3-mm and 0°/6-mm rigid endoscopes, neuronavigated transconjunctival approaches to the orbit were performed on four cadavers. A special endoscopic head frame was designed for this study in order to avoid injury of anatomical structures due to excessive movement of the endoscope tip in the orbit. On each eye, a lateral and medial transconjunctival supra- and infrabulbar endoscopic approach to the extra- and intraconal space were performed. The size of the incision, maximal depth of penetration in the extra- and intraconal space, and the distance to the optic nerve were measured.

**Results:** All showed good exposure and good access to the extra- and intraconal space. The mean size of the transconjunctival incision for the approach was 10.4 mm. The optic nerve could be exposed through all four approaches. The mean maximal depths of penetration in the extraconal space were 28.6 mm for the 30°/3-mm endoscope and 20.7 mm for the 0°/6-mm endoscope. In the intraconal space, the mean maximal depth of penetration was 23.8 mm for the 30°/3-mm endoscope and 19.4 mm for the 0°/6-mm endoscope. Based on the acquired measurements, a new surgical classification of the orbit in quadrants and zones was made for endoscopic procedures.

**Conclusions:** Transconjunctival endoscopic approaches allow a maximal exposure of the extra- and intraconal space through a minimally invasive approach. None of the approaches required a muscle transection. Infrabulbar approaches have better cosmetic results than suprabulbar approaches, which require incision of the eyelid.

#### 042. Augmented Real-Time Navigation with Critical Structure Proximity Alerts for Endoscopic Skull Base Surgery

Benjamin J. Dixon (presenter), Michael Daly, Harley Chan, Allan Vescan, Ian Witterick, Jonathan Irish (Toronto, Canada)

**Introduction:** Image-guided surgery (IGS) systems are frequently utilized during cranial base surgery to aid

in orientation and facilitate targeted surgery. We wished to assess the performance of our recently developed localized intraoperative virtual endoscopy (LIVE)-IGS prototype in a preclinical setting prior to deployment in the operating room. This system combines real-time ablative instrument tracking, critical structure proximity alerts, 3-dimensional (3D) virtual endoscopic views, and intraoperative cone-beam CT image updates.

**Methods:** Skull base procedures were performed on 14 cadaver specimens by seven fellowship-trained skull base surgeons. Each subject performed two clivus drill-outs; one with LIVE-IGS and one using a conventional IGS system in random order. NASA Task Load Index scores were documented for each dissection, and a semistructured interview was recorded for qualitative assessment.

**Results:** The NASA-TLX scores for mental demand, effort, and frustration were significantly reduced when using the LIVE-IGS system compared with conventional navigation ( $P < 0.05$ ). The system interface was judged to be intuitive and most useful when there was a combination of high spatial demand, reduced or absent surface landmarks, and proximity to critical structures. Registration performance was sufficiently accurate (~1–2 mm) for its intended purpose. The development of auditory icons for proximity alerts during the trial better informed the surgeon while limiting distraction.

**Conclusion:** The LIVE-IGS system provided accurate and intuitive, dynamic feedback to the operating surgeon. Further refinements to proximity alerts and visualization settings will enhance orientation while limiting distraction. The system is currently deployed in a prospective clinical trial in skull base surgery.

#### 043. Transoral Robotic Surgery and Endoscopic Endonasal Approach as Complementary Techniques for the Resection of Extensive Malignancies of the Skull Base

R. L. Carrau (presenter), E. Ozer, D. M. Prevedello, D. de Lara (Columbus, USA)

**Background:** Oncologic resection of the clivus, nasopharynx, and craniovertebral junction and infratemporal fossa is a challenging endeavor due to their complex and protected anatomy.

**Objective:** Our goals were to design a cadaveric model that identified the surgical landmarks from the transoral robotic and endoscopic perspectives and identify advantages and limitations of each technique. This would serve as a template for the complementary use of these techniques.

**Material and Methods:** Cadaveric specimens were dissected using a da Vinci surgical robot and endoscopic endonasal instruments in a fashion that mimicked our operating room environment. We then applied the techniques and lessons learned in the laboratory to resect tumors that originated at the nasopharynx or clivus, and extended below the level of the hard palate.

**Results:** In preparation for the dissection of the nasopharynx, we expanded the sinonasal corridor, exposed the pterygopalatine and infratemporal fossae, and completed a transpterygoid EEA with a detailed anatomical dissection of the infratemporal fossa, nasopharynx, posterior skull base (clivus), and craniovertebral junction. Using TORS, we incised the glossopalatine fold and transected the soft palate laterally, dissected the parapharyngeal space and infratemporal fossa, and extended the dissection medially to expose the

nasopharynx. We identified that the ET represented a transition zone that marked the most effective resection field of each approach. TORS did not require a palatal incision to control the craniocervical junction or upper cervical spine.

The EEA and TORS were applied as complementary techniques to treat two patients presenting with a large chordoma of the clivus extending to C2, and an adenoid cystic carcinoma of the nasopharynx extending into the medial pterygoid muscle at a level that was below that of the hard palate. Both surgeries were completed without complications, and the patients recovered uneventfully.

**Conclusions:** A thorough understanding of the anatomy from the endoscopic and robotic perspectives is critical for the planning and safe oncologic resection of tumors in this area. The surgical team must be versed in both robotic and endoscopic techniques before embarking in such a procedure. Our model provides the opportunity to acquire anatomical familiarity; however, clinical experience is mandatory as anatomical models fall short of real clinical scenarios. TORS and EEA seem complementary for select advanced tumors in these complex areas.

#### **044. A Thermal Injury Alarm System in the Expanded Endonasal Approach to the Skull Base**

Bruce L. Tai (presenter), Albert J. Shih, Erin L. McKean, Stephen E. Sullivan (Ann Arbor, USA)

Expanded endoscopic endonasal approaches to the skull base allow the surgeon to access and remove benign and malignant tumors of the ventral and ventral lateral skull base. The procedure utilizes the natural nasal corridors and avoids incisions on the head and face. This technique often includes drilling the bone that surrounds the optic nerve, cavernous sinus, and branches of the trigeminal nerve to expose the pathology. Due to the nature of the shallow, confined space in the skull, the ability to cool the burr tip is limited and high temperature exists at the bone-burr interface. Thermal injury from drilling adjacent to these nerves is of particular concern because neurosurgeons have no way to gauge the tissue temperature. This research aims to develop a system to provide surgeons real-time temperature feedback at critical nerves during the surgery.

The electrical power generated by the drill console is the key information because it drives the drill motor to maintain a certain rotation speed. Changes in drill power are nearly proportional to changes in temperature at the bone-burr interface. As in many cutting processes, approximately 99% of the energy consumption converts into heat, and part of the heat flows into the bone and propagates to the surrounding tissues. Through a statistically designed experimental study, the conversion model of power-to-heat generated can be created. Preliminary results have demonstrated this approach in an ex vivo bone drilling setup.

Having known the heat generation on the burr-bone interface, a bio-heat transfer model can be applied to calculate the temperature response around the drilling site. The model is established from patients' preoperative CT and MRI data with the exact anatomic shape of bone and nerve, and the burr location is tracked via the intraoperative navigation system. This thermal analysis module will be able to provide a real-time thermal map onto the patient 2-D CT images. Surgeons can select CT images of interest to view the drilling temperature simultaneously. This system is expected to dramatically improve the quality of life in patients suffering from skull base tumors.

#### **045. Vagus Nerve Monitoring During Skull Base Surgery: A Transnasal Nerve Monitoring Technique**

Christopher A. Schutt (presenter), Boris Paskhover, Benjamin L. Judson (New Haven, USA)

**Objective:** The vagus nerve is at risk during open resection of skull base tumors involving the high parapharyngeal space and infratemporal fossa, particularly with less invasive approaches where the superior exposure may be limited. Nerve monitoring using an endotracheal nerve monitoring system is well established for thyroid surgery. However, an oral endotracheal tube limits operative exposure of some skull base tumors either by being in the surgical field or by preventing full mobilization of the mandible with transcervical approaches. We describe the novel use of a commercially available nerve-monitoring endotracheal tube, which is placed transnasally during open skull base surgery for infratemporal fossa or high parapharyngeal space tumors.

**Methods:** Ten patients underwent open resection of tumors including paraganglioma (3), nerve sheath tumor (2), meningioma (1), deep lobe parotid tumor (pleomorphic adenoma) (2), poorly differentiated sarcoma (1), and a giant ranula (1). A nerve monitor endotracheal tube (Medtronic, Santa Rosa, CA) was placed transnasally during the initiation of general anesthesia. A video-assisted intubating laryngoscope was used to confirm placement of the endotracheal tube nerve monitor electrodes at the level of the glottis. The vagus nerve was identified lower in the neck, and stimulation confirmed successful monitoring of the nerve. Manipulation of the nerve superiorly, where there was more limited exposure, also stimulated the nerve.

**Results:** In all 10 cases (100%), the vagus nerve was identified and stimulated, confirming successful nerve monitoring. One patient experienced minor epistaxis, which was managed conservatively. Three patients had involvement of the vagus nerve by tumor and had expected postoperative vagal deficits. One patient had dissection of the vagus nerve off of the tumor with a transient vagal deficit. No patients had vagal nerve injury or weakness other than from the intended dissection of the nerve at its interface with the tumor. Five patients underwent transcervical approaches, three underwent maxillary swing with a transcervical approach, and two underwent double mandibular osteotomy.

**Conclusion:** Transnasal vagal nerve monitoring is a novel and simple method that allows for continuous nerve monitoring when using less invasive open surgical approaches for tumors that put the vagus nerve at risk.

#### **046. Postoperative Imaging of the Transpalpebral "Eyelid" Approach for the Surgical Treatment of Anterior Cranial Fossa Lesions: What the Neuroradiologist and Skull Base Surgeon Need to Know**

Allison Weyer (presenter), Michael Spearman, Khaled Abdel Aziz, Erik Happ, Michael F. Goldberg (Pittsburgh, USA)

**Purpose:** The purposes of this study are: (1) To introduce the transpalpebral "eyelid" approach for the surgical treatment of anterior cranial fossa lesions with review of the relevant skull base, orbital, and periorbital anatomy, (2) to review the expected postoperative imaging findings following the transpalpebral approach to the anterior cranial



fossa, and (3) to discuss complications associated with this relatively new surgical technique.

*Description:* The concept of minimally invasive skull base surgery has evolved considerably during the last couple of decades, and it is critical for the neuroradiologist and skull base surgeon to be aware of these developing surgical techniques and expected postoperative imaging appearances. The neurosurgical department at our institution has adapted the traditional supraorbital frontal mini-craniotomy for anterior cranial fossa lesions by utilizing the natural skin crease of the upper eyelid rather than the more traditional ciliary or supraciliary approach.

Fifty patients have undergone this treatment at our institution for a variety of indications (most commonly anterior circulation aneurysm and meningioma), the largest case series at a single institution to date. Based on this experience, the purpose of our presentation will be to (1) describe this technique in detail and review the relevant anatomy; (2) review the expected postoperative imaging findings, such as the unique bony defect seen in this type of craniotomy; and (3) review the wide range of complications that can be well characterized on imaging, including eyelid hematoma, infection, exophthalmos/enophthalmos, CSF leak, and cerebrovascular accident.

*Summary:* This study (1) introduced and described the transpalpebral “eyelid” approach for surgical treatment of anterior cranial fossa lesions, a relatively new technique that is gaining broader use in the neurosurgical community; (2) reviewed the relevant skull base, orbital, and periorbital anatomy; and (3) reviewed postoperative imaging findings, including complications.

#### **047. Intraoperative CT-Guidance to Confirm Decompression Following an Endonasal Approach for the Treatment of Cervicomedullary Compression**

Abhiram Gande (presenter), Matthew J. Tormenti, Maria Koutourousiou, Alessandro Paluzzi, Juan C. Fernandez-Miranda, Carl H. Snyderman, Paul A. Gardner (Pittsburgh, USA)

*Introduction:* Cervicomedullary compression often requires an anterior approach to address the compressive vector. In certain cases an endoscopic endonasal approach is ideal for decompression. It is essential that adequate decompression be achieved and verified before the patient leaves the operating room. The purpose of this study was to evaluate the use intraoperative CT (IO-CT) in assessing the adequacy of decompression.

*Methods:* A retrospective chart review revealed 11 cases of EEA odontoid resection IO-CT verification of decompression. Operative reports and review of imaging was used to determine if further decompression was performed following the intraoperative scan.

*Results:* Out of 11 EEA cases, 4 (36%) patients showed evidence of residual compression following an initial IO-CT. Further operative decompression was undertaken following the first scan in all cases. A second intraoperative scan was then used to confirm complete decompression. No patient left the operating room with residual compression.

*Discussion:* IO-CT provided valuable utility in 36% of the cases after the initial resection was incomplete. The standard fluoroscopic guidance may not provide adequate resolution and enhanced utility like IO-CT.

#### **048. Real-Time Imaging with the O-Arm for Skull Base Applications: A Cadaveric Feasibility Study**

Shaan M. Raza (presenter), Alfred P. See, Michael Lim (Baltimore, USA)

*Introduction:* Although intraoperative imaging/navigation has established its critical role in neurosurgery, its role in cranial base surgery is currently limited. Due to issues such as poor bony resolution and accuracy, surgeons have to rely on anatomic landmarks that can be distorted by pathology when drilling out critical structures. Though originally developed for spinal application, we hypothesized that the O-Arm could address the above issues for use in cranial base procedures.

*Methods:* A cadaveric study was performed where heads underwent a pre-procedure scan via the O-Arm, a fluoroscopic device capable of providing 3-dimensional images through the use of cone-beam technology. Pre-procedure scans were taken and then registered to a Stealth S7 machine. Key cranial base landmarks were identified on these scans and then subsequently identified under direct visualization after (1) endoscopic endonasal dissection and (2) a middle fossa approach. We then quantified the difference in distance between the preplanned and identified structure during surgery. This difference was considered the error.

*Results:* For anterior cranial fossa structures, the mean error was 0.25 mm (anterior septum), 0.27 mm (left septum), and 0.32 mm (right septum). For middle fossa structures, the errors were: 0.11 mm (foramen spinosum), 0.44 mm (foramen rotundum), and 0.21 mm (foramen ovale).

*Conclusion:* Based on this preliminary cadaveric study, we feel the O-Arm can provide the necessary imaging resolution at the skull base to be employed for intraoperative navigation during cranial base approaches (open and endoscopic). This study warrants further investigation into its clinical use in patients undergoing similar surgical procedures.

#### **049. Confocal Laser Endomicroscopy (CLE) for Diagnosis and Histomorphologic Imaging of Brain Tumors in Vivo**

Cleopatra Charalampaki (presenter), Sebastian Foersch, Axel Heimann, Konstantin Mpoukouvalas, Oliver Kempfski (Graz, Austria)

*Introduction:* Intracranial neoplasia forms a heterogeneous group of different neuropathologic entities, some of which belong to the most aggressive types of tumors in humans. Early detection and histopathologic evaluation during surgery are crucial for a curative resection. Confocal laser endomicroscopy (CLE) is a novel technique that allows in vivo histologic imaging with miniaturized endoscopic probes at excellent resolution. The aim of the current study was to evaluate CLE for in vivo diagnosis and histomorphologic imaging in different types and models of intracranial neoplasia.

*Methods:* First, in vivo histomorphology of healthy rat brains and two different C6 glioma cell line xenografts were evaluated in rats ( $n = 13$ ). One cell line expressed EYFP, the other cell line was used for staining experiments with different fluorescent dyes (fluorescein, acriflavine, FITC-dextrane,

and indocyanine green). To evaluate future application in patients, fresh surgical resection specimens of different human intracranial tumors ( $n = 15$ ) were examined with CLE. Tissue specimens included glioblastoma, meningioma, craniopharyngeoma, acoustic neuroma, a brain metastasis, medulloblastoma, and an epidermoid tumor. H&E staining served as gold standard. Healthy brain tissue of the same patient attached to the samples served as control.

**Results:** In all models, CLE yielded high-quality images of the histomorphology of normal brain tissue and different brain tumor types. Different fluorescent agents displayed distinct aspects of tissue and cell structure, such as nuclear patterns, axon pathways, and intercellular configuration. In brain tumor xenografts, the tumor margin could frequently be visualized. CLE diagnosis of and discrimination between neoplastic vs. healthy brain tissue was easy to perform based on tissue and cellular architecture, and resemblance with histopathology was excellent. Even the primary tumor origin of the brain metastasis could be diagnosed.

**Conclusion:** Confocal laser endomicroscopy allows immediate *in vivo* morphologic imaging of normal and neoplastic brain tissue at high resolution. Our findings suggest that this technology might be transferred to scientific and clinical application in neurosurgery and neuropathology. This might impact intraoperative diagnosis and treatment of patients with brain cancer, for example, to screen for free tumor margins, improving the surgical resection of malignant brain tumors, but also open the door to *in vivo* molecular and functional imaging of intracranial neoplasia and other types of neurologic disorders.

#### **050. Combined Intraoperative MRI and Endoscopic Endonasal Approaches for Nonpituitary Skull Base Lesions**

Devon Haydon (presenter), Ravindra Uppaluri, Gregory Zipfel, Bruce Haughey, Anne Getz, Michael Chicoine (St. Louis, USA)

**Introduction:** Endonasal endoscopic approaches and intraoperative MRI (iMRI) are becoming established as valuable surgical techniques for pituitary tumors, but there has been little reported in combining these two techniques for nonpituitary skull-base tumors. We report our initial experience with this strategy using a movable high-field-strength iMRI.

**Methods:** Review of a prospective database of 470 iMRI procedures performed at Barnes-Jewish Hospital since April 2008 identified 11 patients who underwent 13 endoscopic endonasal resections for nonpituitary skull base neoplasms using 1.5T iMRI. Demographic, radiologic, surgical decision making, operative time, extent of resection, patient morbidity, and outcomes data were analyzed.

**Results:** Eleven patients (6 male; 5 female) safely underwent 13 endoscopic endonasal surgeries with iMRI. Mean age at surgery was 44 years (range, 12–70 years). Mean operative time was 10.4 hours (range, 4.9–13.6 hours). Pathology revealed chordoma (3), meningioma (3), epidermoid cyst, chondrosarcoma, craniopharyngioma, adenoid cystic carcinoma, and nasopharyngeal angiofibroma. iMRI demonstrated gross total resection (GTR) in 3 cases and subtotal resection (STR) in 10 cases. Additional resection was performed in 6 STR cases after iMRI (60%). Tumor tissue was pathologically confirmed in all post-iMRI resection specimens. Ten of 11 patients were alive at the time of analysis. One patient developed

persistent pneumocephalus postoperatively, which resolved after a planned second stage operation during that admission. Otherwise, there were no CSF leaks and no meningitis. Patients noted stable or improved preoperative deficits after 12 (92%) of the surgeries. One new deficit was observed consisting of mild diminished sensation in the trigeminal distribution after resection of an angiofibroma invading the pterygopalatine fossa. At last follow-up, surveillance MRI showed stable residual disease in 55% of patients, while 45% had no evidence of disease. Mean follow-up was 12 months (range, 1–27 months).

**Conclusions:** Complex nonpituitary skull base lesions can be resected safely via the endoscopic endonasal approach with a movable high-field-strength iMRI. This method may maximize tumor resection from greater visualization while minimizing operative morbidity through a less invasive trajectory. Additional investigation is needed to determine the most appropriate application of this technique.

#### **051. Posterior Cavernous Anterior Transpetrosal Posteromedial Rhomboid (Dolenc-Kawase Rhomboid) Approach to Posterior Cavernous and Petroclival Lesions** Suri Ashish (presenter), (New Delhi, India)

The anterior transpetrosal approach involves extradural exposure of the posteromedial (Kawase) triangle, which is bounded by the arcuate eminence, the greater superficial petrosal nerve (GSPN), and the petrous ridge. It allows exposure of the tentorium and the middle fossa and the posterior fossa up to the internal auditory meatus. Despite permitting a key access point, the exposure is conical and crowded; it does not allow proper exposure to the Vth nerve. Exiting is from the tentorium, the VIth nerve in the Dorello canal, and the under-surface of the attachment of the tentorium to the posterior clinoid process. Dissection of the posterior cavernous sinus wall over the V2, V3, and gasserian ganglion permits access to a posteromedial rhomboid bounded by the arcuate eminence (posterior), GSPN (lateral), the petrous ridge (medial) and V3, and the gasserian ganglion (anterior). Ligation and division of the superior petrosal sinus close to the posterior clinoid process and gentle elevation of the Vth nerve root permit an enlarged view of the previous inaccessible areas. A posterior cavernous anterior transpetrosal posteromedial rhomboid (Dolenc-Kawase rhomboid) approach with or without zygomatic osteotomy was used in the treatment of petroclival meningiomas (32); giant dumbbell trigeminal schwannoma (11); clival chordoma (6); clival chondrosarcoma (4); trochlear schwannoma (1); giant posterior fossa craniopharyngioma (4); middle + posterior fossa epidermoid (2); hypothalamic hamartoma (1); giant low basilar bifurcation aneurysm (2); petroclival hemangiopericytoma (1); and bilateral petroclival, cavernous, and tentorial histiocytosis (Rosai-Dorfman).

The conclusion of this study is that a posteromedial rhomboid petrous apex approach is technically demanding and requires a thorough knowledge of skull base anatomy and pathology; it provides a safe corridor during the microsurgical treatment of a spectrum of skull base lesions.

#### **052. Identifying RNA and Protein Expression Profile of Bone Invading and Non-Invading Meningiomas** Shahzad Jalali, Takafumi Wataya, Sidney Croul, Gelareh Zadeh (presenter), (Toronto, Canada)

**Introduction:** Although meningiomas are considered as benign primary brain tumors, a subset invades bone and

adjacent neural and soft tissues and causes hyperostosis. Skull base bone-invading meningiomas represent a significant clinical challenge because complete surgical resection is often impossible, resulting in higher recurrence rates and repeat surgery. This study aims to identify differential gene and protein expression profile and altered signaling pathways of bone-invading and non-invading meningiomas, with the ultimate goal to establish potential novel therapeutic targets.

**Methods:** Archived tumor specimens of 75 patients with either bone invading or non-invading meningiomas were selected. RNA and tissue microarray were performed on the samples. The results of the array data were verified using real-time PCR analysis. Meningioma cell lines (IOMM-Lee, CH157-MN and F5) were used for in vitro and in vivo functional studies. Matrigel invasion assay, immunostaining, and western blotting were used to characterize the behavior of these cells in vitro. Xenograft intracranial meningioma tumors were generated in mice. Small-animal MRI was used to study tumor growth pattern and behavior. Meningioma tumor samples were also used for immunohistochemical analysis.

**Results:** RNA microarray data identified 222 differentially expressed genes, of which MMP16 and 19 were selected as novel matrix remodeling metalloproteinases involved in bone invasion. Real-time PCR analysis confirmed the over-expression of these genes in bone-invading meningiomas. In vitro studies identified a direct correlation between the invasive capacity of the meningioma cell lines and expression level of MMP16 and MMP19. siRNA inhibition of MMP16 demonstrated diminished proliferation and invasion in vitro and in vivo. The downstream signaling pathways regulated by MMP16 were identified as MAPK and AKT. In vivo studies using xenograft meningioma tumor models showed the tumor growth and invasion to the underlying bone tissue and confirmed our in vitro data.

**Conclusion:** We identify novel pathways that play an important contributory role to bone invasion in meningiomas. These results provide the basis of future studies to explore potential for targeting MMP16 and 19 in bone-invading meningiomas.

### 053. Meningiomas Involving the Dural Venous Sinuses: Surgical Outcome in 118 Patients

George Al Shamy (presenter), Loyola Gressot, Dima Suki, Raymond Sawaya, Franco Demonte, Nicholas B. Levine (Houston, USA)

**Introduction:** Management of meningiomas involving the dural venous sinuses can be controversial. Neither definitive guidelines nor a general consensus of best management exists. Some surgeons consider tumoral invasion of the dural venous sinuses a contraindication to surgery, whereas others advocate aggressive resection with or without venous sinus reconstruction.

**Methods:** Data from 118 patients who had undergone resection of a meningioma involving a dural venous sinus at MDACC between 1993 and 2010 were reviewed. The average follow-up was 40 months.

**Results:** Meningiomas involved the SSS in the majority of our patients (85%). Average age of presentation was 55 years old, and women were more commonly affected (57%). Majority of tumors were large with an average volume of 32 cm<sup>3</sup>. Among the patients, 25% had undergone prior

surgical intervention and 52% had a meningioma of Sindou grade 3 or more on presentation. Sixty percent of tumors were WHO grade 1. Simpson grade 1 or 2 resections were achieved in 50% of the patients. Recurrence rate for these patients was 18%. Average time to recurrence was 30.8 months. Five patients received postoperative radiation, all had atypical tumors, and three of them recurred. Of the patients with subtotal resection, the rate of progression was 35%, with an average time to progression of 28.6 months. Thirty percent of the patients with subtotal resection received radiation. The majority of these patients had atypical pathology. There was no difference in progression rate whether these patients received radiation or not. The dural venous sinus was ligated for Sindou grade 5 or 6 tumors, while the sinus was maintained for tumors infiltrating a patient's sinus. Sindou grade 1 or 2 tumors adjacent to the sinus were dissected off of the patent sinus. Three-month KPS scores were equivalent to preoperative values. The 30-day neurological complication rate, the majority of which were transient, was 29%.

**Conclusion:** Surgical therapy remains the mainstay of treatment for meningiomas involving the dural venous sinuses. XRT is usually reserved for atypical pathology but may not impact the recurrence rate.

### 054. Long-Term Outcomes of Surgical Treatment and Predicting the Probability of Skull Base Meningiomas Recurrence

Yury A. Shulev (presenter), Ovanes R. Akobyan (St. Petersburg, Russia)

**Objective:** Skull base meningiomas surgery is a complicated problem, and a surgeon always has a question: whether total tumor removal is possible and what the outcomes might be. The purposes of this research were outcome analysis of skull base meningiomas surgical treatment and reliable prognosis scale designing.

**Methods:** Between 1996 and 2010, 231 patients with skull base meningiomas underwent surgical treatment. The mean patient age was 52.2 years (range, 29–80 years), F:M = 3:1. The mean estimated tumor diameter was 3.4 cm (range, 0.5–7.9 cm). Clinical data, magnetic resonance imaging studies, angiographic data, operative reports, histopathological findings, and MIB-1 index were analyzed. Mean follow-up was 74 months (range, 6–146 months). Functional outcomes were evaluated using the Karnofsky Performance Scale (KPS).

**Results:** Total removal (Simpson I) was obtained in 209 patients (83.6%); Simpson II was achieved in 24 patients (9.6%). In the 231 patients, mean preoperative and follow-up KPS scores were 76.2 ± 11 and 84 ± 8, respectively. Tumors of WHO histopathological grades I, II, and III were diagnosed in 222 (96.1%), 6 (2.6%), and 3 (1.3%) cases, respectively. The median MIB-1 index was 1.7% (range, 0–41.6%). Tumor recurrence was observed in 19 patients (8.2%). As authentic predictors promoting meningiomas' recurrence, the following factors were allocated: previous radiation therapy, tumor localization (median, lateral, multiple fossa involvement), the size of a tumor (< 3cm), a lesion of cranial nerves, a brain invasion, degree of resection (Simpson I, II, III, or IV), a tumor histological structure (WHO grade), and MIB-1 index. As a result, a relapse scale was composed to forecast meningiomas. Recurrence rate was measured in terms of points of this scale. Probability of relapse scores were: low, 0–3 points; average, 4–6 points; high, 7 and higher points. Low, moderate, and high recurrence rates consisted of

117 (50.6%), 65 (28.1%), and 49 (21.2%) cases, respectively. Out of 19 patients with tumor recurrence, 1 had low recurrence rate (middle fossa), 6 had moderate (middle fossa and petroclival), 12 had high (middle fossa, petrous ridge, craniocorbital).

**Conclusion:** The authors identified a triad of factors contributing to tumor relapse: midline localization, multiple fossa involvement, and MIB-1 index more than 3%. Combined therapy is indicated for patients with high recurrence rate: microsurgery with following radiosurgery.

### 055. Clinical Characteristics and Surgical Management of Meningiomas Invading Dural Sinus

Joshua W. Osburn (presenter), Alessandra Mantovani, Salvatore DiMaio, Michael R. Levitt, Manuel Ferreira, Laligam N. Sekhar (Seattle, USA)

**Background:** Meningiomas involving the dural sinuses present a challenging problem in surgical management. Aggressive attempts at maximum tumor resection aim to improve patient outcomes and reduce recurrences but must be balanced with patient safety and risk to the cerebral venous circulation. The authors review the institution's experience with sinus-invading meningiomas.

**Methods:** A database of 219 patients with histopathologically confirmed meningiomas undergoing surgical resection from 2007–2011 was reviewed, and 24 patients were identified with tumors invading dural sinuses as confirmed by vascular imaging on formal cerebral angiogram, MR venogram, or CT venogram. We review the characteristics and surgical management of these tumors.

**Results and Surgical Technique:** Of 24 meningiomas (14 female and 10 male) invading dural sinuses reviewed, 18 invaded the superior sagittal sinus and 5 the transverse sinus. On imaging, 9 patients had totally occluded sinuses, 5 subtotally occluded (50–99% stenosis), and 10 partially occluded (<50% stenosis). Twenty patients were WHO grade I, and 4 were WHO grade II. A gross total resection was achieved in 19 cases (79.1%). Fourteen patients underwent sinus opening and reconstruction for tumor removal, 10 of these with primary suturing and 4 with a patch. In order to assist sinus patency when sinus reconstruction was planned, patients were placed on preoperative aspirin and inhibition of platelet function was confirmed with the VerifyNow platelet function test (Accumetrics, Inc.). Antiplatelet therapy was continued 3 months after surgery. On postoperative venogram, 11 (78.6%) of the reconstructed sinuses were patent, and the 3 of 4 postoperatively occluded sinuses had been occluded before surgery. No deaths or major complications occurred in the study population.

**Conclusion:** Our study demonstrates techniques for aggressive surgical management of dural sinus invading meningiomas that carry low morbidity and high sinus patency. The study demonstrates that aggressive sinus resection and reconstruction in conjunction with antiplatelet therapy can be performed safely and potentially lead to improved patient outcomes.

### 056. Bone Invasion in Skull Base Meningiomas Resected by Expanded Endonasal Endoscopic Approaches

Leo F. Ditzel Filho (presenter), Danielle de Lara, Rodrigo C. Mafaldo, Matthew O. Old, Bradley A. Otto, Ricardo L. Carrau, Daniel M. Prevedello (Columbus, USA)

**Background:** Degrees of resection and bone invasion by skull base meningiomas are known prognostic factors.

Endonasal endoscopic techniques allow early bone removal during the approach itself.

**Objective:** The purpose of this study was to analyze evidence of bone invasion in a series of skull base meningiomas treated with endonasal endoscopic techniques.

**Methods:** All imaging and pathology reports of 48 consecutive skull base meningiomas operated on endonasally by the senior author (DMP) in conjunction with the skull base team were retrospectively reviewed. Confirmation of bone invasion was based in pathologic analysis. Cases for which pathologic review of bone invasion was not recorded were discarded.

**Results:** Twenty-three of 48 skull base meningiomas were evaluated for histologic evidence of bone invasion. Tumor location was distributed as follows: the olfactory groove ( $n = 9$ ), tuberculum sellae ( $n = 7$ ), sphenopetroclival ( $n = 2$ ), and sphenocavernous ( $n = 5$ ) regions. Microscopic analysis identified 20 WHO grade I tumors and 3 grade II lesions; there were no malignant meningiomas. Twenty-two (95.65%) of the 23 analyzed patients were positive for bone invasion.

**Conclusions:** Regardless of the route used, surgeons tackling skull base meningiomas must be aware of the high rate of bone invasion related to this pathologic group and address it accordingly. Further prospective studies are necessary to determine whether complete bone removal will render lower rates of recurrence.

### 057. Computer-Aided Volumetric Analysis as a Sensitive Tool for the Management of Incidental Meningiomas

Victor Chang (presenter), Jack Rock (Royal Oak, USA)

**Background:** Meningiomas, which are typically slow growing lesions that depend on location, can be relatively benign. Knowing their exact rate of growth can be helpful in determining whether surgery is necessary.

**Objective:** In this study, we retrospectively reviewed the meningioma practices of the two senior authors (JR, MR). Our goal was to measure meningioma growth using a variety of methods (linear, using diameters, and volumetric, using the computer-aided perimeter and cross-sectional diameter methods) to compare rates of growth among the methods.

**Methods:** Of 295 meningioma patients seen over an 8-year period, we identified a cohort of 31 patients with at least 30 months of follow-up. Volumes were calculated using medical imaging software with T1 post-contrast magnetic resonance imaging. Doubling times and growth rates were calculated.

**Results:** Of the 31 patients, 26 (84%) were shown to have growing meningiomas. The perimeter methodology measured higher growth rates than the diameter method for both doubling times as well as percentage annual growth ( $P < 0.01$ ). The mean doubling time was 13.4 years (range, 2.1–72.8 years) and 17.9 years (range, 4–92.3 years) comparing perimeter and diameter methods, respectively. The mean percentage of annual growth was 15.2% (range, 1.8–61.7%) and 5.6% (range, 0.7–12.2%) comparing perimeter and diameter methods, respectively. Linear growth was calculated at 0.7 mm/year.

**Conclusion:** Overall, the methods traditionally used to track meningiomas using cross-sections underestimated the amount of tumor progression compared with volumes calculated using computer-aided perimeter methods.

### 058. Evaluation of Molecular Alterations in Petroclival Meningiomas and Their Correlation with Extent of Tumor Resection

Vaishali Suri, (presenter), Sawan Kumar, Laxmi Mohan, Utkarsh Bhagat, Ashish Suri, M. C. Sharma, Chitra Sarkar (New Delhi, India)

**Objective:** The purpose of this study was to examine molecular alterations in meningiomas and their correlation with subtotal versus gross total resection.

**Methods:** Twenty cases of petroclival meningiomas at first surgery, 10 with gross total resection (GTR) and 10 with subtotal resection (STR), were included. All the slides were reviewed and diagnosis reconfirmed. Immunohistochemical staining was performed for progesterone receptor status, p53 expression and MIB-1 labeling. Fluorescence in situ hybridization was performed for chromosome 1p and 14q alterations.

**Results:** The majority (95%) of meningiomas were WHO grade I, with meningothelial meningioma being the most common (45%). There was only one case of chordoid meningioma (WHO grade II). Age range was 30 to 60 years with female preponderance (M:F, 1:2.3). Mean MIB labeling index in cases with STR was higher (range, 1–5%; mean 3%) than with GTR (range, 1–3%; mean 2%). There was no significant difference in progesterone receptor expression as 70% cases with GTR and 80% with STR showed immunopositivity. All the 20 cases were immunonegative for p53 protein expression. Interestingly, 20% of cases with STR showed 1p deletion, but 14q deletion was seen in none. All cases with GTR did not show alterations in either chromosome 1p or 14q except one case of chordoid meningioma, which showed deletion for both 14q and 1p.

**Conclusion:** No significant difference was noted with regards to histopathological features, proliferation index, progesterone receptor, or p53 expression in cases with GTR versus STR. Presence of 1p deletion in 20% cases with STR suggests that molecular alterations correlate with the infiltrative nature of the tumor thus allowing identification of biologically aggressive meningiomas. This will possibly improve our ability to stratify patients into prognostic subsets and guide for further therapeutic interventions. Studies on a larger cohort of samples is warranted

### 059. Petroclival Meningiomas

Ibrahim Sbeih (presenter), (Amman, Jordan)

**Introduction:** Petroclival meningiomas are rare tumors constituting 5% of all intracranial meningiomas. They are difficult lesions to treat because of their location and neurovascular relationships.

**Methods:** We operated on 61 cases of petroclival meningiomas in the period between 1990 and 2008. Seven patients were lost for follow-up. We are presenting our experience with 54 cases (average of age 43 years) that we operated on and who were followed up for a period ranging from 13–176 months. There were 36 females, and 18 males. None of our patients had previous surgeries for their meningiomas.

**Results:** The main presenting manifestations were cranial nerve involvement, with abducent nerve deficits being the most common. Other presentations included ataxia, hemiparesis, quadriparesis, and features of raised intracranial pressure. Radiological diagnosis rested on the use of brain MRI, MRA, MRV, and thin slice CT scan of petrous bone and clivus. Surgical approaches used were retrosigmoid in 40 patients, petrosal in

9 patients, and combined approaches in 5 patients. We achieved gross total resection in 38 patients and subtotal resection in 16 patients. Recurrence occurred in all 13 patients who had subtotal resection, and in 7 patients who had gross total resection. After a period of observation, Gamma radiosurgery was used in 11 patients, using 12–15 Gy to the 50% isodose. Tumor control was achieved in 9 patients. Surgical results were: poor outcome in 4 patients, fair outcome in 10 patients, and good outcome in 40 patients. Complications included new cranial nerve deficits in 15 patients, pyramidal weakness, CSF fistula, and hydrocephalus. Mortality occurred in two patients.

**Conclusion:** Petroclival meningiomas are formidable lesions to treat. Factors influencing surgical outcome include neurovascular relationship, bony invasion, and multiple intracranial compartment involvement, among other factors. Every effort should be made to achieve gross radical excision. However, this is not possible in some cases. For such residual tumors, Gamma radiosurgery should be used, after a period of observation.

### 060. Facial Reanimation with Masseteric-Facial Nerve Anastomosis Following Skull Base Surgery

Nobutaka Yoshioka (presenter), (Osaka, Japan)

**Background:** Hypoglossal-facial nerve anastomosis has been widely used for facial reanimation. However, hemiglossal dysfunction remains a possible disadvantage of this procedure. Use of the masseteric nerve has recently been shown to be useful as a primary modality for facial reanimation. We present our experience with masseteric-facial nerve anastomosis for patients with irreversible facial palsy after skull base surgery.

**Methods:** In the period from 2009 to 2011, five patients with irreversible facial palsy after extirpation of skull base tumors were treated with masseteric-facial nerve anastomosis. The age of the patients ranged from 53 to 61 years (mean, 57 years), and all were female. The duration of paralysis was no longer than 11 months. Follow-up periods were from 8 to 31 months (mean, 20 months). The upper division of the facial nerve was generally selected for masseteric-facial nerve anastomosis. In four cases, the procedure was performed in conjunction with a cross-face nerve graft between the contralateral and affected zygomatic branch.

**Results:** Four patients regained facial movements within 5 months postoperatively. They were able to produce a voluntary smile. One case, who had been treated with a steroid for pneumonia, failed to show reanimation. Masseter muscle contraction was preserved in every patient.

**Conclusions:** Masseteric-facial nerve anastomosis is an alternative method for reanimation of the midface. The major advantage over the other cranial nerve donors is the lack of functional impairment of mastication. Moreover, the masseteric nerve has a sufficient nerve length without the need for interpositional nerve grafting for masseteric-facial anastomosis, and this accelerates facial muscle reinnervation.

### 061. Detailed Analysis of Neurological Status and Functional Outcome after Spinal Accessory Nerve-Facial Nerve Anastomosis: Comparison versus Other Reinnervation Procedures in Reported Series

Alexander V. Trashin (presenter), Yury A. Shulev, Vladimir L. Rychkov (St. Petersburg, Russia)

**Introduction:** Few long-term studies of spinal accessory nerve-facial nerve anastomosis (AFA) for facial nerve (FN) palsy exist.

**Objective:** The purpose of this study was to evaluate facial reanimation efficacy after spinal accessory nerve–facial nerve anastomosis (AFA) using scales for neurological and functional outcome analysis. The authors reported their long-term results of AFA and compared them with other substitute procedures according to literature review.

**Methods:** Between 1998 and 2010, 20 patients underwent AFA with the major trunk of the spinal accessory nerve. The mean duration of follow-up was 4.65 years (range, 1–10 yrs). All patients in the series had total facial nerve (FN) function loss after acoustic neuroma surgery. Six patients had conjoined trigeminal nerve dysfunction. The interval between FN loss and the operation was from 1 to 6 months (mean, 4.7). Twelve patients received facial muscles retraining and shoulder exercises as well as a facial electrical stimulation for a year after the surgery. Video-recording of participants were made, so FN and shoulder function were measured in each patient by physicians who did not participate in the surgery. Each patient was carefully evaluated utilizing the House-Brackmann (HB) facial grading systems and the Yanagihara system (YS) for the severity of paresis; the Sunnybrook Facial Grading Scale (SFG) for facial symmetry and synkinesis. Facial Disability Index (FDI) was used for patients' self-assessment. The original questionnaire, Shoulder Disability Index (SDI), which includes four questions about shoulder function, was generated and used for denervated segment self-assessment (full marks: 100 points).

**Results:** Overall, 4 patients (20%) recovered from facial palsy with final HB grade II, 11 (55%) patients with HB III and 5 patients (25%) had HB IV-V. Mean YS score was 27.5 ( $\pm$  4.06), mean postoperative SFG score was 71.1 ( $\pm$  9.38). Self-assessment tools revealed mean total postoperative FDI of 143.75 ( $\pm$  22.82) points and mean SDI of 69.06 ( $\pm$  22.16). Statistical comparison was made for all received data. There was a significant correlation ( $P < 0.001$ ) between the HB, YS, and SFG postoperative scores as well as between total FDI versus SDI ( $P < 0.001$ ). Patients who underwent postoperative exercises and electrotherapy showed better outcomes ( $P < 0.05$ ).

**Conclusion:** AFA results are comparable with other reinnervation procedures. This procedure is feasible and beneficial for patients with total loss of FN function after skull base surgery and improves quality of life. The best functional result provides AFA combined with subsequent physiotherapy. Subjectivity is the main issue in the facial expression evaluation, so assessment and self-assessment scales are needed for the global evaluation of FN functions. Denervated segment function after the substitute procedures must be measured using specific scales.

#### 062. Microvascular Free Tissue Transfer for Facial Reanimation of the Paralyzed Face

Amy L. Pittman (presenter), John P. Leonetti, Sam J. Marzo, Douglas Anderson, Darl Vandevender, Richard Borrowdale (Maywood, IL, USA)

Preoperative facial weakness may be caused by extracranial, intratemporal, or intradural facial nerve invasion by a variety of benign and malignant lateral skull base or posterior fossa neoplasms. Interposition facial nerve grafting is not possible when the paralysis is longstanding, when the facial musculature must be resected, or if a proximal facial nerve stump is not available. In these situations, the best possible alternative is free tissue transfer when the goal is restoring

dynamic facial function. This paper outlines the use of microvascular free tissue transfer techniques that can be used for both defect reconstruction and dynamic facial reanimation. The most commonly used free flaps for facial reanimation are the gracilis, latissimus dorsi, serratus anterior, and inferior rectus abdominus muscle.

Donor muscle flap selection and surgical technique will be described and case examples will be detailed.

#### 063. Practical Approach to Microvascular Reconstruction of Significant Skull Base Defects

Matthew Old, Kiran Kakarala (presenter), Amit Agrawal, Enver Ozer, Ricardo Carrau, Mario Ammirati, Daniel Prevedello, Theodoros Teknos (Columbus, USA)

**Background:** Complex defects of the lateral and anterior skull base present challenges for the reconstructive surgeon. With the increasing use of microvascular free flaps and improved medical modeling technology, reconstruction of large complex defects can be approached with a practical algorithm. However, surgeons must be experienced with the full reconstructive ladder to balance the reconstruction with patient-oriented factors.

**Methods:** We reviewed and consolidated our experience and formulated a practical algorithm for reconstructing significant anterior and lateral skull base defects.

**Results:** A comprehensive algorithm was constructed based on critical analysis of each defect. We included a spectrum of reconstructions from optimal to safe and fast as the surgeon must balance each scenario with patient-oriented factors (health, prognosis, prior treatment) to achieve a safe, functional, and cosmetic wound. We divided the defects based on lateral and anterior skull base and skin versus no skin involvement. Lateral skull base defects are straightforward, and the workhorse for our group is the lateral arm fasciocutaneous free flap with or without a vascularized nerve graft for the facial nerve. Anterior defects are further subdivided based on the amount and site of bone involvement. Significant bone involvement increases the complexity, and we use medical modeling and preplanning for our cases. The scapular system remains the choice of our group for significant skin and bone defects of the anterior skull base.

**Conclusions:** We have constructed a practical algorithm to effectively reconstruct complex anterior and lateral skull base defects. A safe, effective, and functional reconstruction requires an experienced surgeon who is familiar with not only the complex anatomy of the region but also the reconstructive ladder. This must be balanced with patient-oriented factors to optimize reconstruction and achieve a safe, functional, and cosmetic wound.

#### 064. Grading Facial Nerve Function Following Combined Static and Mimetic Surgical Techniques

Joshua M. Sappington (presenter), John P. Leonetti, Sam J. Marzo, Douglas Anderson (Oak Park, IL, USA)

The most commonly used facial nerve grading systems were designed to assess progressive neural recovery with an anatomically intact facial nerve. Advanced lateral skull base tumors that require facial nerve and adjacent musculature resection and cases of longstanding facial paralysis may necessitate the use of free muscle transfer in conjunction with neural grafting, oculoplastic techniques, and static soft-

tissue tightening to optimize the long-term functional and cosmetic results. Traditional facial recovery grading tools are not sufficient to describe and compare functional recovery results in this patient population.

We propose the following grading system for patients undergoing combined facial nerve reconstructive techniques. Case examples will be provided.

#### 065. Magnetic Resonance Imaging after Translabyrinthine Complete Excision of Vestibular Schwannomas

James R. Tysome (presenter), David A. Moffat (San Carlos, USA)

**Objectives:** To determine whether magnetic resonance imaging (MRI) at 2 years following complete vestibular schwannoma (VS) excision using a translabyrinthine approach is sufficient to detect recurrent tumor.

**Design:** Service evaluation of prospective database.

**Setting:** Tertiary referral skull base unit.

**Participants:** Patients who underwent complete translabyrinthine VS excision with prospectively recorded MRI results at 2 and 5 years following surgery.

**Main Outcome Measures:** Evidence of tumor recurrence on MRI at 2 and 5 years after surgery.

**Results:** Of 314 patients in the study, all patients where MRI was reported to show no recurrence at 2 years (97%) also had no signs of recurrence on MRI at 5 years. All eight patients with MRI suspicious of recurrence (linear enhancement of internal auditory canal [IAC]) at 2 years had no progression on MRI at 5 to 15 years. One patient, who had evidence of definite recurrence (nodular enhancement of IAC) at 2 years, went on to have radiosurgery at 8 years.

**Conclusions:** Where patients have MRI with no linear enhancement of the IAC at 2 years, no further imaging is required. Where linear enhancement is seen, no change in enhancement at 5 years is reassuring, and no further imaging is required.

#### 066. Endoscopic Endonasal Approach to Cholesterol Granulomas of the Petrous Apex: A Series of 17 Patients

Alessandro Paluzzi (presenter), Matthew Tormenti, Maria Koutourousiou, Carlos D. Pinheiro-Neto, Juan C. Fernandez-Miranda, Paul Gardner, Carl Snyderman (Pittsburgh, USA)

**Objective:** The aim of this study was to report the results of a consecutive series of patients who underwent an endoscopic endonasal approach (EEA) for drainage of a petrous apex cholesterol granuloma.

**Patients and Methods:** Seventeen cases with a confirmed diagnosis of petrous apex cholesterol granuloma were identified out of a database of more than 1600 patients who underwent an EEA to skull base lesions at our institution from 1998 to 2011. Their clinical outcomes were reviewed and compared with previous series of open approaches.

**Results:** Nine patients underwent a transclival approach and eight patients had a combined transclival and infrapetrous approach. A Silastic stent was used in 11 patients (65%), a mini-flap in 4 (24%), and a simple marsupialization of the cyst was employed in 3 patients (18%). All symptomatic patients had partial or complete improvement of their symptoms postoperatively and at follow-up (mean follow-up was 20 months; range, 3–67 months). Three patients (18%) developed complications

including epistaxis, chronic serous otitis media, eye dryness and a transient 6th nerve palsy. Two patients (12%) had a symptomatic recurrence of the cyst requiring repeat endoscopic endonasal drainage. There were no instances of ICA injuries, CSF leaks, or new hearing loss. The mean postoperative hospital stay was 2 days (range, 0.7–4.6 days). These results were comparable to previous series of open approaches to petrous apex cholesterol granulomas. There was a strong correlation between the size of the cyst and type of approach chosen ( $R_{pb} = +0.67$ ,  $P = 0.003359$ ) and a very strong correlation between the degree of medial extension (defined by the v-angle) and the choice of approach ( $R_{pb} = +0.81$ ,  $P < 0.0001$ ). Based on these observations, an algorithm for guiding the choice of the most appropriate route of drainage is suggested.

**Conclusions:** The EEA is a safe and effective alternative to traditional open approaches to petrous apex cholesterol granulomas.

#### 067. Comparative Analysis of the Transcranial “Far Lateral” versus the Endoscopic Endonasal “Far Medial” Approach: Surgical Anatomy and Clinical Illustration

Arnau F. Benet, Daniel M. Prevedello, Jordina Rincon-Torroella, Ricardo L. Carrau, Juan Carlos Fernandez-Miranda, Leo F. Ditzel Filho (presenter), Alberto Prats-Galino, Amin B. Kassam (Columbus, USA)

**Objective:** Surgical treatment of posterior fossa lesions is challenging. Traditional transcranial approaches have been recently complemented with variants of the endoscopic endonasal route. However, a qualitative and quantitative study about their indications is lacking in the literature. The main aim of the present study was to analyze and compare the surgical anatomy pertinent to the dorsal transcranial transcondylar “far lateral approach” (TC-FLA) to that of the ventral endoscopic endonasal transcondylar “far medial approach” (EE-FMA) route. In addition, we propose a classification of the posterior fossa and provide surgical recommendations based on its boundaries.

**Methods:** Eight cadaveric specimens were dissected and analyzed bilaterally. We measured the degree of brainstem exposure and the dimensions of the surgical corridor. Three clinical scenarios are described to complement the anatomic study and to illustrate the clinical feasibility of the proposed surgical strategies.

**Results:** The hypoglossal nerve, vertebral artery, and hypoglossal canal divide the lower third of the clivus into ventromedial (VMC) and dorsolateral (DLC) compartments. These boundaries define the surgical indications of the studied approaches. The endoscopic endonasal far medial approach provides a significantly larger exposure of the VMC brainstem ( $464.6 \pm 68.34 \text{ mm}^2$ ) than the far lateral approach ( $126.35 \pm 32.25 \text{ mm}^2$ )  $P < 0.01$ . The transcranial exposure to the DLC measured  $295.24 \pm 58.03 \text{ mm}^2$  (74% of the total DLC). The DLC exposure was not possible using the endonasal route. A suitable surgical corridor between the two compartments was observed in 75% of specimens. The spinal root of the accessory nerve divided this corridor in 44% of specimens. The surgical corridor for the far lateral approach was significantly larger ( $78.19 \pm 14.54 \text{ mm}^2$ ) than that of the endoscopic endonasal far medial approach ( $23.77 \pm 15.17 \text{ mm}^2$ ),  $P = 0.03$ . When accessed through a far medial approach, the surgical corridor was obstructed by the cerebellar hemisphere, which prevented DLC dissection, whereas the cerebellar hemisphere was retracted laterally during the far lateral approach allowing dissection of the ventromedial compartment.

**Conclusions:** The ventral approach (EE-FMA) offers a safe, wide exposure of the lower third of the clivus for lesions that expand ventromedially to the hypoglossal nerve. The dorsal (TC-FLA) is most suitable for lesions located dorsolateral to the lower cranial nerves. The VA and hypoglossal canals are the most important landmarks to guide the surgical planning. A combined ventral-dorsal approach should be considered for resection of extensive lesions involving both the ventromedial and dorsolateral compartments.

#### 068. Long-Term Quality of Life Outcomes in Minimally Invasive Pituitary Surgery

Rounak B. Rawal (presenter), Adam M. Zanation, Brent A. Senior, Matthew G. Ewend, Charles S. Ebert (Chapel Hill, USA)

**Background and Methods:** Endoscopic endonasal minimally invasive pituitary surgery (MIPS) has proven to be safe and efficacious. Although some data exist on short-term quality of life (QOL) improvement, virtually no data exist on long-term QOL outcomes after MIPS. Our hypothesis is that patients will report no long-term change in sinus disability after undergoing MIPS. In this study we retrospectively reviewed patients who underwent minimally invasive pituitary surgery (MIPS) from 2002–2009. Rhinosinusitis Disability Index (RSDI) scores and patient demographics were recorded. Patient responses were stratified as <1 month, <2 months, <6 months, <1 year, or >1 year after surgery. Pre- and postoperative mean RSDI scores and the mean absolute change in RSDI were calculated with 95% confidence intervals.

**Results:** The postoperative RSDI surveys were filled out an average of 24 (range, 0–92) months after surgery by 50 patients. Based on RSDI mean scores, there was no significant difference in QOL scores between <1 year postoperative patients ( $n = 24$ ) and >1 year postoperative patients ( $n = 26$ ) ( $P = 0.21$ ). Mean differences in RSDI scores decreased dramatically in the 1–2 month period to  $-22$  ( $n = 3$ ) before becoming positive and approaching 0 at greater than 3 years ( $n = 13$ ). The RSDI score ranges also narrowed during the time course, as <1 year postoperative patients ranged from  $-64$  to  $+65$ , >1 year postoperative patients ranged from  $-53$  to  $+18$ , and the >3 years cohort ranged only from  $-20$  to  $+18$ . There was no statistically significant difference between total pre- and postoperative RSDI scores ( $P = 0.84$ ). A direct comparison with an expanded (beyond the sella) endonasal approach prospective cohort is presented and discussed.

**Discussion:** These data show that MIPS with appropriate postoperative care results in little or no long-term (24 months mean) sinonasal QOL defects after surgery. Although patients may experience QOL defects and high variance in the short term, eventual QOL outcomes should increase and approach similar or better QOL outcomes in the long term. Retrospective design, small sample size, recall bias due to length of time after surgery, and lack of a non-intervention control group may contribute to limitations for this study.

#### 069. Weight Profile in Children Following Endoscopic Endonasal Approach to Craniopharyngioma

Kimberly Foster, Maria Koutourousiou, Matthew Tormenti, Nii Addo, Carl Snyderman, Elizabeth Tyler-Kabara (presenter), Paul Gardner (Pittsburgh, USA)

Despite the histologically benign nature of craniopharyngiomas, their proximity to critical structures can cause them to

behave as neurologically destructive tumors in both adults and children. The majority of pediatric craniopharyngiomas are treated with a transcranial approach, with visual loss, endocrine dysfunction, and obesity commonly reported following resection. With increasing use of the endoscopic endonasal approach (EEA) in the adult craniopharyngioma population, this method is now employed to treat children. We examined our pediatric cohort with particular emphasis on weight profiles before and after surgery.

From July 2007 to present, 14 children underwent resection of their histologically confirmed craniopharyngioma via EEA, with 10 children having this procedure as initial treatment (71.4%). Children presented with headache ( $n = 9$ , 64.3%), visual complaints ( $n = 5$ , 35.7%), pituitary dysfunction ( $n = 4$ , 28.5%), and an incidental finding ( $n = 1$ , 7%). Three children had diabetes insipidus on presentation (21.4%). Preoperative imaging revealed all tumors to be suprasellar, with sellar ( $n = 7$ , 50%), third ventricular ( $n = 7$ , 50%), and retroclival ( $n = 4$ , 28.5%) involvement. Preoperative tumor volume ranged from 1.49 to 45.10 cm<sup>3</sup> (mean, 11.85 cm<sup>3</sup>). Mean length of stay was 16.5 days. All children underwent nasal septal flap reconstruction, 11 (78.6%) had lumbar drainage used until postoperative day 5, and 2 children had placement of EVD intraoperatively. All children had postoperative imaging with MRI, and extent of resection was classified as gross total resection (GTR,  $n = 8$ ) and near total resection ( $n = 6$ ). Two children underwent repeat EEA for recurrence; 1 required postoperative shunting, and 2 underwent adjuvant stereotactic radiosurgery. There were no deaths. Complications included CSF leak ( $n = 1$ ), subdural hematoma following EVD removal ( $n = 1$ ), and intraparenchymal hematoma with intraventricular extension and resultant hydrocephalus ( $n = 1$ ). Seven children had preoperative pituitary dysfunction to some extent (3 of the 4 children who underwent EEA for secondary treatment), and all children required some level of postoperative endocrine supplementation. Visual outcomes showed no new visual deficits and improvement in preoperative deficits on formal ophthalmological evaluation in children with preoperative deficit.

Based on BMI-for-age calculations, no child experienced new-onset obesity following surgery (0%). Five children were obese preoperatively (BMI > 95 percentile) and remained as such postoperatively, three of these had prior treatment with open craniotomy. Two children were overweight (BMI 85 to 95 percentile) and remained as such postoperatively. All these aforementioned children followed the same trend on their growth chart, suggesting there was not a change in their overall weight profile following EEA. One child was obese preoperatively but actually lost weight postoperatively and was no longer obese. Six children had normal BMI-for-age preoperatively and did not experience significant weight gain.

EEA is a safe and effective surgical option for pediatric craniopharyngioma. In particular, it allows for visualization of hypothalamic structures and may help avoid postoperative central obesity.

#### 070. High Incidence of Dural Tumor Infiltration in Endocrine Active Pituitary Tumors without MRI Evidence of Cavernous Sinus Invasion

Marvin Bergsneider (presenter), Marilene B. Wang, Jeffrey Suh, Anthony Heaney, Tracie Pham, William Yong (Los Angeles, USA)

**Introduction:** The incidence of microscopic dural invasion for lateral endocrine-active tumors has not been



extensively studied. Dickerman and Oldfield (J Neurosurg 97: 2002) reported that microscopic dural invasion was found in 62% of reoperations for Cushing's disease (CD). Beginning January 2010, patients with endocrine active lateral adenomas (<15 mm) abutting the cavernous sinus wall, but meeting no MRI criteria for cavernous sinus invasion, were given the option for elective excision of the medial cavernous sinus wall.

**Methods:** From January 2010 to September 2011, 23 of 99 patients undergoing endoscopic pituitary tumor surgery were identified meeting the above criteria. Thirteen patients consented for excision of the adjacent medial cavernous sinus wall. The distribution was 8 CD (3 redo), 2 medically refractory prolactinomas, 2 acromegalies, and one TSHoma; with a mean tumor size of  $6 \pm 4$  mm. Patients declining dural excision were six prolactinomas, two CDs, and two acromegalies. The medial cavernous sinus wall apposing tumor was excised and sent to pathology.

**Results:** Five patients (38%) showed definite dural tumor invasion: one CD (0 redo), two prolactinoma, one acromegaly, and one TSHoma. In two additional patients, the pathology was read as possible dural invasion (one CD, one TSHoma). No tumor invasion was documented in four patients, and indeterminate in two patients. At a median follow-up of 8 months, all 13 patients were in remission. Complications included one patient with temporary 6th nerve palsy and one patient with epistaxis 6 days after surgery.

**Conclusion:** Lateral endocrine-active pituitary tumors appear to have a propensity for dural microinvasion, with an incidence possibly exceeding 50%. Microscopic dural invasion, not predictable based on preoperative MRI, may explain delayed recurrence. Long-term follow-up and more subjects will be required to determine if dural excision improves cure rates. The etiology of the temporary 6th nerve palsy is unclear, but its occurrence weighs into the risk-benefit analysis.

#### 071. Short-Term Risk of Recurrence of Surgically Treated, Radiotherapy-Naive Pituitary Adenomas

Mark P. Piedra (presenter), Nicholas D. Coppa, Aclan Dogan, Chris Yedinak, Jessica Brzana, Peter E. Andersen, Johnny B. Delashaw, Maria Fleseriu (Portland, OR, USA)

**Introduction:** Risk of recurrent pituitary adenoma (PA) seems highest within 5 years following surgery; however, despite comparable studies, the absolute risk is unknown. We aimed to define the natural history of a large cohort with surgically treated, radiation-naive PAs.

**Methods:** A retrospective audit of 812 patients with pituitary tumors treated at our institution between 2001 and 2011 was performed, assessing pituitary function, tumor characteristics, incidence and timing of recurrence, and need for additional surgery. Median follow-up was 88 months (range, 11–494 months). Cushing's and nonadenomatous pathology cases were excluded.

**Results:** Mean time to initial recurrence was 33.2 months (STD, 46.3), documented in 57 patients (7.0%), with 34 males and 23 females and median age 50 years, who underwent 84 transsphenoidal operations and 14 craniotomies. Presenting median tumor volume was  $14.1 \text{ cm}^3$  (range,  $0.2\text{--}175 \text{ cm}^3$ ). Extension into the cavernous sinus and/or suprasellar region was noted in 39 patients. There were 33 non-secreting tumors (60%), 8 growth hormone (15%), 7 silent-ACTH (13%), 5 prolactin (9%), and 1 mixed type (2%).

Early ( $\leq 4$  years) and late recurrence were noted in 45 (79%) and 12 (21%) patients, respectively. All patients had partial or panhypopituitarism and nine underwent three or more operations.

**Conclusion:** The recurrence rate of PA was low, but not insignificant. Patients with cavernous sinus and suprasellar extension had a disproportionately higher risk of recurrence. We conclude that a conservative "wait and see" policy aimed at sparing patients of the side effects of radiation should be adopted for most PA.

#### 072. The Relevance of ACTH Monitoring during Surgical Management of Cushing's Disease

Daniel M. Prevedello, Danielle de Lara (presenter), Leo F. S. Ditzel Filho, Rodrigo C. Mafaldo, Bradley A. Otto, Ricardo L. Carrau (Columbus, USA)

**Introduction:** The treatment of choice for ACTH-producing pituitary adenomas is complete removal using a transsphenoidal approach. However, even after gross total removal, high levels of ACTH and cortisol can be occasionally found in the first postoperative days. These hormonal findings could lead to a misdiagnosis of surgical failure with a later cortisol and ACTH drop. We propose an evaluation of intraoperative plasma ACTH and its correlation to hormonal postoperative findings to help improve the prediction of surgical success in patients with ACTH-producing adenomas.

**Methods:** Over 10 months, seven consecutive patients with ACTH-producing pituitary adenomas were analyzed. A detailed hormonal profile was performed preoperatively followed by at least one intraoperative plasma ACTH measurement during the endoscopic endonasal transsphenoidal resection of the tumor. ACTH and cortisol were evaluated postoperatively. The cases were divided according to tumor size, possible tumor invasion of adjacent structures, and surgical removal (intra- or extracapsular). All tumors were ACTH-producing adenomas, confirmed by pathology.

**Results:** Three patients had a microadenoma and four had a pituitary macroadenoma. One case was an invasive/recurrent adenoma. In all cases, a variable increase in the ACTH levels was observed intraoperatively. The most prominent ACTH increases were found in those cases that an extracapsular resection could not be performed. Minimal elevation in ACTH levels were seen in cases with extracapsular resection, and it correlated with a quick drop in cortisol down to undetectable levels.

**Discussion:** Low cortisol and ACTH levels in the first postoperative days are the ideal findings to predict successful resection of ACTH-producing pituitary adenomas. Occasionally, despite successful tumor removal, these expected values are not found in the early days after surgery. In this study, we found that ACTH levels can be considerably increased during surgery, especially in invasive tumors. This increase in ACTH levels would stimulate cortisol production and, consequently, would delay the expected cortisol "crash" postoperatively.

**Conclusion:** Intraoperative ACTH can be used as a baseline parameter to which postoperative ACTH and cortisol can be compared in the early postoperative period following surgical removal of ACTH-producing pituitary adenomas. A delay of the expected cortisol "crash" after surgery may not be always considered a surgical failure, but can be a predictable consequence of tumor manipulation and intraoperative hormonal release.

### 073. Predictive Value of Early Postoperative Growth Hormone Levels in Determining Long-Term Biochemical Cure of Acromegaly

Tyler J. Kenning (presenter), Peter G. Campbell, Christopher Farrell, David Beahm, Madeline Schaberg, Intekhab Ahmed, Marc Rosen, James J. Evans (Philadelphia, USA)

**Introduction:** Using strict biochemical remission criteria, the authors assessed surgical outcomes after endoscopic transsphenoidal resection of growth hormone (GH)-secreting pituitary adenomas and identified the predictive value of early postoperative GH levels in determining disease remission.

**Methods:** A retrospective review of a prospectively maintained database was performed. A total of 35 endoscopic procedures for adenoma resection were reviewed. The average duration of follow-up was 30.7 months. In the postoperative period, growth hormone levels were obtained immediately postsurgically, and on each postoperative day (POD). The thresholds of an age-appropriate, normalized insulin-like growth factor-1 (IGF-1) concentration, a nadir GH level after oral glucose load of less than 1.0 µg/L, and a random GH level of less than 2.5 µg/L were required to establish biochemical cure postoperatively.

**Results:** Following 45.7% of the operative procedures (16 of 35), an endocrinological cure was achieved. Preoperative GH and IGF-1 levels were not significantly different in those patients who achieved biochemical cure (Group A) and those who did not (Group B). Although, the immediate POD#0 levels were not significantly different, a lower level was achieved on each subsequent POD and noted as early as POD#1 (A:  $1.2 \pm 0.7$  µg/L, B:  $4.2 \pm 3.8$  µg/L,  $P = 0.0003$ ) and POD#2 (A:  $1.2 \pm 0.7$  µg/L, B:  $5.8 \pm 7.2$  µg/L,  $P = 0.0001$ ). In those patients in whom a biochemical cure was attained, nearly all had a GH level < 2.4 µg/L on POD#1 and later. The one exception was a patient with a recurrent adenoma, two previous resections, a preoperative GH level of 9.5 µg/L, and a POD#1 level of 3.0 µg/L. On POD#2, the level had decreased to 1.6 µg/L and continued to decline. In this cohort, the use of a postoperative GH < 2.5 µg/L on POD#1 and later as a predictor of future biochemical remission resulted in a specificity of 100% and a sensitivity of 74%.

**Conclusion:** Following surgical resection, GH levels may decrease to acceptable levels as early as the first postoperative day. The measurement of growth hormone levels in the immediate preoperative period may be helpful in predicting future biochemical remission. Used in conjunction with intraoperative findings and postoperative imaging, obtaining early postoperative GH levels could potentially identify those patients who require additional treatment, including early revision surgery, medical therapy, and radiation.

### 074. Petrous Apex Cholesterol Granulomas: Endonasal vs. Infracochlear Approach

Tiago F. Scopel, Juan C. Fernandez-Miranda, Carlos D. Pinheiro-Neto (presenter), Maria Peris-Celda, Alessandro Paluzzi, Barry E. Hirsch, Paul A. Gardner, Carl H. Snyderman (Pittsburgh, USA)

**Objectives:** This study aims to investigate and compare the surgical anatomy of two different routes to access and drain petrous apex (PA) cholesterol granulomas: the expanded endonasal approach (EEA) and the transcanal infracochlear approach (TICA).

**Methods:** The EEA and TICA to the petrous apex were performed in 11 anatomical specimens with the assistance of image guidance. The PA was categorized in three zones: superior PA, anterior-inferior PA, and posterior-inferior PA. The maximum drainage window achieved by each approach was calculated using the imaging studies of each anatomical specimen.

**Results:** The EEA was able to reach superior PA and anterior-inferior PA in all specimens and posterior-inferior PA in 90% of them. The TICA did not provide access to the superior PA in any case. The TICA was suitable to reach anterior-inferior PA in 80% of specimens and posterior-inferior PA in 60%. Based on the radiological study, the EEA provided a drainage window three times larger than the TICA.

**Conclusions:** The transnasal approach provides reliable access to the PA when combined with internal carotid artery exposure and allows for a large drainage window. The transcanal approach is less versatile and more limited than the transnasal approach but provides access to the most posterior and inferior portion of the PA without eustachian tube transection. Here we propose a new surgical classification that may help to decide the most suitable approach to the PA according to the location and extension of the lesion.

### 075. The Artery of Davidoff and Schechter: An Anatomical Study

Christoph J. Griessenauer (presenter), Martin M. Mortazavi, Shane R. Tubbs (Birmingham, USA)

**Introduction:** Few reports have mentioned the artery of Davidoff and Schechter. Therefore, this tentorial branch of the posterior cerebral artery was studied.

**Materials and Methods:** Twenty adult latex-injected cadaveric heads (40 sides) underwent microdissection with specific attention given to the presence of the artery of Davidoff and Schechter. When identified, measurements were made and observations given to the source and course of this vessel.

**Results:** An artery of Davidoff and Schechter was identified on 10 sides (25%). This artery was found to always be a branch of the P2 segment of the posterior cerebral artery and typically traveled posterolateral under the superior cerebellar artery and superior to the trochlear nerve to enter the deep surface of the tentorium cerebelli roughly near the midpoint of the ipsilateral one half of the incisura. From this point, the vessel traveled posterior to approximately the midline, where it took an upward course to supply the falcotentorial junction. The average diameter of the vessel was 0.8 mm with a mean length of 1.2 cm. The artery was found to be more common in male specimens and was more common on left sides ( $P < 0.05$ ). Bilateral occurrence was seen in only one male specimen.

**Conclusions:** Knowledge of the artery of Davidoff and Schechter may be important during approaches to the ambient cistern or in interpretation of imaging such as in tentorial arteriovenous malformations.

### 076. The Artery of Percheron: An Anatomical Study

Christoph J. Griessenauer (presenter), Martin M. Mortazavi, Shane R. Tubbs (Birmingham, USA)

**Introduction:** One variant branch of the P1 segment of the posterior cerebral artery is the artery of Percheron.

This unilateral trunk supplies both thalami and potentially mesencephalic structures as well. As studies of this vessel are scant in the literature, the present study was performed to better elucidate its morphology.

**Materials and Methods:** Twenty-five adult latex-injected cadaveric heads underwent brain removal and microdissection with specific attention given to the presence of the artery of Percheron. When identified, measurements were made and observations given to the origin and course of this vessel.

**Results:** An artery of Percheron was identified on three sides (12%). The artery was seen on two right and one left side and in one male and two female specimens; it arose on average 8 mm lateral to the basilar artery bifurcation. The average diameter was 2.1 mm, and the length between origin and brain penetration had a mean distance of 1.5 cm. In all specimens, the artery of Percheron had a coiled appearance, especially in its proximal extraparenchymal segment. The contralateral P1 segment of the posterior cerebral artery was not absent or hypoplastic in any of the three specimens. All arteries supplied small branches to the ipsilateral and contralateral thalami and midbrain.

**Conclusions:** Knowledge of the artery of Percheron may be important during approaches to the basilar bifurcation or during interpretation of imaging, especially in patients presenting with bilateral thalamic and midbrain infarctions.

#### **077. Second Stage in Predictive Measure for Transnasal Transsphenoidal Approach to Petrous Apex Cholesterol Granuloma**

Angela M. Donaldson (presenter), Nael Shoman, Jeffrey Ksiazek, Myles L. Pensak, Lee A. Zimmer (Cincinnati, USA)

**Objective:** This study is the second stage in a three-stage study, which aimed to identify the narrowest petrous angle that would allow a transsphenoidal approach for treatment of cholesterol granulomas based on our operative experience.

**Study Design:** Retrospective review.

**Setting:** University of Cincinnati Medical Center.

**Subjects and Methods:** Patients in the study were seen in our tertiary care center from 2000–2010 with isolated petrous cholesterol granulomas on noncontrast orbital/sella/internal auditory canal CT images of the temporal bone. The angle between the medial-most aspect of the vertical portion of petrous internal carotid artery (ICA), vomer, and occipital protuberance was measured. The distance between the posterior sphenoid wall (SW) and the medial aspect of the cholesterol granuloma (CG) was measured.

**Results:** Seventeen patients had radiographically evident isolated petrous CGs, and 17/18 or 94% of the CGs abutted the posterior sphenoid wall (SW), as defined by a sphenoid wall to medial aspect of CG distance of 5 mm or less. In our study, a petrous angle of 10 degrees with SW to CG distance of 7 mm was the narrowest angle for which the transsphenoidal approach was successful.

**Conclusion:** The first study in our three-stage study looked at 400 normal CT scans of the temporal bone and found that the majority of patients had a petrous angle—the angle between the medial aspect of the petrous ICA, the vomer, and the occipital protuberance—between 10 and 20 degrees. This was the second study that looked at a quantitative predictive measure of feasibility of the transsphenoidal approach using three consistent landmarks. We found

that the majority of petrous apex CGs in our practice had an angle between 10 and 20 degrees. We determined that a petrous angle of 10 degrees and a SW to CG of less than 10 mm is a reasonable cutoff for performing incision and drainage of petrous apex CGs in the hands of an experienced surgeon.

#### **078. Accessing the Parapharyngeal Space: An Anatomical Study Comparing the Endoscopic Endonasal and the Subtemporal Preauricular Approaches**

Jason Van Rompaey, Marcos Francisco Mirambeaux Casso (presenter), C. Arturo Solares (Augusta, USA)

**Background:** A subtemporal preauricular approach to the infratemporal fossa and parapharyngeal portion of the skull base has been the traditional path to tumors of this region. However, the high morbidity associated with this procedure has led to the pursuit of less invasive techniques. Endoscopic endonasal access utilizing a minimally invasive transmaxillary/transpterygoid approach could potentially obviate the drawbacks associated with open surgery.

**Methods:** A subtemporal preauricular approach and an endoscopic endonasal transmaxillary/transpterygoid approach were completed. Access was gained to the superior portion of the parapharyngeal space by making a pterional craniotomy and removing the temporal bone lateral and posterior to the foramen ovale extending to the mandibular fossa. The same area was accessed endonasally by removal of the medial and posterior wall of the maxillary sinus. The medial and lateral pterygoid plates were removed with reflection of the medial pterygoid and the tensor veli palatini muscles exposing the relevant anatomy of the parapharyngeal space.

**Results:** The endoscopic endonasal approach provided sufficient access to the superior portion of the parapharyngeal space. The anatomy of this region was easily identified. The open approach also provided adequate access; however it required a larger surgical window causing greater iatrogenic injury to the bone, muscles, and neurovasculature. However, the subtemporal approach did provide improved access to the petrous portion of the internal carotid artery. The endonasal approach provided improved access to the anterior and medial portions of the superior parapharyngeal space.

**Conclusion:** Endoscopic endonasal access using a transmaxillary/transpterygoid approach provided a sufficient surgical window for tumor extirpation. Use of this approach obviated the morbidity associated with an open procedure. Further understanding of the endoscopic anatomy of this region can lead to improvements in morbidity associated with tumor resection in this dense neurovascular region.

#### **079. Mapping of Transverse and Sigmoid Sinus Junction: Application in Vertical Extension of Suboccipital Craniotomy**

Ashish Sonig (presenter), Jai Deep Thakur, Imad Khan, Sashikanth Patil, Cedric Shorter, Anil Nanda, Bharat Guthikonda (Shreveport, USA)

**Introduction:** There is paucity of data regarding the surface landmarks and the vertical course of the sigmoid sinus. Moreover, the junction between transverse and sigmoid sinus is gradual, with transitional dural zone seen over superior and inferior limb and not at a focal point. Earlier studies have addressed the distances between various bone

landmarks and the junction but not the “angle.” We have used the technique of mapping the sinus and defining the “GENU” of the transverse sigmoid junction so that it can aid the vertical extension of suboccipital craniotomy.

**Methods:** Eight sides of cadaver skulls were studied. The asterion and the zygoma root (ZR) were exposed. These two points were connected with a straight line. A line was drawn orthogonal to this, passing the asterion. Distances between several surface landmarks were measured, like asterion and ZR, asterion to digastrics point (DG), asterion to spine of Henle, and asterion to mastoid tip. The entire transverse and sigmoid sinus was exposed. The thinning of dura was taken as the junction point, and it was marked on both superior and inferior limbs. The entire sinus complex was mapped using the x-y coordinate system. The reference point was asterion, which was set as zero.

**Results:** Distances between the various surface landmarks were measured. There was no significant difference between left and right side. The GENU of the transverse sigmoid region was defined where the bend angle starts increasing from 30 degrees and end where the sigmoid vertical limb takes a straight trajectory. The mean angle between the transverse and the sigmoid sinus was 128.42° (SD, 8.7°; range, 115°–138°); the mean angle that the vertical sigmoid limb made with the y axis (orthogonal to ZR-A line) was 46.5° on the right side and 50.1° on the left side. Average thickness of the GENU was 8.5 mm on left side and 8.4 mm on right side. In 85.7% cases, asterion overlay the sinus.

**Conclusions:** Our study focuses on the importance of the GENU of the transverse sigmoid sinus, as it is paramount to the operating surgeon to know the orientation of the vertical limb of the sigmoid sinus while performing the suboccipital craniotomy. A strategic burr hole can be placed on the asterion. From the lower part of the burr hole, at an angle of not more than 45 degrees to the y axis, the vertical extension can be safely made without injuring the sigmoid sinus.

#### **080. Minimally Invasive Access to the Posterior Cranial Fossa: An Anatomical Study Comparing a Retrosigmoidal Endoscopic Approach to a Microscopic Approach**

Jason Van Rompaey (presenter), Carrie Bush, Brian McKinnon, C. Arturo Solares (Augusta, USA)

**Background:** The central location and complex neurovascular structures of the posterior cranial fossa make tumor resection in this region challenging. The traditional surgical approach is a suboccipital craniotomy using a microscope for visualization. This approach necessitates a large surgical window and cerebellar retraction, which can result in patient morbidity. With the advances in endoscopic technology, minimally invasive access to the cerebellopontine angle can be achieved with minimal manipulation of uninvolved structures, reducing the complications associated with the suboccipital approach.

**Methods:** An endoscopic approach was completed on anatomic specimens. To access the central structures of the posterior cranial fossa, a retrosigmoidal approach was undertaken. A keyhole craniotomy was made in the occipital bone posterior to the junction of the transverse and sigmoid sinuses. The endoscope was advanced and photographs were obtained for review. The exposure was compared with that obtained with a microscope.

**Results:** The endoscopic retrosigmoidal approach to the posterior cranial fossa provided increased exposure to the midline structures while minimizing the surgical window. The relevant anatomy was identified without difficulty.

**Conclusion:** An endoscopic retrosigmoidal approach to the midline structures of the posterior cranial fossa is anatomically feasible. The morbidity associated with retraction of the cerebellum could possibly be avoided, improving patient outcomes. Retrosigmoidal endoscopy provides access to anatomical structures that were not possible using a microscope in a suboccipital approach. Further understanding of the endoscopic anatomy of the posterior fossa can allow advances in cranial base surgery with improved safety and efficacy.

#### **081. Meningiomas of the Cerebellopontine Angle: Approaches and Outcomes**

Tarik F. Ibrahim (presenter), John A. Braca, Avinash V. Mantravadi, Andrew Mueller, John P. Leonetti, Douglas E. Anderson (Maywood, IL, USA)

Meningiomas are the second most common tumor of the cerebellopontine angle (CPA), accounting for roughly 10% of all neoplasms in this region. We retrospectively reviewed the medical records of 122 consecutive patients who underwent surgical resection at our institution by the same senior neurootologist (JPL) and neurosurgeon (DEA) to determine the incidence of complications and tumor recurrence with combined approaches versus more conventional techniques. Complete records including progress notes and pathology were reviewed in addition to preoperative and postoperative imaging. Roughly half the patients underwent a single surgical approach, while the other half underwent a combined lateral skull base technique. The single approaches (57% of all performed surgeries) that were used were: retrosigmoid craniotomy (36%), transpetrosal surgery (18%), and trans-labyrinthine (3%). The remaining operations were techniques using combinations of these three and other approaches. We will compare the degree of tumor resection, the incidence of tumor recurrence, facial nerve function, postoperative hearing, and other complications as they pertain to single versus combined approaches. Gross total resection was achieved in 57% of the operations and subtotal resection in 43%. Residual tumors were either managed conservatively with serial imaging (27%) or stereotactic radiosurgery (SRS, 12%), while only one patient required redo surgery. Of the masses for which GTR was achieved, 16% recurred on follow-up imaging. Sixty-six percent were managed conservatively and 33% received SRS. Long-term control was achieved in 68% of tumors with GTR. Ninety-one percent of patients were found to have an immediate postoperative House-Brackmann (HB) score of I–II and 94% achieved a HB I–II at most recent follow-up.

#### **082. Endoscopic Endonasal Skull Base Surgery in the Pediatric Population**

Srinivas Chivukula (presenter), Maria Koutourousiou, Carl H. Snyderman, Paul A. Gardner, Elizabeth C. Tyler-Kabara (Pittsburgh, USA)

**Introduction:** The use of endoscopic endonasal approaches (EEAs) for skull base pathologies in the pediatric population has been facilitated by improvements in visualization and image guidance, as well as by miniaturization of the instruments. These technological advances have allowed us to implement minimally invasive EEAs in treating various pathophysiologies in the smaller confines of pediatric patients by improving navigation through their un-aerated sinuses.

**Methods:** We conducted a retrospective chart and imaging review of 134 pediatric patients who underwent surgeries with EEAs at our institution since July 1999.

**Results:** A total of 172 EEAs were performed for bony abnormalities in 21 patients and for skull base tumors in 113. Eighty-five patients (63.4%) were male and the average age at the time of surgery was 12.7 years (range, 2.3–17.9 years). Bony abnormalities included skull base defects ( $n = 12$ ), basilar invaginations ( $n = 4$ ), optic nerve compressions ( $n = 3$ ), and trauma ( $n = 2$ ); preexisting neurological dysfunction resolved in 12 patients (57.1%), improved in 7 (33.3%), and remained unchanged in 2 (9.5%).

Skull base tumors included angiofibromas ( $n = 24$ ), craniopharyngiomas ( $n = 16$ ), Rathke's cleft cysts ( $n = 12$ ), pituitary adenomas ( $n = 11$ ), chordomas/chondrosarcomas ( $n = 10$ ), dermoid/epidermoid tumors ( $n = 9$ ), and 31 other pathologies. In total, 19 tumors were malignant (14.5%). Fifty-four lesions were solely extradural, and 59 were intradural or intradurally extended. Gross total resection was achieved in 15 angiofibromas (65.2%), 9 craniopharyngiomas (56.3%), 8 Rathke's cleft cysts (72.7%), 7 pituitary adenomas (70%), 5 chordomas/chondrosarcomas (50%), 6 dermoids/epidermoids (75%), and in 9 other pathologies (29%).

Sixteen patients (12.4%) showed tumor recurrence and underwent reoperation. Fifteen patients received adjuvant radiotherapy, and 5 received chemotherapy. Complications included CSF leak in 19 cases (14%), meningitis in 6 (4.5%), transient DI in 8 patients (6.0%), and permanent DI in 11 (8.2%). Eight patients (6.0%) had temporary cranial nerve palsies; in three (2.2%), the palsy became permanent. The mean follow-up time was 22.7 months (range, 1–122 months); five patients were lost to follow-up.

**Conclusions:** In our cohort, EEAs have proved a safe and feasible surgical technique for the management of a variety of pediatric skull base pathologies. When appropriately indicated, EEAs may allow achieving optimal outcomes in the pediatric population.

### 083. Cochlear Radiation Dose Does Not Predict Hearing Loss after SRS for Glomus Jugulare Tumors

Bradley C. Lega, James Stephen (presenter), Michael Ruckinstein, Douglas Bigelow, Michele Alonso-Basanta, Jay Dorsey, John Y. Lee (Philadelphia, USA)

Stereotactic radiosurgery (SRS) has become a mainstay of therapy for glomus jugulare tumors (GJT). Although the length of follow-up remains limited, radiosurgery appears to provide excellent tumor control rates (~90%) with a favorable side effect profile. Specifically, the incidence of new deafness, facial weakness, or swallowing dysfunction after SRS is less than 10%. The low incidence of new hearing loss is surprising given the proximity of GJT to the cochlea (mean cochlear dose >5.3 Gy).

We examined our series of patients who underwent SRS (gamma knife) for GJT, quantifying mean cochlea radiation dose along with tumor control rates, symptomatic relief, and incidence of new cranial neuropathies. Nine patients underwent SRS (mean dose of 15.8 Gy to the tumor margin); two patients had a previous microsurgical resection. We measured tumor volumes, marginal dose, cochlear volume receiving 5.3 Gy of radiation, mean cochlear dose, and mean dose to the internal acoustic canal (IAC).

With a median follow-up of 26 months, one patient required reoperation. In this case, radiation dose to a portion

of the tumor was inadequate (<6 Gy). Six of nine patients presented with pulsatile tinnitus, two with hearing loss, and one with facial weakness. None of these preoperative symptoms improved after GKS. Eight of nine patients had clinically serviceable hearing pre-SRS; in one patient hearing worsened. Three of the four patients who received a mean cochlear dose >8 Gy suffered no hearing loss. Mean radiation received by the cochlear nerve was 4.7 Gy in patients with intact post-GKS hearing and 3.5 Gy in the patient who suffered hearing deterioration.

GKS provides control for glomus tumors, but no symptomatic relief, especially for pulsatile tinnitus. The low rate of hearing loss post-GKS that we report is in line with the literature. Neither dose to the auditory nerve nor the cochlea predicts hearing loss after GKS. This suggests that thresholds for cochlear dose derived from data for acoustic neuromas should not be extrapolated to planning for GJT or other lesions. Data suggest that cochlear dose should not limit radiation given to the superior portion of a glomus tumor, as this may risk progression.

### 084. Tumor Control Rates Using Linac Radiosurgery in Treatment of Growing Vestibular Schwannomas

Peter A. Gooderham, Albert D. Tu (presenter), Brian Westerberg, Brian D. Toyota, Ryojo Akagami (Vancouver, Canada)

**Background:** Vestibular schwannomas are common, histologically benign neoplasms that may have a very indolent or aggressive clinical course. Previous studies have suggested that only 30–65% of detected lesions will continue to grow in size. Treatment may include surgical resection or primary stereotactic radiosurgery. The reported efficacy rate of stereotactic radiosurgery in uncontrolled groups has ranged from 80–100%; however, many of these studies reflect only a short follow-up period. Furthermore, many lesions remain in a quiescent state and the efficacy of a radiosurgery may be overestimated by reflecting patterns of natural history rather than treatment success.

**Objective:** The purpose of this study was to determine the true control rates of stereotactic radiosurgery for vestibular schwannomas with demonstrated ongoing growth.

**Methods:** A retrospective chart review of patients treated with stereotactic radiosurgery for vestibular schwannoma between 1998 and 2006 was carried out. Only patients with demonstrated radiographic evidence of growing lesions as well as greater than 3 years of follow-up were included. Patients with neurocutaneous syndromes or incomplete records were excluded.

**Results:** A total of 46 patients were identified, 80% of whom had greater than a 4-year follow-up period. An overall control rate of 83% was determined. Seventeen percent of lesions demonstrated ongoing growth, although only 9% were referred for further treatment. The average time to treatment failure post treatment was 43 months.

**Conclusions:** Although stereotactic radiosurgery continues to have an important role in the treatment of vestibular schwannomas, this study suggests that its purported efficacy in growing lesions is lower than the unselected control rates currently found in the literature. In addition, a significant proportion of these failures occurred at delayed time intervals, reiterating the importance of close follow-up of these patients despite seeming stability.

### 085. Outcomes of Stereotactic Radiosurgery and Stereotactic Radiotherapy for the Treatment of Vestibular Schwannoma

Marko Spasic (presenter), Patrick Pezeshkain, Brendan Fong, Winward Choy, Teo Soleymani, Daniel Nagasawa, Garni Barkhoudarian, Alessandra Gorgulho, Antonio De Salles, Isaac Yang (Los Angeles, USA)

**Introduction:** Vestibular schwannoma (VS) is a benign tumor derived from Schwann cells typically in association with CN VIII. Common morbidities of these characteristically slow-growing lesions include hearing loss and facial nerve damage. Treatment options include observation, surgical resection, stereotactic radiosurgery (SRS), and stereotactic radiotherapy (SRT). In this study, we assess the outcomes of patients with VS treated with either SRS or SRT.

**Methods:** Patients receiving SRS or SRT for vestibular schwannoma between 1996 and 2009 were reviewed. Inclusion criteria were: (1) histopathologically confirmed vestibular schwannoma, (2) SRT or SRS performed at UCLA Ronald Reagan Medical Center, and (3) functional hearing and/or tumor size assessed pre- and post-SRT or SRS. Functional hearing was categorized as full, partial, or none, with partial being defined as ability to use the phone with the affected ear. Tumor control was categorized as increased in size, stable, or decreased, with a change of greater than 2 mm required to be considered increased or decreased.

**Results:** Fifty-four patients met all of the inclusion criteria. Of these, 46 received SRT and 8 received SRS. Twenty-eight (52%) were male and 26 (48%) were female. The average age at SRT or SRS procedure was 55 years (range, 23–83 years) and average radiation dose for SRT was 180 cGy to the 90% IDL over an average of 30 fractions and for SRS was 1263 cGy (range, 1200–1400 cGy). Patients had an average radiological follow-up of 44 months and average clinical follow-up of 36 months. Overall, 94% of patients had either stable or decreased tumor size on final radiologic follow-up, and 86% had stable or improved functional hearing on final clinical follow-up. SRT was associated with a lower rate of tumor size increase following treatment relative to SRS (6% vs. 25%, respectively;  $P = 0.054$ ). Similarly, SRT was associated with fewer adverse functional hearing outcomes relative to SRS (11% vs. 25%, respectively,  $P = 0.296$ ).

**Conclusions:** Our data show good tumor control over time and preservation of functional hearing with SRS and SRT. Furthermore, SRT was associated with superior tumor control and functional hearing results relative to SRS. Further research will be needed to determine optimal use of SRT and SRS for treatment of VS.

### 086. Role of Radiation Therapy in Clinical Hormonally Active Pituitary Adenomas: An Update of Their Efficacy and Safety

Houman Pebdani, Soroush Larijani, Idara Edem, Boris Krischek, Richard Tsang, Fred Gentili, Gelareh Zadeh (presenter), (Toronto, Canada)

**Introduction:** Radiation therapy (RT) plays an important role in treatment of pituitary tumors that are resistant to medical and surgical therapy. The continuous development in the field of RT warrants a reassessment of its role as either initial or adjuvant therapy in the treatment of pituitary tumors and the adverse effects of this treatment.

**Objective:** The purpose of this study is to assess the outcome of RT as observed in the treatment of hormonally active and inactive pituitary adenomas. An emphasis is placed on identifying potential prognostic factors, determining the control rate after radiation and evaluating late toxicity.

**Methodology:** From 1997 to 2010, 125 patients with pituitary adenomas received RT, 35 of which were hormonally active pituitary adenomas. The median age was 52 years (range, 28–79 years), with 21 females and 14 males for the hormonally active patients. There were 18 patients with growth hormone secreting, 5 prolactinoma, and 12 with Cushing's disease. The median follow-up was 2.2 years. Tumor control was defined as normalization of basal hormone level and lack of progression of adenoma assessed by imaging studies. The variables assessed for tumor control were: age, sex, tumor type, tumor extension, radiation dose, and radiation field size.

**Results:** Radiotherapy resulted in stable outcome in 95% of patients with inactive pituitary adenomas. Stable outcome was seen in 74% of hormonally active patients with 24% not requiring any further drug therapy. Hypopituitarism in one or more axis was observed in 52% of the cases, with inactive pituitary adenomas and 29% of the cases with hormonally active disease. One patient died due to development of pituitary carcinoma. Cause-specific survival rate was 97% during the course of the study. None of the prognostic factors for tumor control were found to be significant. On univariate and multivariate analyses, none of the factors investigated were identified as predictors of response to RT.

**Conclusions:** Postoperative RT is indeed effective in gaining tumor control and thus nullifying the space-occupying effects of hormonally active pituitary adenomas. However, RT falls short in the sphere of biochemical control, which was observed in less than half of the cohort in our study. In terms of acute and late effects of RT, data from our study support the previously well documented adverse effects, with new-onset hypopituitarism as the most frequent complication. No patient experienced radiation optic neuropathy or CNS malignancy in the field of radiation. No predictors of adverse radiation effects were identified.

### 087. Does Pretreatment Growth Rate of Vestibular Schwannomas Predict Response to Radiosurgery and Adverse Radiation Effects?

Soroush Larjani, Houman Pebdani, Caroline Hayhurst, Michael Cusimano, Fred Gentili, Gelareh Zadeh (presenter), (Toronto, Canada)

**Introduction:** Stereotactic radiosurgery (SRS) is a well-established treatment option for vestibular schwannomas (VSs). An important clinical question is whether pretreatment tumor growth rate (TGR) predicts pattern of growth response to SRS and is a determinant of adverse radiation effects (AREs).

**Methodology:** A retrospective review of a prospectively maintained database of all VS patients treated at our institution between December 2005 and 2011 using Model 4C Gamma Knife Unit was carried out. All AREs were recorded. Patients with clinical and radiological follow-up at least 12 months before and after SRS were selected. Tumor volume was determined from T1-weighted and FIESTA MRI scans obtained at 6-month intervals (pre- and post-SRS) using the ITK-SNAP software. Linear regression and multivariate analyses were performed with SPSS version 19.0.

**Results:** Mean growth rate pre-SRS was +94.6%/year, and post-SRS was -10.8%/year. We classified tumors into three categories based on volumetric growth rate: class I (<52%), class II (52%–73%), and class III (>73%). We did not find a direct correlation between pre- and post-treatment TGR ( $P > 0.40$ ). A significant correlation was found between pre-treatment TGR and the extent of reduction in TGR post-SRS ( $P > 0.001$ ). Thirty-three percent of VS patients treated with GKRS experienced non-auditory ARE. Pretreatment growth rate did not correlate with the occurrence of any AREs. Post-treatment TGR was a predictor of facial nerve dysfunction.

**Conclusion:** Tumors with greatest pretreatment growth rate had the most favorable response to SRS. TGR pre-SRS did not predict ARE, though target volume predicted facial nerve dysfunction. Response patterns to SRS can be categorized into three classes. These results demonstrate that there are clearly different subtypes of VSs that need further molecular profiling and correlative molecular imaging to be able to guide treatment decision. The present results will aid in patient counseling and decision making for best management options and expected outcomes following SRS for VS.

**088. Survival in Squamous Cell Carcinoma of the Temporal Bone: 1965–2011**  
Mitchell R. Gore (presenter), Adam M. Zanation (Durham, USA)

**Background:** Squamous cell carcinoma (SCC) of the temporal bone is an uncommon entity that has a poor prognosis. Tumors may present at an advanced stage given the proximity of the temporal bone to critical structures. We reviewed the literature from 1965 through 2011 to determine factors affecting survival, as well as to determine whether there is a survival advantage for different treatment modalities.

**Methods:** A meta-analysis was conducted using individual patient data available from papers published from 1965 through 2011. Patient data were collected for overall survival at 3, 5, and 10 years. Only patients with histologically confirmed SCC were included, with other malignancies excluded. Patients were grouped using the University of Pittsburgh staging system, and were also grouped according to treatment modality.

**Results:** A total of 71 papers and 1355 patients were identified. Overall survival at 3, 5, and 10 years was 47%, 42.3%, and 20.6%, respectively. There was a significant decrease in survival for T3/T4 tumors vs. T1/T2 tumors at 3, 5, and 10 years (69%, 69%, and 34.8% for T1/2 vs. 42.6%, 34.9%, and 10.6% for T3/4, respectively,  $P < 0.0005$ ). We found a male predominance of 1.3:1 ( $P = 0.0078$ ). We found the presence of hearing loss, facial nerve paralysis, and parotid involvement to all indicate a significant decrease in survival vs. patients without these clinical signs ( $P < 0.05$ ). We found a statistically significant survival advantage at 3 years for surgery alone (72.5%) vs. radiotherapy alone (55.7%),  $P = 0.006$ .

**Conclusions:** We present a comprehensive meta-analysis of patients treated for SCC of the temporal bone reported from 1965 through 2011, totaling 1355 patients. Statistically significant survival decreases were seen with involvement of the parotid or facial nerve, as well as with hearing loss on presentation. There was a statistically significant decrease in survival for T3/T4 tumors vs. T1/T2 tumors. Additionally, we found a survival advantage for patients treated with surgery alone vs. patients treated with radiation alone at 3 years. To our knowledge, this represents the largest meta-analysis of

patients with SCC of the temporal bone, and provides valuable prognostic and treatment-specific survival data on this uncommon malignancy.

**089. Temporal Meningoencephaloceles: Diagnostic Pitfalls, Surgical Repair, and Associated Pathologies**  
Hwa J. Son (presenter), Alexandre A. Karkas, Ravi N. Samy, Philip V. Theodosopoulos, Myles L. Pensak (Covington, OH, USA)

**Objectives:** We present our experience in the diagnosis and treatment of meningoencephaloceles of the temporal bone, specifically focusing on etiology, intraoperative findings, concomitant obesity, and recurrence rate.

**Patients and Methods:** We performed a retrospective chart review of all patients operated on for meningoencephaloceles of the lateral skull base in a tertiary referral center from 1999 to 2011. We included encephaloceles diagnosed preoperatively and the ones discovered incidentally intraoperatively. All imaging scans were retrospectively analyzed to try to correlate pertinent imaging details to intraoperative findings.

**Results:** There were a total of 35 patients, 22 females and 13 males. The average age was 51 years, ranging from 16 to 86 years. The meningoencephalocele was found on the right side in 16 patients and on the left in 17; 1 patient had bilateral disease. Clinical manifestations consisted primarily of clear otorrhea with associated conductive hearing loss. Other common symptoms included aural fullness, rhinorrhea, and headache. The distribution of the etiologies was: idiopathic (22), chronic otitis media or cholesteatoma (9), iatrogenic (2), and trauma-induced (2). The relationship between body mass index and spontaneous cerebrospinal fluid (CSF) leak was analyzed. The surgical repair of the meningoencephalocele was performed via a transmastoid approach in 17 cases, middle fossa approach in 1, and combined transmastoid/middle fossa approaches in 14; there were 3 cases where an anterior transpetrosal approach was added. The most frequent site of brain herniation was the tegmen tympani and/or mastoid, but two cases involved the petrous apex and two others involved the sinodural angle. Recurrence was seen in four patients.

**Conclusion:** This is one of the largest series of meningoencephaloceles of the lateral skull base. They continue to present as diagnostic and treatment challenges for skull base surgeons. They may also be growing in importance due to an increase in the population of patients with obesity.

**090. Surgery for Temporal Bone Encephaloceles: A Review of 85 Cases**  
Spiros Manolidis (presenter), Raj Shrivastava (New York, USA)

**Objective:** To describe the presentation, etiology, and surgical management of brain involvement of the temporal bone.

**Materials and Methods:** A retrospective chart review was conducted of 85 patients with tegmen dehiscence, meningoencephalocele, or cerebrospinal fluid leak in the middle ear.

**Results:** The most common etiology was chronic ear disease with or without cholesteatoma (67%). In 61%, potential iatrogenic cause for the problem existed due to previous surgery for chronic ear disease. Twenty-one of the 85 had

extensive dural exposure alone, 49 had a meningoencephaloceles, and 15 had CSF leak. The majority of patients required a minicraniotomy, mid-fossa approach for repair (61%), grafting with cartilage or calvarium (94%) and soft tissue reconstruction (53%). Dural exposure alone was largely amenable to transmastoid repair (70%), whereas meningoencephaloceles were more likely to require minicraniotomy mid-fossa approaches (73%). Facial nerve involvement by chronic ear disease often required a minicraniotomy mid-fossa approach. Approximately half needed a soft tissue flap for reconstruction. Flaps used were pedicle fascia flaps: temporoparietal fascia flap or superficial temporalis fascia flap. Only 17% of patients who had undergone a prior procedure were amenable to transmastoid repair.

**Conclusions:** Tegmen defects are most commonly due to chronic ear disease. Dural exposure alone may be repaired via a transmastoid approach, whereas herniation of intracranial contents into the mastoid will likely need a more extensive approach. Facial nerve involvement, spontaneous lesions, and history of prior surgery may require a minicraniotomy mid-fossa approach. Grafts are often needed for support. Soft tissue flaps frequently are required for appropriate repair, especially in patients with facial nerve involvement.

#### 091. Immediate Single-Stage Reconstruction of Complex Frontofaciobasal Injuries

Akram M. Awadalla (presenter), Hesham Ezaldeen, Nagla F. Mohamed (Tabuk, Saudi Arabia)

**Objectives:** To determine if immediate (within 6 hours) single-stage repair of complex craniofacial injuries could be accomplished with acceptable appearance, morbidity, and mortality.

**Patients and Methods:** Twenty-six patients (19 men, 7 women), with ages ranging from 8–58 years and Glasgow Coma Scale scores of 5 to 15, had a combined single-stage repair within 6 hours of their admission after resuscitation. All patients had accurate CT-3D. Bicoronal skin flap was used for maximum exposure for frontal sinus exenteration, dural repair, cortical debridement, calvarial reconstruction, and titanium mesh placement. Dural grafts were necessary in 22 of 26 patients (85%), and supplementary bone grafting was required in 19 of 26 patients (73%), of which 6 patients (23%) had iliac bone grafts, whereas split calvarial grafts were used in 12 patients (46%) and a full thickness calvarial graft was used in 1 case (3.8%).

**Results:** Neurosurgical outcome at both early and late evaluation was judged as good in 22 of 26 patients (85%), moderate in 3 of the 26 (11%), and poor in 1 of the 26 (3.8%). Cosmetic surgical outcome at early evaluation showed 17 of 26 (65%) to be excellent, 4 of 26 (15.5%) to be good, 4 patients (15.5%) to be fair, and 1 patient (3.8%) to be poor. At late reevaluation, the fair had improved to good with only one additional reconstructive procedure, and the poor had improved to fair with another surgery. Complications occurred in 3 patients (11%): one case (3.8%) had tension pneumocephaly and meningitis, one case (3.8%) had delayed cerebrospinal fluid leak with recurrent attacks of meningitis, and one case had maxillary sinus infection (3.8%) secondary to frontomaxillary fistula associated with wound infection and hardware exposure. These results compare favorably with historical data in which an overall infection rate for a staged repair would be 12.5 to 17.7%.

**Conclusion:** The immediate single-stage repair of complex craniofacial injuries can be performed with an acceptable

rate of morbidity and mortality, a decreased need for reoperation, and an improved cosmetic and functional outcome.

#### 092. Transcranial Exposure of Large Dural Venous Sinuses for Direct Transvenous Embolization of High-Grade Dural Arteriovenous Fistulas

James K. Liu (presenter), Osamah J. Choudhry, Aclan Dogan, Stanley Barnwell, Johnny Delashaw, Jr. (Elizabeth, NJ, USA)

**Introduction:** High-grade dural arteriovenous fistulas (DAVFs) with retrograde cortical leptomeningeal drainage are formidable lesions because of their risk for intracranial hemorrhage. Treatment is aimed at occluding venous outflow to achieve obliteration of the fistula. In DAVFs that involve a large dural venous sinus, occluding venous outflow can be accomplished endovascularly with transvenous embolization. In cases of DAVFs with reflux into cortical leptomeningeal veins, there is usually venous restrictive disease downstream that can prohibit endovascular access via the transfemoral or transjugular routes.

**Methods:** In this study, we describe our technique of surgically assisted transvenous embolization in three patients with high-grade DAVFs involving a large dural sinus with retrograde cortical leptomeningeal drainage.

**Results:** Surgically assisted transvenous embolization of the DAVF resulted in complete angiographic obliteration in all three patients on postembolization angiography. All had improvement of their preoperative symptoms, and there were no recurrences and no further clinical events after a mean follow-up of 37 months. There were no complications of venous hypertension or venous infarction.

**Conclusion:** Our technique is unique in that the craniectomy and embolization procedures are performed as a single stage in the operating room with intraoperative angiography and stereotactic image guidance. In these instances, a transcranial approach can be performed to expose the large dural venous sinus distal to the site of occlusion for direct catheterization of the venous outflow for transvenous embolization. This combined surgical and endovascular strategy provides direct access to the venous outflow and bypasses the site of thrombotic obstruction.

#### 093. Meta-Analysis of Published Data on Outcome of Endoscopic versus Open Management of Juvenile Nasopharyngeal Angiofibromas

Ashutosh Kacker (presenter), Joshua Halpern, Jeffery Liu, Theodore H. Schwartz, Michael G. Stewart (New York, USA)

**Introduction:** Juvenile nasopharyngeal angiofibroma (JNA) is a vascular neoplasm of the nasopharynx that presents in adolescent males. Open surgical removal in the past could entail significant morbidity. Recently, endoscopic resection has been reported with good results. The purpose of this study was to perform a comparative analysis of JNA patients in the reported literature who have undergone endoscopic resection versus open resection, to better understand differences in outcomes. We gathered multiple data points, to attempt to control for tumor characteristics and see if there were outcome differences attributable to surgical technique.

**Methods:** A PubMed search was performed of journal articles in English with the terms "nasopharyngeal



angiofibroma” and “endoscopic.” We selected articles containing primary data, which reported both endoscopic and open surgical techniques, as well as series from the same authors who had used one of these techniques. Articles were examined for multiple clinical variables, including preoperative embolization, need for transfusion, postoperative complications, and recurrence. Tumors were categorized as “limited” or “advanced” disease using both Fisch/Andrews and Radkowski/Sessions tumor staging systems. We performed multivariate analysis, controlling for multiple variables, to best identify the independent effect of each independent variable.

**Results:** Thirty-eight articles were identified with a total of 383 patients treated for JNA. Of these, 259 underwent endoscopic resection, and 124 underwent open resection. In terms of tumor stage, patients with limited disease were more likely to undergo endoscopic resection than open resection (77.2% vs. 22.8%), whereas patients with advanced disease were more likely to undergo open resection (57.0% vs. 42.0%). Among endoscopic-only patients for whom complications data were available, 8 (3.7%) postoperative complications were reported (five synechia, two paresthesias, and one infraorbital nerve anesthesia). Among open surgery patients for whom complications data were reported, 19 (26.0%) experienced postoperative complications. Of 333 patients for whom tumor recurrence data were reported, 39 (11.7%) had recurrence. Twenty-one of 259 (8.1%) endoscopic-only treated patients had a recurrence, whereas 18 of 74 (24.3%) open patients had a recurrence ( $P < 0.001$ ). However, multivariate analysis, controlling for tumor stage, revealed that the endoscopic approach was not a significant variable influencing tumor recurrence ( $P = 0.25$ ). Only advanced tumor stage was an independent predictor of tumor recurrence ( $P = 0.02$ ).

**Conclusion:** Endoscopic resection of JNA in selected patients appears to be a safe technique with a very low reported risk of morbidity, mortality, and tumor recurrence. We recommend that surgical approach be selected on an individual-case basis.

#### 094. Skull Base Approaches to Posterior Circulation Aneurysms: A Single-Surgeon Experience from Louisiana State University, Shreveport

Ashish Sonig (presenter), Anirban Deep Banerjee, Imad Khan, Anil Nanda (Shreveport, USA)

**Introduction:** Posterior circulation aneurysms continue to generate significant challenge and controversy. Various approaches have been described based on extent of bone resection. We share our experience with consecutively operated-on posterior circulation aneurysms, so as to present the role of microneurosurgery with *minimal bone resection* as a realistic management option for these difficult aneurysms.

**Methods:** We retrospectively reviewed the medical records of all the patients consecutively operated on by the senior author (AN) from January 1998 till August 2011. A total of 86 patients were operated on and 92 posterior circulation aneurysms were clipped. The following paragraphs describe the skull base approaches that were used by the senior author.

**Pterional Craniotomy and Its Modifications:** High basilar-top aneurysms were approached via a pterional approach with an orbitozygomatic extension. Normal anatomical level was approached via a pterional or combined “half-and-half”

approach. Upper clival (low-riding) aneurysms, posterior cerebral artery (PCA), and superior cerebral artery (SCA) were tackled via a subtemporal transtentorial approach, with or without posterior clinoid process drilling.

**Modified Far-Lateral Approach:** Aneurysms of the basilar artery, from the origin of the anterior-inferior cerebellar artery (AICA) to the vertebral-basilar (VB) junction and proximal PICA (posterior inferior cerebellar artery aneurysm) were clipped using this approach. It does not require drilling of occipital condyles, but gives an excellent corridor anterior to brainstem. Distal PICA and low-origin PICA aneurysms were clipped using retromastoid-suboccipital, midline-suboccipital craniectomy.

**Results:** Average age of the patients was 59.92 years, with a F:M ratio of 2.4:1. Fifty-two patients with basilar artery apex aneurysms, eight with PCA aneurysms, and six with SCA aneurysms underwent surgical clipping by pterional craniotomy with cranial base modification. Five patients with proximal-basilar aneurysms (AICA-BA junction and VA-basilar junction), and seven patients with PICA aneurysms were approached by a modified far-lateral approach. Distal PICA was approached by midline suboccipital craniectomy in eight patients. Six patients were lost in follow-up; mean duration of follow-up was 14.6 months. In 79.1% of the patients, good outcome was seen in the basilar group (Glasgow outcome scale score [GOS] of 4/5). Mortality rate was 10.4%. Most patients (75%) approached by the modified far-lateral approach had good outcome (GOS 4/5) and zero mortality. Outcome was significantly influenced by clinical grade ( $P < 0.001$ ). Larger aneurysms had higher risk of intraoperative rupture ( $P < 0.02$ ).

**Conclusion:** In the present controversial scenario regarding the management of posterior circulation aneurysms, the onus is on microneurosurgery to prove itself as a possible alternative to endovascular intervention for certain select cases. Our study has shown that the majority of posterior circulation aneurysms can be clipped with minimal bone-resection. The modified far-lateral approach provides an excellent corridor for clipping the aneurysms along the lower clivus and anterior to the brainstem with decreased operative times and morbidity.

#### 095. Dissecting Circle of Willis Arteries via Endoscopic Endonasal Techniques

Anand V. Germanwala (presenter), Adam M. Zanation, Murray Ramanathan (Baltimore, USA)

**Introduction:** Endoscopic endonasal approaches for intracranial and intradural tumors have gained increasing attention. Previous limitations for removal have included the involvement of underlying cerebral vasculature. With increasing experience, resections of more challenging lesions are being attempted.

**Methods:** A retrospective review was performed analyzing endoscopic endonasal resections of anterior skull base intracranial tumors between July 2007 and December 2010 by a single team at a single institution. Lesions with involvement of cerebral vessels were defined, on MR imaging, as those in which arteries of the circle of Willis either directly abutted or passed through the tumor. Resection, stroke, and vascular injury rates were reviewed.

**Results:** Of 105 total cases, 27 met radiographic criteria for some circle of Willis involvement. Tumor types included meningioma, giant pituitary adenoma, and

craniopharyngioma. Resection included dissection of the anterior cerebral, anterior communicating, posterior cerebral, posterior communicating, and basilar arteries. The rate of gross total resection was 20/27 (74.1%), stroke 1/27 (3.7%), and vascular injury 1/27 (3.7%).

**Conclusion:** Complex skull base intracranial tumors with intimate involvement of the cerebral vasculature can be resected with endoscopic endonasal techniques with acceptable rates of resection and morbidity. In the setting of vascular injury, immediate endovascular intervention may be needed. More experience will lead to improved resection and lowered morbidity rates.

#### 096. Supraorbital Keyhole Approach for Aneurysm Ali Ayad (presenter), Martin Glaser (Mainz, Germany)

**Introduction:** The main aim in surgery is to achieve the greatest therapeutic effect while causing the least iatrogenic injury. The evolution of microsurgical techniques with refined instrumentation and illumination and the enormous development of preoperative and intraoperative diagnostic tools enable neurosurgeons to treat different lesions through limited and specific keyhole approaches. The concept of keyhole surgery is based on the careful preoperative study of diagnostic images (MRI, CT, angiography) to determine the anatomic windows that provide access to the pathological processes, taking into consideration the individual patho-anatomic situation of the patient.

The special architecture of the anterior cranial fossa offers several anatomic windows to reach deep-seated lesions. However, when the approach is made from an anterior subfrontal direction, the suprasellar anatomic structures are free for surgical dissection and are not hidden by any brain structures.

**Methods:** During the period between June 2000 and June 2009, we treated 422 patients with anterior circulation aneurysms using a supraorbital keyhole approach. The locations of the aneurysms were: internal carotid artery (149), middle cerebral artery (142), anterior cerebral artery (52), and anterior communicating artery (79).

**Results:** The postoperative complications associated with this approach were: (1) permanent partial supraorbital hypesthesia related to a lesion of the supraorbital nerve in 11 patients, (2) permanent palsy of the frontal muscle related to a lesion of the frontal branch of the facial nerve in 9 patients, (3) permanent hyposmias in 8 patients, (4) wound-healing disturbances in 5 patients, and (5) subcutaneous cerebrospinal fluid collection and leak in 4 patients.

**Conclusion:** In our experience, the supraorbital craniotomy allows a wide, intracranial exposure for extended, bilaterally situated, or even deep-seated intracranial areas, according to the strategy of keyhole craniotomies. The supraorbital craniotomy offers equal surgical possibilities with less approach-related morbidity owing to limited exposure of the cerebral surface and minimal brain retraction, thus contributing to improved postoperative results and shorter hospitalization times. Patients have a reduction in the risk of complications, such as bleeding or rebleeding, with neurological deterioration, postoperative epilepsy, leakage of cerebrospinal fluid, and infection. In addition, the short skin incision within the eyebrow and careful soft tissue dissection result in a pleasing cosmetic outcome.

#### 097. Technical Nuances of Temporal Muscle Dissection and Reconstruction for the Pterional Keyhole Craniotomy

Nancy McLaughlin (presenter), Neil A. Martin (Los Angeles, USA)

**Introduction:** The supraorbital (SO) keyhole approach offers limited access for aneurysms located at the MCA bifurcation with long M1 segments or distal MCA aneurysms. Alternative minimally invasive routes centered on the pterion have been developed to address these aneurysms. Appropriate dissection and reconstruction of the temporal muscle (TM) are important for optimal exposure and best cosmetic results with the pterional keyhole craniotomy (PKC).

**Methods:** The authors describe the technical nuances of TM dissection and reconstruction adapted to the PKC.

**Results:** After incising the scalp in a curvilinear fashion behind the hairline, an interfascial dissection is performed, allowing anterior reflection of the superficial temporal fat pad and superficial temporal fascia (STF). The TM is incised 1.0 cm below its insertion at the superior temporal line. The deep temporal fascia (DTF) and TM are incised vertically, completing a "T" shape incision. Subperiosteal dissection of both TM flaps preserves the deep temporal arteries and nerves. A craniotomy measuring 3 cm × 3 cm is cut above the pterion. Dissection of the Sylvian fissure and of the MCA aneurysms proceeded without the use of retractors. The bone flap and associated hardware is entirely covered by the TM, which is reconstructed in two layers: the TM/DTF and the STF.

**Conclusion:** This dissection technique prevents damage to branches of the facial nerve and minimizes TM damage. Dividing the TM in half and reflecting both parts anteriorly and posteriorly prevent suboptimal illumination and visualization under the microscope. Covering the bone flap and related hardware with a multilayer anatomical reconstruction optimizes cosmetic results.

#### 098. Vascular Lesions of the Skull Base: Correlation with Imaging

Elon Granader (presenter), Ashok Srinivasan (Ann Arbor, USA)

**Purpose:** Radiologic imaging plays a vital role in the recognition and diagnosis of vascular lesions of the skull base. The purpose of this educational exhibit is to provide an interactive MDCT and MRI imaging review of both common and unusual vascular lesions of the skull base with an emphasis on their imaging profile and clinical implications.

**Content Organization:** The normal foramina of the skull base will be reviewed through illustrations and images with discussion of contents. The MDCT and MRI appearance of vascular lesions of the skull base (including some arterial and venous lesions) will be presented with attention to their clinical significance. Some of the lesions presented will include: aberrant internal carotid artery, high-riding jugular bulb, jugular bulb dehiscence, persistent stapedia artery, persistent dorsal ophthalmic artery, and glomus jugulare/glomus tympanicum. A case-based, interactive quiz format will be used throughout the exhibit.

**Summary:** Familiarity with the imaging appearance of skull base vascular lesions is crucial to lesion diagnosis and plays a critical role in management and surgical planning.

### 099. What Is the Best Approach? A Cadaver-Based Anatomic Comparison of the Ipsilateral and Contralateral Approach to Superior Hypophyseal Artery Aneurysms

Brian D. Milligan (presenter), John Roufail, Gregory Anderson, Johnny B. Delashaw (Portland, OR, USA)

**Introduction:** Superior hypophyseal artery (SHA) aneurysms are proximal inferomedially projecting intracranial internal carotid artery aneurysms. Although the SHA provides the major blood supply to the intracranial optic nerve, visualization of the SHA branch via an ipsilateral approach to an SHA aneurysm is usually suboptimal but may be improved using a contralateral approach. The objective of this study is to compare the contralateral and ipsilateral approaches to the SHA region.

**Methods:** Using five formalin-fixed, latex-injected cadaver heads, we performed a standardized pterional approach to the contralateral SHA branches of eight carotid arteries working between the two optic nerves. We used a frameless stereotactic workstation to quantify the deep working area and approach angle freedom. We recorded the number of SHA branches visible and evaluated the feasibility of clip placement for a hypothetical SHA aneurysm. Following anterior clinoidectomy and opening the falxiform ligament, we assessed the ipsilateral approach.

**Results:** On average, the deep working area was  $1.7 \pm 0.5$  times larger ( $P < 0.01$ , paired  $t$ -test), and the approach angle freedom was  $2.3 \pm 0.7$  times larger ( $P < 0.001$ ) for the ipsilateral approach over the contralateral approach. However, only 60% (9/15) of SHA branches were seen via the ipsilateral approach, and the origin of the SHA branches was never seen without significant manipulation of the supraclinoid carotid artery. Therefore, clips placed for hypothetical aneurysms via an ipsilateral approach risked incorporating the SHA branch. Although 3 of 5 specimens harbored a prefixed optic chiasm narrowing the contralateral deep working area, we determined that by varying clip choice and length it would be anatomically feasible to clip smaller aneurysms in this location via a contralateral approach without excessive optic nerve manipulation while preserving the SHA branch origin.

**Conclusion:** Although the contralateral approach to the SHA origin narrows the approach corridor and reduces the deep working area each by about one half, clipping aneurysms in this location seems to be feasible despite optic chiasm configuration and may reduce the risk of optic nerve ischemia by allowing clip placement under direct vision to ensure protection of SHA perforators. During a contralateral approach, proximal control would require cervical carotid exposure.

### 100. Extradural Transcavernous Approach to Cavernous Sinus Hemangiomas: Series of 12 Cases

Ashish Suri (presenter), (New Delhi, India)

**Objective and Importance:** Cavernous sinus hemangiomas (CSHs) are uncommon lesions and comprise less than 1% of all parasellar masses. Because of their location, propensity for profuse bleeding during surgery, and relationship to complex neurovascular structures, they are notoriously difficult to excise.

**Clinical Presentation:** The author describes his experience with 12 cases of CSHs. Headache and visual impairment were the most common presenting com-

plaints, followed by facial hypesthesia and diplopia. CT revealed isodense to hyperdense expansile lesions in the region of the cavernous sinus and middle cranial fossa. MRI examinations revealed hypo- and isointense lesions on T1-weighted images (W1) and markedly hyperintense on T2-W1, with marked homogeneous enhancement after contrast administration.

**Intervention:** All CSHs were treated by a purely extradural transcavernous approach. This involved reduction of sphenoid ridge, exposure of superior orbital fissure, drilling of anterior clinoid process, coagulation and division of the middle meningeal artery, and peeling of the meningeal layer of the lateral wall of the cavernous sinus off the inner membranous layer. The cranial nerves in the lateral wall of the cavernous sinus were exposed (III, IV, V1, V2, and V3 cranial nerves). The tumor was accessed through its maximum bulge either through the lateral or the anterolateral triangle. The tumor was removed, using rapid decompression, coagulation of feeder from the meningohypophyseal trunk, and dissected along the cranial nerves. All but one patient had complete tumor excision. Transient ophthalmoparesis (complete resolution in 6–8 weeks) was the most common surgical complication.

**Conclusion:** We describe one of the largest series of pure extradural transcavernous approach to the CSHs.

### 101. Surgical Salvage of Acoustic Neuroma after Failed Radiation Treatment

Rick A. Friedman (presenter), Karen Berliner, Marc Bassim, Joseph Usick, Marc S. Schwartz, Derald E. Brackmann (Los Angeles, USA)

**Objectives:** The purpose of this study was to determine if a more conservative management scheme for surgical salvage after failed radiation leads to better facial nerve outcomes.

**Study Design:** This study was an Institutional Review Board (IRB)-reviewed retrospective review using a prospectively planned database.

**Setting:** The study took place at a private practice tertiary neurotology/neurosurgery referral center.

**Patients:** A total of 108 patients from our institution have undergone surgical salvage after failed radiation for tumors of the posterior fossa. Included in this study were the 73 patients in this group with vestibular schwannoma who had undergone primary radiosurgery with no other intervention followed by tumor removal using the translabyrinthine approach.

**Intervention:** Translabyrinthine craniotomy was performed for vestibular schwannoma salvage surgery after failed radiation, with either gross total or partial tumor removal.

**Main Outcome Measures:** Long-term (1 year) House-Brackmann (HB) facial nerve grades were measured pre- and postoperatively, and changes in facial nerve grades pre- and postoperatively were noted.

**Results:** Of the 73 patients, 79.5% had gross total removal; 5.5% had planned partial resection (subtotal or near total); and 15.1% had intraoperatively elected partial removal, with the vast majority of these being near total removal. At 1-year follow-up, 50% of patients who underwent gross total removal had good facial nerve function (H-B I/II) compared with 85.7% in those with partial removal ( $P \leq 0.03$ ). HB grade

remained the same or improved postoperatively in 45.8% of the total removal group compared with 78.6% of the partial removal group ( $P \leq 0.037$ ), with 21.7% of the total removal group having unsatisfactory outcomes (HB V or VI). In contrast, only 7.1% of patients managed conservatively with partial or near total removal had such poor outcomes. To date, no patient has required additional treatment.

**Conclusions:** Currently, failed radiosurgery is the most common indication for salvage surgery at our institution, with an ever-increasing population. Taking a conservative approach with a willingness to perform partial and near total tumor removals leads to better facial nerve outcomes with no current evidence of treatment compromise.

### 102. Facial Nerve Schwannomas of the Cerebellopontine Angle: The Mayo Clinic Experience

Jeffrey T. Jacob (presenter), Colin L. Driscoll, Michael J. Link (Rochester, USA)

**Background:** Cerebellopontine angle (CPA) facial schwannomas (FNS) are infrequent, accounting for less than 20% of all FNS. There is often controversy regarding the most optimal management strategy and debate as to whether, when, and how to intervene in these patients. Here we present the Mayo Clinic experience and management paradigm for these rare tumors.

**Methods:** The clinical and radiological outcomes in 14 patients with cerebellopontine angle (CPA) facial nerve schwannomas treated at our institution from 1998 to 2011 were reviewed. Management modalities included observation, resection, and/or stereotactic radiosurgery. All patients were managed by the senior author (MJL).

**Results:** Patients presented with clinical facial nerve dysfunction ( $n = 7$ ), hearing loss ( $n = 5$ ), or brainstem symptoms ( $n = 2$ ) at the time of treatment. Nine patients were followed conservatively for a mean and median time of 60 and 48 months, respectively, prior to treatment (range, 12–132 months). Eleven patients underwent surgery for exploration ( $n = 4$ ), resection with anatomic nerve preservation ( $n = 3$ ), and resection with nerve resection followed by hypoglossal-facial nerve anastomosis ( $n = 4$ ). Six patients underwent gamma knife radiosurgery (GKS) at the time of clinical or radiographic progression. One patient remains under observation. Five out of the six tumors that underwent GKS were either stable or decreased in size, and one tumor showed cystic degeneration and enlargement. All those that underwent resection showed no evidence of tumor recurrence, and the tumor under observation remained unchanged with normal facial function at the time of the last follow-up. Collectively, in the patients that underwent surgical resection of their tumor, there was a decrease in facial function in 57%, no change in facial function in 14%, and an improvement in facial function in 29%. All six patients who underwent GKS had a pretreatment House-Brackmann (HB) of 1 to 2, and this remained unchanged in four patients (67%). Two of the patients who underwent GKS (33%) had complete facial paresis (HB 6) within the first week after treatment. Serviceable hearing was maintained in 50% of patients in the GKS group and in 67% of patients in the tumor resection group. Overall, the mean and median follow-up was 48 and 43 months, respectively (range, 12–95 months).

**Conclusions:** Facial nerve schwannomas of the CPA are rare, and the lack of a consistent treatment approach poses a challenge in the management of these tumors. Those

with normal facial nerve function should be observed when encountered with what appears to be a facial nerve schwannoma, either radiographically or during an approach to a CPA tumor. Microsurgery with or without nerve resection and stereotactic radiosurgery can be used in particular circumstances with regard to a patient's preoperative facial nerve function, age, health, progressive neurologic symptoms, and tumor enlargement.

### 103. The Learning Curve for Surgical Resection of Vestibular Schwannoma

Tamir Ailon (presenter), Ryojo Akagami (Vancouver, Canada)

**Introduction:** The surgical learning curve describes the time taken, or number of procedures, that an average surgeon requires to perform a procedure independently and with a reasonable outcome. Several studies in the literature suggest that this typically comprises the first 20–30 cases. We sought to determine the learning curve for resection of vestibular schwannoma and hypothesized that patient outcome—as measured by improved facial nerve function and decreased complications—would improve with successive cases.

**Methods:** We conducted a retrospective review of 285 successive cases performed by the senior author over a 10-year period. The majority of tumors were resected through a retrosigmoid approach (254); the remainder had translabyrinthine (18), PLPA (10), or middle fossa (3) approaches. Intraoperative monitoring was used routinely. Outcome measures included all complications, facial nerve function, and hearing preservation.

**Results:** A plot of the cumulative percent complication rate demonstrated an initial sharp decrease, which then leveled off after approximately 50 patients. Facial nerve function was [House-Brackmann] grade 1–2 in 237, grade 3–4 in 41, and grade 5–6 in six patients. There was a decrease in significant facial nerve palsy (grade 3 or higher) after the first 50 patients that remained relatively stable thereafter. The rate of hearing preservation increased steadily with successive cases and was greatest in the last group of patients operated on.

**Conclusion:** There is a learning curve for surgical resection of vestibular schwannoma as demonstrated by a decrease in overall complication rate and improved facial nerve function. This learning curve appears to comprise approximately the first 50 operative cases.

### 104. Importance of Low Amplitude Positive Facial Nerve Stimulation Following CP Angle Tumor Surgery

Bharat Guthikonda (presenter), Cedric Shorter, Jai Thakur, Jamie Toms, Anil Nanda (Shreveport, USA)

**Introduction:** Preservation of facial nerve function is crucial to a successful CP angle tumor resection. Intraoperative facial nerve monitoring is a routine component of CP angle surgery. We sought to correlate short-term and long-term facial nerve function with respect to the minimum amplitude of stimulation required to obtain facial nerve identification at the conclusion of tumor resection.

**Methods:** We performed a review of a prospectively maintained database of all patients who underwent CP angle tumor surgery between September 2007 and March 2011. The minimum amplitude necessary to achieve positive facial nerve stimulation was noted in all cases. Facial nerve

function outcomes (based on the House-Brackmann grading scale) were noted at three different postoperative times: immediately after surgery (postoperative day 1), 1 month postoperatively, and 6 months postoperatively.

**Results:** Twenty-six CP angle tumor/mass resections were performed in our study time span (18 acoustic neuromas, 5 meningiomas, 1 ganglioglioma, 1 juvenile pilocytic astrocytoma, and 1 mucormycosis mass). Positive facial nerve stimulation was achieved in all cases at the conclusion of the tumor resection. The minimum threshold to achieve this final positive stimulation ranged from 0.1 to 1 mA (mean, 0.26 mA). Immediate postoperative facial function varied from HB 1 to HB 4 (mean, 1.81). One month postoperatively, facial function varied from HB 1 to HB 3 (mean, HB 1.45). Six-month postoperative facial function varied from HB 1 to HB 2 (mean, 1.04). A trend was observed in which the higher the stimulation required to obtain final positive stimulation, the worse the initial facial nerve outcome and the longer the deficit took to return toward normal.

**Conclusions:** Our study showed that final facial nerve stimulation with low amplitude led to good facial nerve outcomes in the long term. We also noted that despite some sub-optimal immediate postoperative facial nerve function, excellent long-term facial function was seen in all patients. Our data stress the importance of maintaining electrical (as well as anatomic) integrity of the facial nerve; we advocate doing this at all costs, even if a thin layer of tumor is left adherent to the facial nerve.

#### 105. Surgical Management of Endolymphatic Sac Tumors

Michael Hoa (presenter), Rick A. Friedman, Derald E. Brackmann (Los Angeles, USA)

**Objective:** The purposes of this study were to (1) review the cumulative experience of surgical management of endolymphatic sac tumors (ELSTs) in the literature, (2) review the experience with ELST management at a tertiary referral-based otology-neurotology practice, and (3) present our approach to management.

**Study Design:** A retrospective review was conducted of patients at a referral-based otology-neurotology practice.

**Methods:** A review of all available records from the House Clinic of patients with ELSTs was performed. Presentation, diagnostic workup, microsurgical approach, and outcomes were reviewed. A literature review using MEDLINE of studies reporting surgical outcomes of patients with ELSTs was also performed.

**Results:** The retrospective chart review revealed 10 patients with available charts. Of these patients, 6 had been previously reported on and updated follow-up is presented. Furthermore, outcomes in 10 more patients had been previously reported from our institution. Grouping of these patients provides surgical outcomes on the largest group of mostly non-von Hippel-Lindau (vHL) patients with ELSTs in the literature. Patients most commonly presented with sensorineural hearing loss, tinnitus, and dizziness. A majority of patients presented with large tumors exhibiting significant destruction of surrounding structures, including the cochlea, vestibule, and internal auditory canal. Patients underwent microsurgical resection with the intent for complete resection.

**Conclusions:** Although the extensive nature of ELSTs at time of diagnosis often precludes hearing preservation, complete microsurgical resection can be achieved safely with preservation of facial function in the majority of cases.

#### 106. Retrospective Review of Tegmen Dehiscence Presentation and Repair Using a Combined Transmastoid and Middle Cranial Fossa Approach

Melvin Field, Aftab Patni, Lena Ning (presenter) (Orlando, USA)

**Objective:** Tegmen dehiscence is an uncommon and often underdiagnosed condition. It is associated with an increased risk of meningitis, intracranial abscess, cranial neuropathy, and seizure. Various surgical approaches for tegmen dehiscence repair have been documented, but the comparative efficacy of differing surgical techniques remains unclear. The presentation and repair using a combined transmastoid and middle cranial fossa approach for a series of cases is described and evaluated in this study.

**Methods:** A series of 15 cases of patients diagnosed with tegmen dehiscence was retrospectively reviewed. These patients were all treated with a combined transmastoid and middle cranial approach to surgical repair. Data on presentation, surgical technique, and outcome were collected and analyzed. Preoperative and postoperative audiogram results were also compared.

**Results:** The patient series was 67% women with a mean age of 51.3 years and an average BMI of 37.8. Although each patient's presentation varied, the most common symptoms were hearing loss, otorrhea, tinnitus, and ear fullness. A majority of patients had a history of cholesteatoma, infection, and/or prior surgery in the middle ear or mastoid area. All patients underwent a combined approach to multilayered surgical repair using a temporal bone graft and temporalis fascia. DuraGen, Tisseel glue, abdominal fat graft, DuraGuard, and DuraSeal glue were also used in selected patients. Postoperative complications were minimal, with no serious unresolved consequences. One patient experienced recurrent CSF leak, and one developed a mastoid infection following revision surgery; both of these resolved with treatment. Two patients experienced worsened hearing, while seven had improved hearing following surgery. Overall, a 77% improvement was found between incidence of all examined preoperative and postoperative symptoms.

**Conclusion:** This case series demonstrates the variable presentation of tegmen dehiscence and points to diagnostic factors that should arouse suspicion. Surgical closure is necessary to prevent further infection and neurological sequelae. A combined approach through both the transmastoid and middle cranial fossa routes provides adequate exposure of the defects. A multilayered repair technique including a temporal bone graft is advocated to provide a strong and lasting closure of the dehiscence area.

#### 107. Acoustic Neuroma Treatment and Symptomatology: 25-Year Trends Based on Analysis of Patient Surveys from the Acoustic Neuroma Association

J. Patel, R. Vasan, S. Agazzi (presenter), J. M. Sweeney, G. Danner, A. S. Youssef, H. van Loveren (Tampa, USA)

**Objectives:** To use the 1998 (1983–1998 inclusive) and 2008 Acoustic Neuroma Association (ANA) patient surveys to report trends and evolution in acoustic neuroma (AN) presentation, treatment, and treatment-related outcomes on a national level.

**Materials and Methods:** This cohort study analyzed the reported experiences of 1,934 members of the 2008 ANA survey. The results of the ANA survey were reviewed to determine respondents' pre- and postoperative symptoms and

treatment. The responses were analyzed to detect trends of presenting symptoms, tumor size, treatment modality, and treatment outcomes. Results of the 2008 survey were compared with the 1983–1998 survey to establish 25-year trends in patient presentation and care. SPSS software was used to conduct statistical analysis.

**Results:** Patients with AN most commonly presented with hearing loss (88%), tinnitus (73%), and balance disturbance (59%). Similarly, patients of the 1998 survey reported hearing loss (88%), tinnitus (64%), and balance disturbance (64%) as presenting symptoms. In the last decade, tumor size at diagnosis decreased significantly (1998:  $23\% \leq 1.5$  cm; 2008:  $38\% \leq 1.5$  cm). From 1998 to 2008, the use of microsurgery (85%), radiosurgery/radiotherapy (5%), and observation (4%) showed a decrease in microsurgery (60%) and an increase in both radiosurgery/radiotherapy (20%) and observation methods (20%). The decrease was noted in two major subcategories of AN microsurgery: Translabyrinthine approach (1998–51% to 2008–33%) and retrosigmoid/suboccipital approach (1998–28% to 2008–17%).

**Discussion:** Although acoustic tumor size at diagnosis has decreased in the past 10 years, patient symptomatology has remained largely unchanged. This national level, patient-driven review also confirms that management of acoustic tumors has seen significant decline in microsurgical treatment while radiation therapy/radiosurgery and observation have gained popularity. Persisting patient morbidities may merit a reevaluation of the shift in treatment strategy.

**Conclusion:** This review provides a glimpse into the changing face of acoustic tumor management from a patient's perspective over a 25-year period.

### 108. The Anatomically Intact but Electrically Unresponsive Facial Nerve Following Vestibular Schwannoma Resection

Matthew L. Carlson (presenter), Kathryn M. Van Abel, William R. Schmitt, Colin L. Driscoll, Charles W. Beatty, Brian A. Neff, Michael J. Link (Rochester, USA)

**Objective/Background:** Permanent facial nerve paresis following vestibular schwannoma (VS) surgery is devastating to both the patient and surgeon. Intraoperative electrophysiological testing has proven invaluable in reducing the incidence of severe facial nerve injury and may assist in prognosticating long-term function. To the authors' knowledge, no study to date has specifically evaluated functional outcomes among patients with an intact but electrically unresponsive facial nerve.

**Study Design:** A retrospective chart review was conducted.

**Materials and Methods:** All patients undergoing VS surgery between 2000 and 2010 at a single tertiary academic referral center were identified. Intraoperative facial nerve testing (minimum proximal threshold and supramaximal stimulation ratios) and definitive facial nerve outcomes were reviewed, and all patients with an anatomically intact but electrically unresponsive facial nerve were included. Data were collected with respect to preoperative, immediate postoperative, and definitive postoperative facial nerve scores using the House-Brackmann facial nerve grading (HBC) system, tumor characteristics, and basic demographic data.

**Results:** Over the last decade, 350 patients underwent microsurgical resection of VS; of these, 12 patients (median age 49 years, 8 women) met inclusion criteria. The

median (mean, range) preoperative, and definitive postoperative facial nerve scores were 1 (1.5, 1–5), and 3 (3.3, 2–5) respectively. All patients experienced immediate complete facial nerve paralysis following surgery. The median time to definitive facial nerve recovery was 10 months.

**Conclusions:** Following VS resection, a small subset of patients is left with an anatomically intact but electrophysiologically unresponsive facial nerve. Most patients will recover to a HBC 2 to 4 over a period of approximately 1 year. Although somewhat unpredictable, these outcomes are on par or better than what could be expected with interposition graft or reinnervation techniques. These data can help guide operative decision making and postoperative patient counseling.

### 109. Use of Preoperative MRI to Predict Vestibular Schwannoma Intraoperative Consistency and Facial Nerve Outcome

William R. Copeland (presenter), Jason M. Hoover, Jonathan M. Morris, Brian A. Neff, Colin Driscoll, Fredric B. Meyer, Michael J. Link (Rochester, USA)

**Introduction:** Vestibular schwannoma firmness can be a factor in resectability. We sought to identify if preoperative tumor MRI T1 and T2 intensities might predict intraoperative consistency. We then determined whether intraoperative consistency correlated with facial nerve outcomes.

**Methods:** Operative reports from 1999–2011 were searched for surgeon description of the schwannoma as “soft” and/or “suckable” or “firm” and/or “fibrous.” MRI T1 and T2 sequences were then retrospectively reviewed to identify preoperative intensities compared with grey matter. Facial nerve function was recorded at the time of most recent follow-up.

**Results:** Forty-two patients (27 soft, 15 firm) were included. Median age of patients with soft and firm tumors was 63 and 53 years, respectively. Firm tumors were found in 7 men and 8 women while soft were found in 15 men and 12 women. On preoperative noncontrast MRI, none of the schwannomas were T1 hyperintense. Soft schwannomas were more likely than firm schwannomas to be T1 hypointense ( $P = 0.74$ ). On T2 sequences, soft schwannomas were much more likely to be hyperintense ( $P < 0.005$ ), whereas firm schwannomas were much more likely to be hypointense ( $P < 0.005$ ). There was a tendency for firm schwannomas to have worse facial nerve outcomes, with 6 of the 15 exhibiting House-Brackmann grade 3 or worse, compared with 8 of the 27 that were soft ( $P = 0.52$ ). Gross or near total resection was more commonly achieved with firm schwannomas ( $P = 0.089$ ). A translabyrinthine surgical approach was more often employed with soft schwannomas ( $P = 0.049$ ). Median size of firm schwannomas was smaller than soft (2.0 cm vs. 2.8 cm, respectively). Median follow-up of patients with firm schwannomas was shorter than with soft (3 months vs. 14 months, respectively).

**Conclusion:** Although prediction of vestibular schwannoma consistency based on T1 intensity does not appear reliable, prediction based on T2 intensity seems promising. Soft schwannomas tend to be hyperintense on T2 sequences, whereas firm schwannomas tend to be hypointense. Firm schwannomas tended to have worse facial nerve outcomes, though this was not statistically significant. This potential ability to predict intraoperative consistency and its correlation with facial nerve outcome may assist the surgeon in preoperative planning and patient counseling.

### 110. Patterns of Dural Involvement in Anterior Skull Base Tumors: Prospective Correlation of MRI and Histopathologic Findings

Pete S. Batra (presenter), John B. McIntyre, Carlos L. Perez, Mrudula Penta, Liyue Tong, John Truelson (Dallas, USA)

**Introduction:** The presence of dural invasion serves as an important negative predictive factor for survival in sinonasal and skull base neoplasms. The objective of this study was to prospectively correlate preoperative MRI findings with intraoperative surgical findings and histopathology to establish key correlates for dural involvement in sinonasal tumors.

**Methods:** Prospective blinded MRI review of 50 sinonasal and anterior skull base neoplasms was performed by a staff neuroradiologist. Retrospective chart review was performed to accrue salient patient and tumor data.

**Results:** The mean patient age was 54.6 years with male:female ratio of 1.8:1. The most common tumor histology included adenocarcinoma (18%), squamous cell carcinoma (18%), mucosal melanoma (8%), and olfactory neuroblastoma (8%). MR imaging demonstrated dural enhancement in 20 patients (40%), with 1 mm and  $\geq$  2 mm thickening being noted in 14 (70%) and 6 (30%) cases, respectively. Spectrum of MR findings in these 20 patients included linear enhancement in 15 (75%), nodular thickening in 5 (25%), and loss of hypointense zone in 13 (65%) cases. Intraoperative findings and histology confirmed dural invasion in 12 of 20 cases (60%). Positive predictive value (PPV) of linear and nodular dural enhancement for dural invasion was 46.7% and 100%, respectively. One mm and  $\geq$  2 mm of dural thickening demonstrated PPV of 42.9% and 100%, respectively. Loss of the hypointense zone had PPV of 92.3% for dural invasion. Fisher's exact test demonstrated that loss of hypointense zone and dural thickening  $\geq$  2 mm statistically associated with dural involvement ( $P$ -value  $<$  0.05).

**Conclusion:** The presence of  $\geq$  2 mm of dural thickening, loss of hypointense zone, and nodular dural enhancement were highly predictive for presence of dural invasion by sinonasal malignant tumors. Preoperative knowledge of these MRI patterns may better guide surgical planning and patient counseling.

### 111. Outcomes of Endoscopic Endonasal Resection of Esthesioneuroblastoma

Carlos D. Pinheiro-Neto (presenter), Raj Dedhia, Eric Wang, Ricardo L. Carrau, Juan C. Fernandez-Miranda, Paul A. Gardner, Carl H. Snyderman (Pittsburgh, USA)

**Objectives:** Evaluate the outcomes of the endoscopic endonasal resection for esthesioneuroblastoma.

**Methods:** A retrospective analysis was conducted of 35 patients who underwent endoscopic endonasal resection of esthesioneuroblastoma at UPMC in a period of 9 years. The mean age at the time of the surgery was 48 years (range, 16–79 years), and 63% were men. The Kadish classification, reconstruction, lumbar drain, postoperative complications, adjuvant treatment, and outcomes were analyzed.

**Results:** The majority of patients were Kadish B (75%); 16% were Kadish C, 6% Kadish A, and 3% Kadish D. The reconstruction was done with septal flap in 54%, pericranial flap in 11%, and grafts in 17%. In 18%, no reconstruction was done as dural resection was not needed. Lumbar drain was

used in only one patient (3%). Postoperative complications occurred in 21% of the patients including: diplopia (6%), CSF leak/meningitis (3%), epistaxis (3%), intracranial hematoma (3%), orbital emphysema (3%), and depression in the glabella from the bone window drilled for the pericranial flap (3%). Radiation was done in 63% and chemotherapy in 14%. Local recurrence occurred in one patient (3%) treated with multiple surgeries. The mean follow-up period was 35 months (range, 1–110 months), and 100% were NED after surgical salvage.

**Conclusions:** Endoscopic endonasal resection seems to be an effective surgical modality to treat esthesioneuroblastoma with low complications and good outcomes. The low frequency of postoperative CSF leak demonstrates the efficacy of the endoscopic technique for reconstruction of the anterior cranial base defect.

### 112. Computer Modeled Multiportal Approaches to the Skull Base

Randall A. Bly (presenter), David Su, Manual Ferreira, Kris S. Moe (Seattle, USA)

Surgical approaches to the skull base have evolved significantly to minimize collateral tissue damage and improve access to complex anatomic regions. Technological advancements in optics and materials have mirrored and been critical in enabling this progress. Recently, transorbital portals that allow safe, direct pathways to skull base pathology have been described. These offer opportunities to approach regions that were previously inaccessible endoscopically. These can be combined in multiportal approaches that allow improved angles for visualization and instrumentation, thereby optimizing the ability to safely achieve the surgical goal. The decision of which portal and pathway to use to access a target is becoming more complex as more options are becoming available.

To assist in this decision making, a 3-dimensional computer model was created to analyze transorbital and transnasal surgical approaches. Pituitary targets were modeled as they are relatively common, and the standard treatment involves surgical resection, often via a transnasal or open approach. Eleven specific regions were defined around the pituitary gland as locations that would typically demand an open craniotomy approach in the surgical treatment. Virtual surgery was performed on 10 adult CT scans with normal skull base anatomy to access the 11 regions through multiportal endoscopic approaches. Data were collected on length of approach, angle between instruments, instrument collision, and approach angle to the target plane. Optimal configurations of instruments and endoscope portals were derived using the computer model. Four cadaver dissections were performed with navigation to validate the measurements and feasibility of the surgical approaches.

The data demonstrated that in many cases the shortest, most direct pathway to pituitary targets was through transorbital portals. For example, the length of the pathway to the posterior chiasmatic region was 105 mm through a transnasal portal, compared with 75 mm using the precaruncular transorbital approach. The addition of transorbital portals allowed the angle between instruments to increase substantially. In the case of accessing the lateral cavernous sinus, the angle between two transnasal instruments was 12 degrees. Adding a precaruncular transorbital port increased that angle to 31 degrees, and adding a lateral retrocanthal portal increased it to 56 degrees.

Depending on the location of the pathology, multiple configurations are possible to maximize target visualization and instrumentation. A computer model may play an important role in surgical planning as complex multiportal endoscopic approaches become more common in the treatment of skull base pathology.

### 113. Esthesioneuroblastoma: Updating Histologic Grading as It Relates to Prognosis

Kelly Gallagher (presenter), Jon Paul Pepper, Emily Light, Erin McKean, Lawrence Marentette, Jonathan McHugh (Ann Arbor, USA)

**Background:** The Hyams grading system has been extensively used to predict prognosis in patients with esthesioneuroblastoma (ENB). However, most studies showing prognostic correlation group grading into I/II versus III/IV essentially compare low grade versus high grade. In addition, these studies include patients with variable treatment regimens, including some that were treated with chemoradiation alone. We aimed to determine whether additional histologic variables correlate with outcome with regard to disease-free and overall survival in a series of patients universally treated with anterior skull base resection with or without adjuvant chemoradiation.

**Methods:** A retrospective review of 27 patients with ENB was conducted. The sections of tumor were studied and reviewed with attention to percent lobularity, degree of pleomorphism, degree of neurofibrillary matrix, and degree of apoptosis. In addition, the presence or absence of rosettes, necrosis, calcification, spindle cells, gland hyperplasia, and bone invasion were noted. Finally, the number of mitoses per high-power field and the nature of chromatin (fine vs. coarse) was recorded. The histopathologic features of these 27 ENBs were reviewed and correlated with clinical outcome. They ranged in age from 22 to 77 years. These patients were uniformly treated with subcranial resection and with or without adjuvant radiation and chemotherapy. The patients were followed for a median of 46 months (mean, 65.5 months). The disease-free survival was determined by the last follow-up visit without imaging, looking for recurrence or biopsy-proven recurrence. The overall survival was based on date of death, last known follow-up visit, or data from the Social Security Death Index

**Results:** Preliminary statistical analysis shows that bone invasion may be the most important histologic finding that correlates to overall survival. However, further analysis, including likely stratification/grouping of multiple histologic variables, must be performed to identify a more objective prognostic pathologic grading instrument.

**Conclusion:** An updated histologic grading system may provide more valuable prognostic information in patients with esthesioneuroblastoma treated with a standardized treatment paradigm.

### 114. Postoperative Performance Status with the Anterior Subcranial Approach

Andrew G. Shuman, Stephen Y. Kang (presenter), Jason A. Heth, Stephen E. Sullivan, Lawrence J. Marentette (Ann Arbor, USA)

**Objectives:** This study determined the postoperative performance status of patients undergoing extirpation of mass lesions via the anterior subcranial approach.

**Design:** A retrospective case series was performed.

**Setting:** The study was carried out at an academic medical center.

**Participants:** Selected patients underwent the anterior subcranial approach to address masses involving the anterior skull base ( $n = 153$ ).

**Main Outcome Measures:** Karnofsky scores were assessed preoperatively and 3 months postoperatively. Clinical and demographic data were collected by chart abstraction and statistical analysis was employed to identify predictors of changes in Karnofsky scores.

**Results:** The mean preoperative and postoperative Karnofsky scores were 87.3 and 86.9 points, respectively; there was no statistical difference between these values using samples  $t$  test,  $P = 0.621$ . Half of the patients demonstrated no change from their preoperative to postoperative Karnofsky score; 23% of patients had a decrease in score by an average of 15 points, and 27% had an increase in score by an average of 11 points. Patients with malignant tumors ( $P < .001$ ) and those receiving adjuvant radiation ( $P = .001$ ) or chemotherapy ( $P = .047$ ) had a statistically significant decrease in functional status 3 months after surgery, although only malignancy was significant on linear regression analysis ( $P < .001$ ). There was a trend toward worsened scores with increasing age ( $P = .053$ ). Gender, location of tumor, intradural involvement, and concurrent procedures did not correlate with a significant change in Karnofsky scores.

**Conclusions:** The anterior subcranial approach enables many patients to retain their preoperative functional status 3 months after surgery.

### 115. The Orbital Angle: Understanding the Role of Skull Base Topography in Determining Access to the Midline via a Supraorbital Craniotomy

Shaan M. Raza (presenter), Alfred P. See, Sandra Ho, Alfredo Quinones-Hinojosa (Baltimore, USA)

**Introduction:** The role the topography of the anterior skull base (i.e., the angulation of the orbital roof with the cribriform plate) plays in determining access to the midline via the supraorbital craniotomy (via an eyebrow incision) has not been studied. To quantify the feasibility of this approach to various midline points in the anterior cranial fossa, we analyzed the CT images of 25 patients (50 orbits) to understand the angulation of the orbital roof with the cribriform plate and the role of individual patient variation.

**Methods:** Using a rotated coronal plane, which included the proposed supraorbital craniotomy and the target point on the midline anterior skull base, we approximated the line of sight required to access the skull base at 0.5-cm increments anterior to the tuberculum sella, measured on an axial cut parallel to the planum sphenoidale. We then measured the vertical requirement (VR), which is the distance from point A (intersection of the axial plane at the superior margin of the orbit, sagittal plane at the lateral margin of the orbit, and the skull) to point B (intersection of the line of sight and the coronal plane defined by point A). A larger VR indicates that the craniotomy would need to be larger to access the specified point; hence, not accessible via a standard supraorbital craniotomy.

**Results:** The typical orbit topography is relatively flat between the supraorbital craniotomy and the tuberculum sella, becoming more obstructed by the orbit when moving anteriorly until a peak of 3 cm, and becoming less obstructed



when progressing past 3 cm. Only three orbits had a maximum VR at 0–2 cm from the anterior margin of the tuberculum. The most common distance to maximum VR was at 3 cm (21 orbits). Another 21 orbits had a maximum VR at 4–6 cm. This reflects the typical trend of VR, which starts at an average of  $0.6 \pm 0.2$  cm at the anterior margin of the sella, and reaches  $2.3 \pm 0.3$  cm at 3 cm anteriorly. Using linear interpolation between each pair of adjacent measurements, a craniotomy measuring 2 cm vertically would be able to access as far anteriorly as 2.36 cm on the average orbit. In addition, the average skull base flattens out anterior to the 3-cm point, and the VR reaches  $1.5 \pm 0.2$  cm at 5 cm anterior to the sella.

**Conclusions:** These results indicate that the angle at which the orbit intersects with the cribriform plate varies in an anterior-posterior direction and in between patients; these factors must be contemplated when considering the supraorbital craniotomy for midline anterior cranial fossa lesions.

#### **116. Efficacy and Safety of Frontal Sinus Cranialization** Gilad Horowitz (presenter), Nevo Margalit, Moran Amit, Ziv Gil, Dan M. Fliss (Tel Aviv, Israel)

**Objective:** To compare the efficacy and safety of frontal sinus cranialization to that of obliteration after extirpation of benign lesions of the frontal sinus.

**Study Design:** A retrospective case series with chart review was conducted.

**Methods:** Between 1994 and 2011, 69 patients underwent open excision of benign frontal sinus pathology and reconstruction by either frontal obliteration ( $n = 41$ , 59%) or frontal cranialization ( $n = 28$ , 41%). The incidences of postsurgical complications, such as skin infections, cerebrospinal fluid (CSF) leak, meningitis, and pneumocephalus, were compiled, as was the need for sequential surgical procedures following secondary mucocele formation due to reconstruction failure.

**Results:** Pathologies included osteoma ( $n = 34$ , 49%), mucocele ( $n = 27$ , 39%), fibrous dysplasia ( $n = 6$ , 9%), and encephalocele ( $n = 2$ , 3%). Complications included local infections ( $n = 6$ ), postoperative cutaneous fistula ( $n = 1$ ), telecanthus ( $n = 4$ ), diplopia ( $n = 3$ ), nasal deformity ( $n = 2$ ), and epiphora ( $n = 1$ ). No patients suffered postoperative CSF leak, meningitis, or pneumocephalus. Six patients, all of whom had previously undergone frontal sinus obliteration, required revision reconstruction for postoperative mucocele. One revision was a sequential obliteration, and the obliteration had been converged to cranialization of the frontal sinus in the other five cases. Cranialization of the frontal sinus was significantly superior to obliteration ( $P = .037$ , Fisher's exact test) for preventing secondary mucoceles.

**Conclusion:** Cranialization of the frontal sinus is a safe procedure that provides definitive reconstruction after excision of benign lesions via open approach, and it is superior to frontal sinus obliteration.

#### **117. The Transconjunctival Transorbital Approach: A New Keyhole Approach to the Midline Anterior Skull Base**

Shaan M. Raza (presenter), Alfredo Quinones-Hinojosa, Kofi D. Boahene (Baltimore, USA)

**Objective:** Keyhole approaches were initially described as a means to overcome risks associated with traditional craniofacial approaches for particular benign

anterior cranial fossa pathology. These minimally invasive craniotomies are anterolaterally based and are limited in their access to the midline. We report our initial experience with a medial transorbital approach to the midline skull base done via a transconjunctival incision.

**Methods:** We retrospectively reviewed our clinical experience with this approach in the management of benign cranial base pathology. Preoperative imaging, intraoperative records, hospitalization charts, and postoperative records were reviewed for relevant information.

**Results:** Between 2009 and 2011, five patients underwent a transconjunctival craniotomy done by a neurosurgeon along with an otolaryngologist head and neck surgeon. The indications for surgery were: esthesioneuroblastoma (1), juvenile angiofibroma (1), and recalcitrant CSF leaks (3). Three patients had prior cranial base surgery (either open craniotomy or an endonasal approach) done at another institution. The mean length of stay was 3.8 days; mean follow-up was 6 months. Surgery was considered successful in all cases (negative margins or no leak recurrence) and no complications were noted.

**Conclusion:** The transconjunctival medial orbital craniectomy provides a minimally invasive keyhole approach to those lesions along the anterior cranial fossa that are in the midline with lateral extension over the orbital roof. Based on our initial experience with this technique, the working space afforded limits to complex surgical dissection; hence, this technique is primarily well suited for benign or less extensive pathology.

#### **118. An Analysis of 114 Cases of Skull Base Aspergillosis over a Decade**

Sandeep Mohindra (presenter), Satyawati Mohindra, Sunil Gupta (Chandigarh, India)

Invasive intracranial aspergillosis remains a disease with a high morbidity and mortality. The rapid increase in the incidence of this disease led us to review the literature and formulate a treatment protocol for such patients. An analysis of 114 patients with invasive intracranial aspergillosis is presented, and the subgroups of extradural and intradural variety are evaluated with different treatment strategies. The radiological profile, hallmark features, and differential diagnoses are presented. Patients with extradural form of disease had 100% survival, whereas antifungal chemotherapy preloading tends to provide a better outcome. The comparison of Amphotericin B administration with voriconazole is also made. The timing of surgical debridement is also discussed. Extradural aspergillosis does not need chemotherapy preloading, whereas intradural variant may have improved survival chances following preloading. Liposomal formulation has an advantage of shortened time duration for preloading, as the daily administration dose is six times higher than conventional preparation. Voriconazole needs to be evaluated further as first-line antifungal chemotherapy against skull base aspergillosis.

#### **119. Surgical Management of Skull Base Encephaloceles**

Daniel M. Prevedello, Danielle de Lara (presenter), Leo F. S. Ditzel Filho, Rodrigo C. Mafaldo, Bradley A. Otto, Ricardo L. Carrau (Columbus, USA)

**Background:** Surgical treatment of encephaloceles is recommended to prevent the occurrence of meningitis, epilepsy, and other complications. Among otolaryngologists,

the endoscopic endonasal approach (EEA) has become the preferred technique to repair the anterior fossa (AF) encephaloceles. However, neurosurgeons generally prefer a craniotomy to approach these lesions. Middle fossa (MF) encephaloceles can be more difficult to treat and pose even more controversy related to the approach best suited to address them.

**Objective:** The purpose of this study is to evaluate the use and efficacy of different surgical options for the treatment of encephaloceles according to their location. We present our experience as a case series.

**Methods:** Twenty-one consecutive patients with skull base encephaloceles were surgically treated by a multidisciplinary skull base team including the senior author (DMP). Preoperative symptoms, encephalocele location, surgical technique, postoperative complications, and recurrence were assessed. The AF encephaloceles were treated using the EEA and reconstruction with vascularized flap. The MF encephaloceles were subdivided in two groups. The sphenoidal lesions were treated by EEA with vidian nerve transposition and reconstruction using a vascularized flap. The tegmental ones were treated by a craniotomy with extradural approach and reconstruction with temporalis muscle rotation. On the second postoperative day, all patients underwent a lumbar puncture to assess opening pressure. When elevated intracranial pressure (ICP) was diagnosed, a ventriculoperitoneal (VP) shunt was performed.

**Results:** Nine patients had AF and 12 had MF encephaloceles. The presenting symptoms were CSF leakage, convulsions, conductive hearing loss, and recurrent meningitis. All of the sphenoidal encephaloceles treated with EEA and vidian nerve transposition (five patients) had preserved nerve function. One patient that had a craniotomy for MF encephalocele repair needed reoperation because of persistent CSF leakage through a previous mastoidectomy. Ten patients underwent a VP shunt due to elevated ICP (47.6%). No complications were observed.

**Conclusion:** Both endoscopic technique and craniotomy may be used to repair skull base encephaloceles with good results. A thorough evaluation of the encephalocele location and anatomical characteristics must be performed to choose the best surgical option.

## 120. Retrospective Cohort Study of Endoscopic Versus Microscopic Vascular Decompression

Maxwell B. Merkow (presenter), Daniel Kramer, John Y. K. Lee (Philadelphia, USA)

**Background:** The use of the endoscope continues to grow in skull base surgery. Endoscopic retrosigmoid approaches, however, are relatively new with little literature describing safety and efficacy. We compare our initial experience with endoscopic (E-MVD) to microscopic microvascular decompression (MVD) surgery for trigeminal neuralgia.

**Methods:** A retrospective comparison of patients who underwent microvascular decompression between January and August 2011 by a single surgeon was performed. Baseline and 1-month Brief Pain Index (BPI)–Facial score (which is the only reliable and validated questionnaire for patients with trigeminal neuralgia and uses an 11-point [0–10 Likert] scale), duration of operation, and complications were collected via chart review.

**Results:** Nine patients were identified in each arm. Six additional patients were excluded because they underwent

endoscope-assisted microvascular decompression. No patient had undergone prior procedures. Mean age was 54 years. OR time was  $132 \pm 35$  minutes for MVD and  $137 \pm 0$  minutes for E-MVD. Major complications were absent in both groups. Pain change scores were only available in five patients in each arm. NRS improved 7.5 points in MVD and 5.6 in the E-MVD. BPI general and facial interference scores improved 5.7 and 6.8 points in MVD and 4.15 and 4.5 points in E-MVD ( $P > 0.05$  for all comparisons).

**Conclusions:** This preliminary study suggests that E-MVD and MVD provide similar pain outcomes without increase in the OR time or increase in surgical risks. Although the use of the endoscope in retrosigmoid approaches is preliminary, its use may provide significant future advantage. This study uses a validated outcome scale (BPI-Facial) to quantify patient benefit. E-MVD is safe and effective. Further studies, however, are necessary.

## 121. Complications Associated with a Transpterygoid Approach to Meningoencephalocele Repair

Nadieska Caballero (presenter), Kevin Welch, Lauren Lininger (Park Ridge, USA)

**Background:** Meningoencephaloceles within the lateral recess of the sphenoid sinus are uncommon. Moreover, data regarding the management and postoperative complications of these lesions are sparse as well. In this study, we describe endoscopic repair of lateral sphenoid meningoencephaloceles via a transpterygoid approach and report complications associated with this technique.

**Methods:** A retrospective review was conducted. Patients who underwent endoscopic repair via a transpterygoid approach from 2007–2011 were identified. Data collected included demographics, BMI, defect size, associated sinus pathology, and placement of a lumbar drain. Postoperative complications including V2 numbness, ocular dryness, CVA events, headaches, bleeding, sinusitis, seizures, metabolic disturbances, infection, sepsis, meningitis, brain abscess, meningoencephalocele recurrence, and death were also noted.

**Results:** Ten patients (7 women and 3 men) were treated for lateral sphenoid sinus encephaloceles over a 4-year period. The average age was 55. The average BMI was  $35.3 \text{ Kg/m}^2$ . CSF rhinorrhea was the most common presenting symptom (70%). Three patients (30%) presented with meningitis, one patient (1%) had headaches and orbital pain/pressure, one patient (1%) was asymptomatic, three patients (30%) had a right-sided encephalocele, and seven patients (70%) had a left-sided lesion. All patients had preoperative imaging. Six patients (60%) had a lumbar drain placed. In one of these patients, the lumbar drain malfunctioned and was replaced without complications. Defect size was reported in six patients. The average size of the defect was 0.97 cm. Neurological complications included postoperative intraparenchymal hemorrhage (1/10), seizure (1/10), hemipalatal hypesthesia (2/10), and headaches (5/10). Ocular complications were limited to dry eyes (5/10). Acetazolamide was used in eight patients, four of which developed electrolyte disturbances requiring cessation of treatment. None of the patients developed epistaxis postoperatively. There were no cases of sepsis, meningitis, or brain abscesses. One patient had a postoperative MI 26 days following the procedure and died. Endoscopy was the main tool used to evaluate recurrence in all patients during follow-up. The average duration of follow-up was 14 months. Meningoencephalocele and CSF leak repair was successful in 100% of cases.

**Conclusion:** Lateral sphenoid sinus meningoencephaloceles are rare and difficult to access endoscopically. The transpterygoid approach described in the present study represents a highly effective and low-morbidity/mortality technique to repair these lesions.

### 122. Endoscopic Approach to Lateral Sphenoid Encephaloceles Originating in Sternberg's Canal

Deepak R. Dugar (presenter), Rounak Rawal, Brent Senior, Charles S. Ebert, Jr., Adam M. Zanation (Chapel Hill, USA)

**Objective:** Our institution has performed endoscopic surgical repairs for over 125 encephaloceles and CSF leaks since December 2004, of which more than 40 cases have been identified as sphenoid encephaloceles or CSF leaks, of which eight cases have been specifically identified as encephaloceles in the lateral wall of the sphenoid sinus originating in Sternberg's canal. The success of the endoscopic approach for the treatment of lateral sphenoid encephaloceles is discussed. We performed a retrospective review of eight cases diagnosed with lateral sphenoid encephaloceles originating in Sternberg's canal with a history of CSF leak who were treated using endoscopic surgical approaches at the Department of Otolaryngology-Head and Neck Surgery at The University of North Carolina in Chapel Hill, NC.

**Methods:** Retrospective chart review revealed eight patients (seven women, one man) between 40 and 74 years of age at time of surgery (mean age, 56 years) with lateral sphenoid encephaloceles originating in Sternberg's canal. All patients suffered from CSF leaks and two patients had previous associated head trauma. All patients underwent a transnasal endoscopic approach to the sphenoid sinus.

**Results:** The follow-up of the patients ranged from 6 to 50 months (mean, 23 months). Eight patients underwent 11 endoscopic repairs at our institution. Seven of the eight patients (9 of the 11 repairs) have shown no sign of recurrence in their respective follow-ups. One patient had a subsequent head trauma 3 years later causing an opposite-sided lateral encephalocele, which was also endoscopically repaired. One patient required two additional surgeries for recurrences from the same site. One patient had three prior surgeries (two endoscopic, one open) at outside institutions prior to being treated here. Average hospital stay was 4.2 days. Five patients had lumbar drains prior to their surgeries. The most common complication was spinal headache following lumbar drain removal. Eight of the 11 repairs used abdominal fat grafts. Three repairs used pedicled nasoseptal flaps. Four of the repairs used mucosal grafts from varying sites.

**Conclusions:** From our experience, the endoscopic approach is very successful in surgical management of encephaloceles in the lateral wall of the sphenoid sinus originating in Sternberg's canal. Different grafts materials have shown to be beneficial in our skull base reconstruction.

### 123. Critical Appraisal of Extent of Resection of Clival Lesions Using the Expanded Endoscopic Endonasal Approach

Aaron R. Cutler (presenter), Marilene Wang, Jeffrey Suh, Marvin Bergsneider (Los Angeles, USA)

**Background:** The expanded endoscopic endonasal approach has become a well-accepted technique for accessing clival lesions. Cadaveric anatomical studies have demonstrated the unobstructed view of the clivus and

ventral brainstem that may be achieved with this approach. Critical neurovascular structures, primarily the paraclival internal carotid artery (ICA) segments, are generally considered to represent the lateral limits of safe exposure. To determine what true anatomic limitations exist using an endoscopic endonasal approach in patients with actual clival lesions, a detailed analysis of the postoperative imaging following resection of these lesions was performed.

**Objective:** The purposes of this study are to (1) present a critical evaluation of our experience using an expanded endoscopic endonasal approach to clival lesions and (2) evaluate, based on the location of residual tumor, the anatomic limitations to the approach.

**Methods:** A retrospective review of all patients undergoing an endoscopic endonasal operation at UCLA Medical Center from 2008 through 2011 was performed. Nineteen patients with lesions involving the clivus were identified. Extent of resection was determined by pre- and postoperative tumor volumes. Results were divided into gross total resection (GTR), >95% resection, and <95% resection.

**Results:** Lesions included nine chordomas, five invasive pituitary adenomas, one adenocarcinoma, one meningioma, one adenoid cystic carcinoma, one fibrous dysplasia, and one leiomyosarcoma metastases. Mean patient age was 54.6 years. Mean initial tumor volume was 26.2 cm<sup>3</sup>. Three patients underwent planned subtotal resections. Of the remaining patients GTR was achieved in 8/16 (50%), >95% in 5/16 (31%), and <95% in 3/16 (19%). Average initial tumor volume for the group with <95% resection was 39 cm<sup>3</sup>. Complications included three postoperative CSF leaks, two new VIth nerve palsies, one temporary worsening of a VIth nerve palsy, and one new V2 partial injury. Residual tumor occurred most commonly with tumor extension posterior and lateral to the clival and intracavernous ICA segments. Other limitations included caudal tumor invasion at the level of the occipital condyle and inferior extension to the bottom one third of the dens.

**Conclusion:** The endoscopic endonasal approach represents a safe and effective technique for the resection of clival lesions. Despite excellent overall visualization of this region, we did find that adequate exposure of the most lateral and inferior portion of large tumors is often difficult to obtain, even with the angled endoscope, and may represent the anatomic limitations to this approach. Knowledge of these limitations allows us to determine preoperatively which tumors are best suited for an endoscopic endonasal route and which may be more appropriate for an open skull base or combined technique.

### 124. Quality of Life after Transsphenoidal Pituitary Surgery: A Qualitative Study

Shelly Lwu (presenter), Mark Bernstein, Gelareh Zadeh, Fred Gentili (Victoria, Canada)

**Background:** Microscopic and endoscopic approaches are both used for transsphenoidal resection of sellar and parasellar lesions. The endoscopic approach has been gaining in popularity over the past decade; however, quality of life studies comparing the microscopic and endoscopic approaches are lacking in the literature.

**Objective:** We aim to compare the patients' perceptions of their postoperative recovery periods following microscopic and endoscopic procedures.

**Methods:** Qualitative research methodology was used for this retrospective study. Twenty-seven patients participated in the study. Each participant underwent a single

semistructured, open-ended interview based on an interview guide. Each participant has undergone at least one microscopic and one endoscopic transsphenoidal procedure for resection of sellar and parasellar lesions. The interviews were audiotaped and transcribed. The transcripts were then analyzed for overarching themes. Demographic information was also collected.

**Results:** The following six overarching themes emerged from the data: (1) the endoscopic procedure was better tolerated than the microscopic procedure; (2) the endoscopic procedure was the preferred approach by 22 out of 27 patients and also the approach they would choose should they require another surgery in the future; (3) most patients did not know that they underwent two different surgical approaches; (4) other than foul odor, rhinologic complications (including drainage, crusting, changes in smell) following the endoscopic procedures were comparable to those following the microscopic procedures; (5) a patient's postoperative experience from the microscopic procedure had an impact on his or her expectations of the endoscopic procedure; and (6) any significant pain or discomfort experienced from either procedure was mainly related to nasal packing or fascia lata graft donor site.

**Conclusions:** The endoscopic procedure was the preferred approach by the majority of patients when compared with the microscopic approach. It was better tolerated and was associated with less quality of life disturbances. Rhinologic complications, which are generally perceived to be more of an issue in the endoscopic approach, were in fact the same as the microscopic approach.

### 125. Radiographic Enhancement of the Vascularized Nasoseptal Flap Does Not Predict CSF Leaks

Nithin D. Adappa (presenter), Kim Learned, James N. Palmer, Jason G. Newman, John Y. Lee (Philadelphia, USA)

**Background and Purpose:** Cerebrospinal fluid (CSF) leaks continue to be the most common postoperative complication in expanded endonasal skull base procedures. Currently, a multilayer closure with a vascularized nasoseptal flap is used as a standard for closure of the skull base in an effort to avoid CSF leaks. Because vascularized mucosa enhances avidly after intravenous (IV) contrast administration, we hypothesized that watertight closure of the ventral skull base would correlate with immediate postoperative radiographic enhancement of the nasoseptal flap with magnetic resonance imaging (MRI).

**Material and Methods:** We retrospectively reviewed a cohort of 24 consecutive patients who underwent advanced complexity, endoscopic endonasal resections of tumors and lesions. We excluded patients who underwent pituitary tumor resections. We calculated the incidence of CSF leak and measured the presence of nasoseptal flap enhancement. Additional variables of interest included age, gender, complexity of surgery, chronology of surgery, use of free fat graft, use of free fascia lata graft, use of collagen substitute, and use of a lumbar drain. This study was thus designed as a retrospective cohort study.

**Results:** Of the 24 patients, 19 had immediate postoperative MRIs; 3 had postoperative CSF leaks. Fifteen of 19 patients had radiographically enhancing nasoseptal flaps. Of these 15 patients, 3 developed a CSF leak. In contrast, of the four patients with no evidence of flap enhancement, none developed a postoperative CSF leak (Fisher's exact test,  $P = 1.0$ ). CSF leak was associated with posterior fossa lesions ( $P = 0.25$ ). Nasoseptal flap enhancement was associated with younger age ( $P = 0.15$ ).

**Conclusion:** The vascularized pedicled nasoseptal flap has become a staple of complex endoscopic skull base closures. This retrospective cohort study fails to confirm the correlation between CSF leak and immediate, postoperative radiographic enhancement of the nasoseptal flap. Hence, this negative study calls to question the assumption that it is the vascularity of the nasoseptal flap that has resulted in lowering of overall CSF leaks in expanded endonasal skull base procedures.

### 126. First-Bite Syndrome: Incidence, Risk Factors, Treatment, and Outcomes

Gary Linkov (presenter), Luc G. Morris, Jatin P. Shah, Dennis H. Kraus (Merrick, USA)

**Background:** First-bite syndrome (FBS) refers to pain in the parotid region after the first bite of a meal. It is a potential sequela of surgery involving the infratemporal fossa (ITF), parapharyngeal space (PPS), and deep lobe of the parotid gland. The incidence, risk factors, treatment options, and outcomes of FBS remain poorly defined.

**Methods:** We reviewed the charts of 499 patients (mean age, 50 years; range 12–81 years) undergoing surgery of the deep lobe of the parotid gland, PPS, and ITF between 1992 and 2010. All patients were followed for a minimum of 3 months postoperatively. Patient, tumor, and FBS characteristics were analyzed. Incidence was calculated using the Kaplan-Meier method. Univariate analyses and a multivariable logistic regression model were used to identify independent risk factors for FBS. Patients developing FBS were interviewed by phone.

**Results:** FBS developed in 45 patients (9.6%), at mean time of 97 (6–877) days from surgery. On multivariable analysis, three variables were significant independent risk factors for FBS: sympathetic chain sacrifice (OR 4.7,  $P = 0.008$ ), PPS dissection (OR 8.7,  $P = 0.001$ ), and resection of only the deep lobe of the parotid gland (OR 4.2,  $P = 0.002$ ). FBS developed in 48.6% of patients undergoing sympathetic chain sacrifice, 22.4% of patients undergoing PPS dissection, 38.4% of patients undergoing deep lobe parotid resection, and 0.8% of patients undergoing total parotidectomy. Partial resolution of FBS symptoms occurred in 69%, and complete resolution in 13%. Of 45 FBS patients, 15 (33%) underwent at least one type of treatment for symptomatic relief. No treatment consistently provided effective symptomatic relief. Out of 16 FBS patients interviewed, only 2 (13%) recall being informed of the risk of FBS before surgery, but 9 (56%) stated that they would have liked to know.

**Conclusions:** The strongest independent risk factors for FBS are: PPS dissection, deep lobe of parotid resection, and sympathetic chain sacrifice. Patients undergoing surgery with potential compromise of these anatomical sites and structures should be thoroughly counseled about the risk of developing FBS.

### 127. Preliminary Validation of a Clinical Instrument for Rhinological Outcomes in Endonasal Anterior Skull Base Surgery: The Anterior Skull Base Nasal Inventory

Andrew S. Little (presenter), Peter Nakaji, John Milligan, William White (Phoenix, USA)

**Introduction:** The nasal cavity is becoming more commonly exploited as a corridor to address anterior skull base lesions, but little emphasis has been placed on rhinological outcomes and quality of life. The goal of this project was to develop a simple, prospectively validated,

site-specific quality-of-life instrument specifically for assessing nasal outcomes following endonasal skull base surgery. Preliminary results are presented.

**Methods:** A 10-item patient survey (Anterior Skull base Nasal Inventory, or “ASK Nasal Inventory”) focusing on the most common postoperative complaints, such as crusting, sense of smell, sinusitis, pain, and ease of breathing, was developed by the anterior skull base team at the Barrow Neurological Institute. Content was validated in structured patient interviews and by four subject matter experts. This survey was self-administered before and 3 and 6 months after surgery to 94 patients (52 who underwent endonasal surgery and 42 controls) between October 2010 and August 2011. Standard methods for psychometric evaluation were applied to the ASK Nasal Inventory.

**Results:** Cronbach's alpha was 0.83, indicating good internal consistency. Test-retest reliability using a Pearson correlation was 0.91 ( $P < 0.001$ ), indicating good reliability. Discriminant validity was evaluated by comparing mean scores at 3 months in the endonasal group with the control group (13.5 vs. 17.2,  $P = 0.001$ ), thus confirming expected changes in nasal functioning in the endonasal surgery patients. Standardized response mean was 0.17, suggesting that the scale was sensitive to clinical change. Concurrent validity was determined by mean ASK Nasal score for each level of self-reported overall functioning using ANOVA. We noted the expected differences in the mean ASK Nasal Inventory scores for different overall levels of nasal functioning ( $P = 0.001$ ).

**Conclusions:** Preliminary evaluation of the performance of the ASK Nasal Inventory quality-of-life tool suggests that it meets basic psychometric criteria and has potential as a clinical and research instrument in anterior skull base surgery. Final validation awaits the completion of an ongoing multicenter rhinological outcomes study.

### 128. Intranasal Cross-Sectional Area Changes Following Endoscopic Skull Base Surgery and Their Relation to Postoperative Quality of Life

Jeffrey C. Bedrosian (presenter), Edward D. McCoull, Vijay K. Anand, Theodore H. Schwartz (New York, USA)

**Objectives:** Endoscopic skull base surgery has the potential to significantly alter the intranasal architecture. Sphenoidotomy, nasoseptal flaps, turbinate reduction, and septectomy all may be necessary to achieve adequate visualization and access to the skull base target. The effect of these procedures on postoperative nasal airflow and their corresponding effect on sinonasal quality of life are not well studied. We sought to quantify the changes in nasal architecture following skull base surgery and explore the association of those changes with sinonasal quality of life.

**Methods:** Acoustic rhinometry was performed on 118 patients preparing to undergo endoscopic skull base surgery. These data were compared with prospective postoperative measurements taken at 6 months or greater following surgery, once postoperative sinonasal changes stabilized. Patients also completed the Sinonasal Outcome Test (SNOT-22) before and after surgery. Beginning 6 weeks postoperatively, patients were followed longitudinally, assessing the evolution of sinonasal architectural and quality-of-life changes.

**Results:** Each nasal cavity was analyzed independently following topical decongestion with phenylephrine

to account for cross-sectional changes in the nasal cycle. Cross-sectional area (CSA) was measured at the anterior portion of the inferior turbinate (CSA1), the anterior portion of the middle turbinate (CSA2), and the mid-portion of the middle turbinate at the maxillary ostium (CSA3). Results were averaged between nostrils. As expected, CSA1 did not decrease from preoperative values (0.08 cm<sup>2</sup> change,  $P = 0.22$ ), reflecting the fact that no surgical manipulation occurs at the internal nasal valve. Postoperative CSA2 increased by mean (SD) 1.23 (0.71) cm<sup>2</sup> ( $P = 0.008$ ), and postoperative CSA3 increased by mean (SD) 4.3 (5.1) cm<sup>2</sup> ( $P = 0.047$ ), reflecting changes after a mean (SD) follow-up of 16.7 (7.2) months. Postoperative SNOT-22 scores were significantly improved ( $P = 0.001$ ), with mean (SD) preoperative and postoperative values of 23.0 (19.0) and 17.8 (13.3), respectively. Correlation was present between acoustic rhinometry values and SNOT-22 scores.

**Conclusions:** Endoscopic skull base surgery may have a beneficial effect on sinonasal quality-of-life. Acoustic rhinometric measurements objectively demonstrate the expected postoperative increases in intranasal volume. Improvements in subjective SNOT-22 data correlate with improved postoperative nasal patency and represent improved sinonasal quality-of-life.

### 129. Hypoglossal Schwannomas: Single Institutional Experience of 14 Cases

Ashish Suri (presenter), Sumit Bansal, Bhawani Sharma, Ashok K. Mahapatra, Sharad S. Kale, Sarat P. Chandra, Manmohan Singh, Rajender Kumar, Manish Sharma (New Delhi, India)

**Background:** Hypoglossal schwannomas are very rare intracranial neoplasms. Microsurgical resection with the goal for cure is the aim of management, but is associated with a high rate of postoperative morbidity.

**Objective:** The objective of the study was to outline the clinical presentation, radiological characteristics, surgical techniques, postoperative morbidity, and long-term follow-up results for hypoglossal schwannomas.

**Methods:** Patients treated for hypoglossal schwannoma at the department of neurosurgery of a tertiary level referral institute from January 2001 till December 2010 were analyzed retrospectively using hospital records.

**Results:** There were 14 patients who were treated in the study period. Tongue atrophy and swallowing difficulties were the most common presenting symptoms. Twelve patients underwent definitive surgery and two were given primary gamma knife stereotactic radiosurgery. Five patients who had small residual tumors received GK subsequently. There was no mortality in the series. Three patients had permanent morbidity in the form of cranial nerve paresis. Immediate postoperative complications like infection, CSF leak, and pneumonia were present in four patients.

**Conclusion:** Hypoglossal schwannomas are rare tumors that are best treated by total surgical resection, with acceptable results of low rates of mortality and permanent morbidity. Subtotal resection is appropriate for tumors with adhesions to vital structures and in medically unfit patients. Small recurrences should be treated with GK therapy.

### 130. Endoscopic Transpterygoid Nasopharyngectomy: Correlation of Surgical Anatomy with Multiplanar CT

Seyed Mousa Sadr Hosseini, Nancy McLaughlin, Ricardo L. Carrau (presenter), Daniel M. Prevedello, Adam Zanation, Juan C. Fernandez-Miranda, Amin B. Kassam (Tehran, Iran)

**Background:** The complex and protected anatomy of the nasopharynx presents a challenge for oncologic resections in the area. Our purpose was to design a surgical model that illustrates the anatomical landmarks from the endoscopic standpoint and serves as a training model.

**Material and Methods:** Cadaveric specimens were injected with red and blue silicone dyes into the great vessels of the neck. Digital data acquired from a high resolution CT scan was imported to a surgical image guidance system. An endoscopic endonasal dissection of the nasopharynx was completed under conditions that mimicked our operating suite.

**Results:** Preparation of the sinonasal corridor, harvesting the nasoseptal flap, and dissections of the pterygopalatine and infratemporal fossae were performed prior to the dissection of the nasopharynx. A detailed anatomical dissection of the nasopharynx was correlated to the image guidance (navigation) system. This provided a surgical map highlighting critical neurovascular structures and illustrating the potential endoscopic surgical corridors.

**Conclusions:** A thorough understanding of the modular skull base approaches required prior to the nasopharyngectomy as well as knowledge of the regional anatomy viewed from the endoscopic perspective facilitates safe surgical planning.

### 131. Transorbital Approach to Sphenoorbital Meningiomas: Selected Cases Series

Alfio P. Piva (presenter), (San Jose, Costa Rica)

**Objective:** The purpose of this study was to describe a surgical technique used to treat selected sphenoorbital meningiomas (SOMs) using a transorbital surgical route through a direct upper eyelid crease incision.

**Design:** A retrospective noncomparative case series was conducted with a description of the surgical technique.

**Participants:** From 2007 to 2010, 12 patients (11 women, 1 man) with SOMs, which were limited to the lateral orbital wall and roof and not invading any further than the foramen rotundum and anterior clinoid, underwent surgical resection by the described technique. The average age of the patients was 59.5 years (range, 49–73 years).

Possibly because of the nature of our referral basis, which receives all orbit-related conditions in our country, most of our patients were sent with variable degrees of unilateral proptosis (range, 2–5 mm; average, 3 mm). Only two patients presented some visual impairment due to compressive optic neuropathy, and none presented with trigeminal symptoms or oculomotor dysfunction.

**Intervention:** Transorbital resection of SOM was successfully attempted in selected cases using a 5.23-cm average incision length made along the upper eyelid crease extended laterally toward the superior edge of the zygomatic bone 1–2 cm posterior to the lateral orbital rim.

A self-retaining retractor holds skin and subcutaneous tissues assisting dissection on the lateral orbital rim, making it possible to reach from 1 cm above the frontozygomatic

suture to the zygoma's superior edge inferiorly. A single layer of tissue that includes periosteum and the anterior aspect of temporalis fascia at the orbital rim is sharply dissected off and reflected anteriorly toward the orbit.

Temporalis muscle insertion is exposed such that it can be bloodlessly detached and retracted posteriorly, acquiring full exposure of the true pterion, so that the superficial aspect of the greater sphenoid is fully exposed along with the whole tip of the temporal squama and inferolateral aspect of the frontal bone.

Such exposure allows direct burring of meningioma-infiltrated bone so that total resection of the greater sphenoid wing and orbital roof can be reached. The orbitotemporal dural band is identified and transected to reach the base of the anterior clinoid extradurally. This allows clinoid removal, if necessary, and extradural dissection of V1 and V2, which is necessary to lift off the meningioma-infiltrated temporal floor dura. En bloc resection of the dura was performed after opening the dura and dissecting meningioma off the brain tissue using standard microsurgical techniques.

**Conclusion:** Simpson 1 was achieved in all selected cases using the upper eyelid crease transorbital surgical route. The described technique is suitable to reach satisfactory resection of SOM for selected cases.

### 132. Incidence and Significance of Intraoperative CSF Leak in Endoscopic Pituitary Surgery Using Intrathecal Fluorescein

Dejan Jakimovski (presenter), Greg Bonci, A. Tsiouris, Theodore Schwartz (Kumanovo, Macedonia)

**Introduction:** The true rate of intraoperative (i)CSF during pituitary surgery is not well known because small iCSF leaks are easily missed as clear fluid mixed with blood can be difficult to detect.

**Objectives:** We administered intrathecal fluorescein preoperatively in a large series of pituitary adenomas to determine the rate and significance of iCSF leaks.

**Methods:** The appearance of intraoperative fluorescein was noted prospectively in a consecutive series of 203 patients undergoing endonasal endoscopic resection of their pituitary adenomas. The rate of iCSF leak was correlated with tumor diameter (all cases), tumor volume (160 cases), rate of gross total resection (GTR), the learning curve (first 50 cases), reoperation, and hormone production. Rate of postoperative CSF leak, complications from fluorescein and utility of the nasoseptal (NS) flap in preventing postoperative leaks was also noted. Chi-square and Fisher exact tests were used for significance.

**Results:** In the entire cohort, rate of iCSF leak was 61%. Tumor diameter and volume were strong predictors. The iCSF leak rate ranged from 44% for tumors <2 cm to 72% for tumors  $\geq 2$  cm ( $P < 0.001$ ). It was 35% for tumors <1.5 cm<sup>3</sup> and 68% for tumors  $\geq 1.5$  cm<sup>3</sup> ( $P < 0.001$ ). The rate of GTR and the learning curve did not influence the rate of iCSF leak. Reoperations had a higher rate of iCSF leak but only for tumors >2 cm. Postoperative CSF leak was significantly lower once the learning curve was passed (0.7% versus 10%;  $P < 0.005$ ). For tumors >2 cm, the introduction of the NS flap reduced the CSF leak rate from 5.6% to 1.4%. We did not find any complications related to the use of intrathecal fluorescein.

**Conclusions:** Using intrathecal fluorescein, we determined that the rate of iCSF leak may be higher than previously suspected. Tumor diameter and volume are the best

predictors of the risk of iCSF leak. Based on this knowledge and a consistent algorithm for closure, which can include lumbar drainage and the NS flap for larger tumors (>2.5 cm), the rate of postoperative CSF leak remains exceptionally low, particularly once the learning curve is overcome.

### 133. “Pseudocapsular” Resection of Pituitary Adenomas: Technical Nuances and Unexpected Consequences

Marvin Bergsneider (presenter), Marilene B. Wang, Jeffrey Suh (Los Angeles, USA)

**Introduction:** Following a visit to our institution in June 2010 by Edward Oldfield, we began a more diligent pursuit of the use of the so-called pseudocapsule to excise pituitary tumors. We were at first frustrated in the inability to identify the pseudocapsule plane in the vast majority of patients. Over a period of 8 months, however, we were increasingly successful in developing the pseudocapsule plane, eventually achieving it in more than 40% of cases. An unexpected consequence was a drop in the intraoperative CSF leak rate.

**Methods:** In this retrospective analysis, medical records and operative videos were reviewed of 189 consecutive pituitary adenoma operations using the combined neurosurgery-otolaryngology endoscopic endonasal resection approach from April 2008 to September 2011. The percentage of successful pseudocapsular dissections—defined as circumferential dissection of the tumor maintaining near complete integrity of the tumor “capsule” that was in contact with normal pituitary tissue—was determined on a quarterly basis, along with incidence of intraoperative CSF leaks. Over the last three quarters, the resection technique evolved significantly, more closely resembling standard techniques for resection of meningiomas.

**Results:** Prior to the third quarter of 2010, the average quarterly intraoperative CSF leak rate was  $39 \pm 10\%$ , with only one pseudocapsular dissection accomplished among 109 patients (1%). Over the next two quarters, pseudocapsular dissection was possible in 8% of cases, but the intraoperative CSF leak rate remained at 33%. Over the subsequent three quarters, successful pseudocapsular dissection increased to 42%, with the intraoperative CSF leak rate dropping to 13%. There has been only one intraoperative leak among the last 23 cases (mean tumor size,  $21 \pm 12$  mm; gross total resection rate of 81%).

**Conclusion:** A surgical approach of initially identifying and developing the tumor-gland interface, centrally debulking tumor as needed and then completing the pseudocapsular dissection circumferentially, allows earlier and easier visualization of key normal structures. In our experience, this has significantly reduced the number of incidental tears of the diaphragm sella/arachnoid membrane, while maintaining (enhancing) the ability to remove all tumor tissue.

### 134. Comparison of the Outcomes of Endoscopic and Microscopic Surgery in Cushing’s Disease

Hussein Alahmadi (presenter), Kenneth Woo, Ameen Mohammed, Michael Cusimano, Jeannette Goguen, Harley Smyth, Kalman Covacs (Toronto, Canada)

**Background:** Cushing’s disease (CD) constitutes a challenging condition even for the experienced pituitary surgeon. It is uncertain whether the endoscopic technique has improved the results compared with the traditional microsurgical technique.

**Methods:** A retrospective review was conducted for CD cases at our institution between 1998 and 2010. Patients’ charts were reviewed for demographic, clinical, laboratory, and radiological details in all cases. We also reviewed surgical technique and outcome. Analysis was done to identify predictors of outcome and the details of failed cases. Remission was defined as normal postoperative 24-hour urinary free cortisol (24-h UFC) or suppression of morning serum cortisol to  $<50$  nmol/L after 1 mg of dexamethasone.

**Results:** Forty-two patients met our inclusion criteria. Thirty-one (74%) were women. The average age of the patients was 50 years (range, 20–69 years). Eighteen patients (43%) had a microadenoma, 15 patients (36%) had a macroadenoma, and 9 patients (21%) showed no evidence of an adenoma on MRI. The surgeon identified a pituitary adenoma intraoperatively in 37 cases. Thirty-six patients had selective adenectomy and 6 patients had hypophysectomy. Seventeen patients had an endoscopic transsphenoidal surgery (endo TSS) and 25 had microscopic transsphenoidal procedure (micro TSS). Remission was achieved initially in 31 patients, while long-term remission was achieved in 29 (69%) patients. Repeat transsphenoidal surgery and cavernous sinus (CS) invasion predicted lack of postoperative remission ( $P$  value  $< 0.0001$  and  $0.0249$ , respectively). Patients’ subjective symptomatic improvement and drop of serum cortisol in the postoperative period to less than 100 nmol/L correlated with long-term remission ( $P$  values  $< 0.0001$  and  $0.0046$ , respectively). There was no significant difference in remission rate between the endo TSS and the micro TSS ( $P$  value  $0.5046$ ). Average follow-up period was 33 months (range, 3–102 months).

**Conclusions:** Revision surgery and CS invasion predicted poor remission rate for CD. Within the size of our study, there was no difference in outcome between endo TSS and micro TSS.

### 135. Silent Corticotroph Adenomas, a Clinical and Pathological Comparison with Nonfunctional Adenomas

Hussein Alahmadi (presenter), Daniel Lee, Caroline Hayhurst, S. Asa, O. Mete, Fred Gentili, Gelareh Zadeh (Toronto, Canada)

**Background:** Silent corticotroph adenomas (SCAs) represent a distinct pathological subtype of nonfunctional pituitary adenomas (NFAs), with reports suggesting a distinct clinical behavior and higher incidence of recurrence.

**Methods:** A retrospective review was conducted of silent corticotroph adenomas at our institution over the last 10 years. We reviewed the clinical and radiological features, extent of resection based on postoperative imaging, and clinical outcome. All pathological specimens were reviewed and analyzed for proliferation rate, markers of invasion (beta-1 integrin, osteopontin, matrix metalloproteinase-1 and FGFR-4), and CD31 staining. The series was compared with a matched cohort of nonfunctional adenomas.

**Results:** Twenty patients had silent corticotroph adenomas. Sixteen patients had complete clinical and radiological follow-up and were included in the final analysis. Nine patients (56%) were women. Mean age was 52 years (range, 24–78 years). Six patients (38%) presented with visual deterioration. All the tumors were macroadenomas and five (29%) had frank cavernous sinus (CS) invasion.

Three tumors had evidence of hemorrhage (two presented with frank pituitary adenoma apoplexy and one presented with visual deficit after a hemorrhage in a tumor cyst). Gross total resection was achieved in eight cases (50%). Two tumors (12.5%) recurred over a mean follow-up period of 36 months. Compared with nonfunctional adenomas (NFAs), SCAs were more likely to bleed ( $P = 0.014$ ). Pathologically, SCAs had less expression of FGFR4 ( $P = 0.0302$ ), more expression of osteopontin ( $P = 0.02$ ), and less expression of CD31 in the tumor vasculature ( $P = 0.002$ ). There was no difference in recurrence rate between SCAs and NFAs ( $P = 0.8$ ).

**Conclusion:** SCAs are more likely to present with hemorrhage. SCAs demonstrate a different pathological profile to NFAs with respect to markers of invasion and angiogenesis. Over a short follow-up period, their risk of recurrence is not increased compared with NFAs. Postoperative radiation should be reserved for tumors with evidence of recurrence.

### 136. Endonasal Management of Sellar Arachnoid Cysts: Simple Cyst Obliteration Technique

Nancy McLaughlin (presenter), Alexander Vandergrift, Leo F. S. Ditzel Filho, Kiarash Shahlaie, Amy Eisenberg, Ricardo L. Carrau, Daniel F. Kelly (Santa Monica, USA)

**Introduction:** Symptomatic sellar arachnoid cysts (SAC) have typically been treated via the transsphenoidal route. After cyst fenestration, cyst wall resection and increasing communication between the SAC and suprasellar subarachnoid space (SAS) have been performed. We describe a simplified approach to reinforce a defective diaphragma sellae or unseen arachnoid diverticulum by deliberately not enlarging the SAC-SAS communication and obliterating the cyst with adipose tissue.

**Methods:** A retrospective analysis was conducted of patients who underwent an endonasal transsphenoidal obliteration of symptomatic SAC with a fat graft and skull base repair.

**Results:** Between January 2001 and September 2010, eight patients with a SAC were identified (mean age, 57 years). Clinical presentation included headache ( $n = 4$ ), endocrine dysfunction ( $n = 4$ ), and visual dysfunction ( $n = 4$ ). Maximal cyst diameter averaged 22 mm (range, 15–32 mm).

In all cases, the SAC-SAS communication was deliberately not enlarged. The endoscope was used for visualization in 8/9 procedures. Postoperatively, headache improved in 100%, vision in 100%, and partial resolution of endocrine dysfunction (hyperprolactinemia and/or recurrent hyponatremia) occurred in 75% of patients. No new endocrinopathy, CSF leak, meningitis or neurological deficits occurred. Two patients had cyst reaccumulation; one with a symptomatic recurrence required reoperation 43 months after her initial procedure.

**Conclusion:** SAC can be effectively treated by endonasal fenestration and obliteration with fat with resultant reversal of presenting symptoms in most patients. This simplified technique of SAC cavity obliteration without enlarging communication to the SAS has a low risk of CSF leakage and, in most cases, appears to effectively disrupt cyst progression. Longer follow-up is required to monitor for cyst recurrence.

### 137. Minimizing Intraoperative CSF Leaks in Endonasal Endoscopic Transsphenoidal Pituitary Surgery: Technical Considerations and Case Series Review

Claudio De Tommasi (presenter), Jennifer Anderson, John Lee, Michael Cusimano (Toronto, Canada)

**Objective:** Endonasal endoscopic transsphenoidal surgery (ETSS) has become a widely accepted technique for management of pituitary and associated skull base tumors since our first description in 1996. Several reconstructive options to repair skull base defects have been described in the literature to minimize the risk of postoperative cerebrospinal fluid (CSF) leak. However, another important technical consideration involves the dissection around the arachnoid membrane to minimize the risk of an intraoperative CSF leak altogether. The objective of this paper is to specifically describe our steps in ETSS to minimize the risk of an intraoperative CSF leak and to present a series of patients who underwent with this technique. A review of the literature is also provided.

**Methods:** This was a retrospective review of a consecutive series of patients undergoing endonasal transsphenoidal surgery for suspected pituitary tumors between January 2009 and August 2011 at St. Michael's Hospital, Toronto, Canada. All patients underwent the same surgical technique for approach and tumor removal. We routinely employ a nasoseptal flap for reconstruction (unless the flap is unavailable). Patient demographics, intraoperative findings, and postoperative outcomes were recorded.

**Results:** A total of 88 patients (46 women, 42 men) were included in this review. The mean age was  $48.6 \pm 16.2$  years (range, 16–83 years). The majority of tumors were macroadenomas (76 patients, 86.4%), and 11 cases (12.5%) had a history of previous pituitary surgery. Intraoperative CSF leak occurred in only 16 patients (18.2%) and was transient in 8 and persistent in 8. Only eight patients required duraplasty or fat graft. None of these 16 patients developed a postoperative CSF leak. The overall postoperative CSF leak rate for the 88 patients was 1.1% (1 patient). This patient required a second surgery for repair. No meningitis was observed.

**Conclusion:** Endonasal transsphenoidal pituitary surgery can be performed with a low risk of a postoperative CSF leak. However, this risk may be further minimized by decreasing the rate of an intraoperative CSF leak during tumor dissection and being meticulous with the skull base reconstruction.

### 138. A Relationship between Sphenoid Sinus Anatomy and Suprasellar Extension of Pituitary Tumors?

Vijay R. Ramakrishnan (presenter), Bert W. O'Malley, James N. Palmer (Aurora, USA)

**Introduction:** Tumors are generally known to follow a path of least resistance. Pituitary macroadenomas commonly extend into the suprasellar region as they enlarge. The sphenoid sinus is known to have a variable pneumatization pattern, and we hypothesize that midline insertion of the sphenoid intersinus septum may act as a structural buttress to resist tumor expansion into the sphenoid sinus, thereby directing tumor growth into the suprasellar space. The aim of this study is to determine if midline insertion of a sphenoid intersinus septum is associated with suprasellar extension of pituitary tumors.



**Methods:** A retrospective analysis was conducted of 106 consecutive surgical cases of pituitary macroadenoma. The presence or absence of suprasellar tumor extension and the location of insertion of the intersinus septum were recorded on radiographic review. Pearson's chi-squared test of independence was used to examine statistical association between these findings.

**Results:** Of the 106 cases, 69 patients had a midline insertion of the intersinus septum (65.1%). Forty-nine of these 69 patients had suprasellar extension of their pituitary tumors (71.0%), whereas 22 of the 37 patients without midline insertion of an intersinus septum were found to have suprasellar extension of their tumors (59.4%) ( $P = 0.23$ ). Fifteen of the 106 patients had more than intersinus septation (14.2%).

**Conclusions:** The possible function of the sphenoid intersinus septum as a buttress to resist pituitary tumor growth cannot be asserted. Growth of pituitary macroadenomas may extend in a suprasellar direction or into the sphenoid sinus regardless of the sphenoid sinus anatomy.

### 139. Giant Invasive Pituitary Adenoma Ibrahim Sbeih (presenter), (Amman, Jordan)

Pituitary adenomas are the third-most common intracranial tumor after meningiomas and gliomas. Some adenomas are typical, but others may be invasive, aggressive, premetastatic or carcinomatous. Invasive adenomas can infiltrate bone, dura, nasal sinuses, cranial nerves, and venous sinuses. The goal of surgery in the invasive nonsecretory adenomas is gross total resection, followed by radiotherapy, radiosurgery, or conservative follow-up. In the invasive secretory group, surgery is followed by medical treatment, radiotherapy, or radiosurgery.

We are presenting our experience with giant invasive pituitary adenomas in the period between 1985 and 2008. Fifty-six patients were encountered: 33 men and 23 women. Age of patients ranged from 16–68 years with mean age of 36.7 years. Main presentation was visual failure and endocrinological manifestations.

Thirty-six patients had nonsecreting adenomas, 16 had prolactin secreting adenomas, 2 had ACTH, and 2 had GH secretion. Fifty patients needed transcranial and eight patients needed transnasal surgical excision. Indication of surgery in nonfunctioning adenoma was neurosurgical deterioration. In the secretory group, indication was deterioration of neurological condition in spite of medical treatment. Transcranial surgery was needed where invasive adenoma extended to posterior, middle, or anterior fossa. One of our preferred surgical approaches is transbasal subfrontal, but others are also favored. The aim of surgery was gross total resection whenever possible. Postoperative adjuvant therapy was needed for all patients: radiotherapy in 54 patients, gamma radiosurgery in 12 patients, and drug therapy in 12 patients. The dose in gamma knife varies between 14 and 22 Gy. Follow-up in our patients ranged from 20–154 months, with a mean follow-up period of 58.2 months. Mortality in this series occurred in two patients—one patient died of meningitis after major CSF leak and one died of pulmonary embolism. No carcinomatous change was seen in any of our patients.

We believe that surgical cure is not possible for all invasive secretory and nonsecretory adenomas. Invasiveness is an issue decided by radiological, histological, and operative findings. Most invasive adenomas are giant ones.

### 140. Endoscopic Endonasal Approach for Giant Pituitary Adenomas: Advantages and Limitations

Maria Koutourousiou (presenter), Juan C. Fernandez-Miranda, Carl H. Snyderman, Paul A. Gardner (Pittsburgh, USA)

**Introduction:** Giant pituitary adenomas (measuring more than 4 cm in maximum diameter) are associated with high rates of residual tumor regardless of the surgical approach. We present the results of the endoscopic endonasal approach (EEA) and analyze the factors that influence the degree of resection.

**Methods:** We retrospectively reviewed the medical files and imaging studies of 54 patients (85% men) with giant pituitary adenomas who were managed with EEA.

**Results:** The maximum tumor diameter varied from 40 to 90 mm (mean, 50 mm). Nonfunctioning pituitary adenomas represented 74% of the cases. Preoperative visual impairment was present in 45 patients (83%), partial or complete pituitary deficiency occurred in 28 cases (52%), and 7 patients (13%) presented with apoplexy. Gross total or near total (>90%) tumor resection was obtained in 36 patients (66.7%). Vision was improved or even normalized in 36 cases (80%), remained unchanged in 6 (13%), and deteriorated (due to apoplexy of residual mass) in 2. Pituitary function remained unchanged in 44 patients (81.5%); new pituitary insufficiency occurred in 9 patients (16.7%). Significant factors that limited the degree of resection were a multilobular configuration of the adenoma ( $P = 0.002$ ), extension to the middle fossa ( $P = 0.048$ ), and previous treatment (surgical or medical) ( $P = 0.047$ ). Size, intraventricular extension, and invasion of the cavernous sinus did not influence the surgical outcome. Apoplexy at presentation was associated with higher rates of resection. Complications included apoplexy of residual adenoma in two cases (3.7%), permanent diabetes insipidus in five (9%), transient cranial nerve palsies in six (11%), and cerebrospinal fluid leak in 9 (16.7%). After EEA, 13 patients underwent radiotherapy for residual mass, and 4 with functional pituitary adenomas received medical treatment. During a mean follow-up of 29.3 months (range, 1–109 months), seven patients were reoperated for tumor recurrence.

**Conclusions:** The main goals of surgery for giant pituitary adenomas are decompression of the optic pathway and maximum safe tumor reduction. EEA provides effective initial treatment of giant pituitary adenomas with fewer limitations compared with the traditional transsphenoidal or open approaches. Despite the satisfactory results with tumor reduction, the high incidence of residual mass frequently requires the use of adjuvant therapies.

### 141. Reconstruction of the Intraseptal Tumor Resection Cavity Is Not Necessary to Prevent Optic Chiasm Prolapse Following Transsphenoidal Removal of Pituitary Macroadenomas

Christopher J. Farrell (presenter), Raul Sharma, Tyler Kenning, D. D. Beahm, Madeleine R. Shaberg, Marc R. Rosen, James J. Evans (Philadelphia, USA)

**Introduction:** Secondary empty sella syndrome associated with delayed visual deterioration has been reported following transsphenoidal resection of pituitary adenomas. To prevent postoperative herniation of the optic apparatus, reconstruction of the intraseptal tumor resection cavity with autologous tissues such as adipose tissue or muscle

is commonly employed. Harvesting of such tissues may be complicated by cosmetic deformity, infection, or hematoma formation. In our practice, the resection cavity is not reconstructed, and we sought to determine the incidence of postoperative optic chiasm prolapse following removal of pituitary macroadenomas.

**Methods:** A retrospective review was performed for 100 consecutive patients with pituitary macroadenomas who underwent transsphenoidal resection with postoperative clinical and radiographic data greater than 6 months from the date of initial surgery. The position of the optic chiasm was determined on sagittal MRI and defined as the distance above a line constructed between the superior aspect of the tuberculum sellae and the dorsum sellae. The position of the optic chiasm was compared between the preoperative MRI and the available MRI most distant from the date of surgery. Visual data were obtained from the clinical record.

**Results:** All patients underwent endoscopic transsphenoidal resection of pathologically demonstrated pituitary adenomas without packing of the tumor resection cavity using synthetic or autologous materials. Preoperative MRI demonstrated the presence of a macroadenoma with suprasellar extension in all cases, with a mean tumor height dimension of 23.4 mm (SD 5.1). The average position of the optic chiasm preoperatively was 7.6 mm (SD 3.3) above the superior aspect of the sella turcica. The mean time between the date of surgery and postoperative MRI was 422 days (SD 239). No patient reported delayed visual deterioration postoperatively, and the mean position of the optic chiasm on postoperative MRI was 1.1 mm (SD 0.7). Despite the presence of a large intrasellar tumor resection cavity in all cases, inferior prolapse of the optic chiasm was observed on delayed postoperative MRI in only 1/100 cases and was not associated with visual impairment.

**Conclusions:** Reconstruction of the tumor resection cavity following transsphenoidal removal of pituitary adenomas, including macroadenomas, is not necessary to prevent optic apparatus prolapse and delayed visual deterioration.

#### 142. Preoperative Lumbar Drain Placement in Anterior Skull Base Surgery

Paul D. Ackerman (presenter), Drew A. Spencer, Vikram C. Prabhu (Maywood, IL, USA)

Inserting a drain into the lumbar subarachnoid cistern is an acceptable strategy in managing postoperative cerebrospinal fluid (CSF) leak. The technique promotes closure of dural defects that plague 12–18% of posterior fossa craniotomies and reduces the incidence of open correction in the operating room. This retrospective study evaluates the safety and effectiveness of preoperative lumbar drain (LD) placement in preventing CSF rhinorrhea following anterior cranial fossa (ACF) surgery. Since 2006, 93 LDs have been placed at our institution: 43 before ACF tumor resection (predominantly pituitary adenomas, meningiomas, and esthesioneuroblastomas), 21 before encephalocele repair, 13 before either traumatic or postoperative CSF leak, 9 prior to aneurysm clipping or non-ACF tumor resection, and 7 as part of an LD trial in normal pressure hydrocephalus. We had no difficulty introducing the catheter into the lumbar cistern at the L4–5 disc space using a 14-gauge Touhy needle with the patient in the left lateral decubitus position. In 41 of the 93 cases, the LD was placed in patients undergoing elective ACF sur-

gery unrelated to trauma without a preoperative CSF leak. Of those 41 patients, we report four iatrogenic CSF leaks (4/41 = 9.8%), all in our endoscopic patient population ( $n = 21$ ; 4/21 = 19%), with two of those instances occurring in the same patient. We encountered no postoperative CSF leaks in our open ACF cohort ( $n = 20$ ). In nearly all cases, 10 cc/hour of CSF were removed via the LD in the neurological ICU for 1 to 2 days. The LD was then routinely clamped for 24 hours prior to its removal. No instances of tension pneumocephalus were noted. However, two postoperative mortalities merit discussion. One patient underwent uncomplicated anterior cranial base reconstruction for spontaneous CSF rhinorrhea and later developed a cerebral abscess with subsequent, fatal intraventricular rupture. Another patient developed malignant cerebral edema and intractable seizures following an uneventful bicoronal craniotomy and resection of a giant olfactory groove meningioma with fatal consequences.

Preoperative LD placement is an effective means by which to minimize postoperative CSF leak after anterior skull base craniotomy, but potential, significant intracranial complications may occur and merit careful consideration prior to LD placement in any patient.

#### 143. Endoscopic-Assisted Microsurgical Approach for Anterior Skull Base Lesions

Ali Ayyad (presenter), Jens Conrad (Mainz, Germany)

**Objective:** The priority in contemporary surgery is to achieve the greatest therapeutic effect while causing the least iatrogenic injury. The evolution of microsurgical techniques with refined instrumentation and illumination and the enormous development of preoperative and intraoperative diagnostic tools enable neurosurgeons to treat different lesions through limited and specific keyhole approaches. The concept of keyhole surgery is based on the careful preoperative study of diagnostic images (MRI, CT, angiography) to determine the anatomic windows that provide access to the pathological processes, taking into consideration the individual pathoanatomic situation of the patient.

The introduction of the endoscope in neurosurgical procedures has brought a further new dimension into the field of intraoperative visualization. It provides, in contrast to the microscope, a panoramic view of the surgical field, which makes the surgical procedure more controlled, effective, and safe.

**Methods:** During a 9-year period between October 2000 and June 2010, we have performed 676 endoscopic-assisted microsurgical procedures for ant. Skull base lesions included: 262 aneurysms (ICA, A.C.A, A.Com.A, P.Com.A), 136 meningiomas, 86 craniopharyngiomas, 66 pituitary adenomas, 43 arachnoid cysts, 32 epidermoid/dermoid cysts, 27 astrocytomas, 8 germinomas, 11 teratomas, and 5 hamartomas.

**Results:** The postoperative complications associated with the approach were: (1) permanent partial supraorbital hypesthesia in 17 patients, (2) palsy of the frontal branch of the facial nerve in 14 cases, (3) permanent hyposmia appeared in 17 patients, (4) wound-healing disturbances in 4 cases, (5) subcutaneous CSF collection and leak in 8 patients, (6) postoperative bleeding 9 cases, and (7) pituitary insufficiency 4 cases.

**Conclusion:** The supraorbital craniotomy allows a wide, intracranial exposure for extended, bilaterally situated, or even deep-seated intracranial areas, according to the strategy of keyhole craniotomies. The supraorbital craniotomy offers equal surgical possibilities with less approach-related

morbidity owing to limited exposure of the cerebral surface and minimal brain retraction. The optical advantages of the endoscopic visualization in anatomical orientation and surgical dissection improve the surgical outcome. All these factors contribute to improving the postoperative results due to reduction of the complications. In addition, the minimal invasiveness of the procedure results in pleasing cosmetic outcome.

**144. “Round the Clock” Surgical Access to the Orbit**  
Alessandro Paluzzi (presenter), Matthew Tormenti, Maria Koutourousiou, Susan Stefko, Juan C. Fernandez-Miranda, Paul Gardner, Carl Snyderman, Joseph Maroon (Pittsburgh, USA)

*Introduction:* Surgical approaches to orbital lesions represent challenging procedures that often require the combined effort of different specialists. To minimize the risk of injuring important neural and vascular structures in this area, surgical approaches must be available to provide 360 degrees of access to the orbit. Endoscopic endonasal approaches complement the traditional microsurgical approaches for biopsy or resection and offer the potential to reduce morbidity.

*Methods:* A review of 12 selected patients operated on at our institution over the last 3 years was performed, recording clinical presentation, pathology, and location in relation to the extraocular muscles. In addition, preoperative coronal MRI and/or CT views were compared using a “clock model” of the orbit with its center at the optic nerve. The rationale for choosing an external, endoscopic, or combined approach is discussed for each case.

*Results:* Five patients underwent an endoscopic endonasal transorbital approach, with two of them also requiring a medial transconjunctival approach; five patients were treated through an external approach; and two patients required a combined endoscopic and external approach. The pathologies treated included two cavernous hemangiomas, two foreign bodies, two melanomas, one angioleiomyoma, one orbital osteoma, one metastasis, one pleomorphic adenoma of the lacrimal gland, one inflammatory lesion, and one neuroendocrine tumor. Using the right orbit for demonstration of the clock model, the medial transconjunctival approach provides access to the anterior orbit from 1 to 6 o'clock; endoscopic endonasal approaches provide access to the mid- and posterior orbit and orbital apex from 1 to 7 o'clock. The lateral micro-orbitotomy gives access to the orbit from 8 to 10 o'clock. The frontotemporal craniotomy with orbital osteotomy accesses the orbit from 9 to 1 o'clock; addition of a zygomatic osteotomy to this extends access from 6 to 8 o'clock.

*Conclusions:* Combined, the above approaches provide 360 degrees of access to the entire orbit with the choice of the optimal approach guided primarily by the avoidance of crossing the plane of the optic nerve.

**145. Preservation of Multidimensional Quality-of-Life after Endoscopic Resection of Pituitary Adenoma**  
Edward D. McCoul (presenter), Vijay K. Anand, Jeffrey C. Bedrosian, Theodore H. Schwartz (New York, USA)

*Objective:* Pituitary adenomas are ideally suited to resection by a minimal-access endoscopic technique. Although rates of tumor resection are equivalent to traditional approaches, few studies have investigated the effect of

endoscopic surgery on quality of life (QOL). Of these studies, most have relied on generalized QOL measures, and prospective pre- and postintervention data are lacking. Our aims were to (1) assess the impact of endoscopic pituitary adenoma resection on site-specific QOL and sinonasal-related QOL using two validated instruments and (2) to assess the correlation between these measurements.

*Methods:* Consecutive patients undergoing endoscopic endonasal resection of pituitary adenoma were prospectively enrolled from a tertiary referral center. All patients completed the Anterior Skull Base Questionnaire (ASBQ) and Sinonasal Outcomes Test (SNOT-22) preoperatively and postoperatively at regular intervals. Patients younger than 18 years and those who did not complete pre- and postoperative surveys were excluded from study.

*Results:* Of 223 consecutive patients, 80 met inclusion criteria for study, with a median follow-up time of 14 months. This cohort included 40 (50.0%) nonsecreting tumors and 40 (50.0%) hormonally active tumors, including 15 (30.0%) with acromegaly and 10 (12.5%) with Cushing's disease. Nasoseptal flap closure was used in 37 (46.3%) cases, and graft harvest from a second surgical field was performed in 43 (53.8%) patients. There was no decline in mean ASBQ score up to 12-weeks postoperatively ( $P > 0.05$ ), and significant improvement was seen at 6-month follow-up ( $P = 0.02$ ). Mean SNOT-22 scores transiently worsened at 3 weeks postoperatively ( $P < 0.001$ ), returned to baseline at 6 weeks through 6 months postoperatively, and showed significant improvement at 1 year postoperatively ( $P = 0.008$ ). The presence of a nasoseptal flap or a graft donor site did not contribute to decreased QOL on either scale. Cavernous sinus involvement was present in 20 (25.0%), which was not associated with a difference in ASBQ or SNOT-22 score ( $P > 0.05$ ). A postoperative CSF leak occurred in one (1.3%) case, which did not require reoperation.

*Conclusions:* Endoscopic resection of pituitary adenoma is associated with improvements in both sinonasal and site-specific QOL when assessed pre- and postoperatively with validated instruments. Cavernous sinus involvement does not adversely impact postoperative QOL, and a low rate of postoperative CSF leak is achievable.

**146. The Clinical Importance of Quality-of-Life Scores in Patients with Skull Base Tumors**  
Moran Amit (presenter), Avraham Abergel, Dan M. Fliss, Nevo Margalit, Ziv Gil (Tel Aviv, Israel)

*Background:* Health-related quality-of-life (QOL) outcomes are frequently used by clinicians, patients, and researchers for assessing the effectiveness of an intervention. Although small differences in QOL may be statistically significant, their clinical relevance has not been clarified. We aimed to determine the smallest changes in QOL scores of the anterior skull base surgery questionnaire (ASBS-Q) that could be considered clinically significant.

*Methods:* We assessed the QOL of 115 patients undergoing open or endoscopic skull base tumor resection. The minimal clinically important difference (MCID), defined as the smallest difference in QOL that patients perceive as beneficial and that would mandate a change in management, was calculated. A retrospective cohort ( $n = 79$ ) was used to calculate MCID using the distribution-based methods (half standard deviation [SD], effect size [ES], and standard error of measurement [SEM]). A prospective cohort ( $n = 36$ )

was used to calculate MCID using an anchor-based method. A population-based approach was used to assess the differences based on histology (benign vs. malignant), surgical approach (open vs. endoscopic), and postoperative period.

**Results:** The median MCID for the ASBS-Q was 0.4 (range, 0.34–0.42), reflecting an 8% change in QOL score. The population-based subgroup analysis showed a significant clinical difference in performance according to histological groups and postoperative period (7.9% and 13.4%, respectively). The surgical approach yielded a significant clinical difference in physical function and emotional status (9.8% and 16.4%, respectively). The MCID in the prospective cohort was 0.44 (range, 0.44–0.64), reflecting an 8.8% change in QOL score. Physical function and specific symptoms significantly changed during the early postoperative period (15% and 14%, respectively). The median change in scores was significantly different between patients reporting improvement (responders) and those reporting no change (nonresponders) in QOL ( $P = 0.003$ ). A reliable change index threshold of 1.59 (33% change) revealed that 93% (14/15) of the responders had a significant improvement in QOL as opposed to only 31% (5/16) of the nonresponders ( $P < 0.001$ ).

**Conclusions:** The MCID of the ASBS-Q is 0.4 (8%). Any change above this score can be considered as being clinically significant. Histology, postoperative period, and surgical approach have significant clinical impact on different QOL domains.

#### 147. The Transpalatal Approach to Repair of Congenital Basal Sphenoethmoidal Meningoceles

Stephen R. Hoff (presenter), Peter J. Koltai (Chicago, USA)

**Objective:** The purpose of this study is to provide an in-depth discussion of the transpalatal approach for resection of basal sphenoethmoidal meningoceles, including high-definition videos, images, and illustrations.

**Methods:** Two cases are described of infants with a midline skull base defect and associated basal sphenoethmoidal meningocele, with a focus on surgical technique of the transpalatal repair.

**Results:** Two infants presented to the otolaryngology service with basal sphenoethmoidal meningocele. The first patient had a midline skull base defect with meningocele bulging into the nasopharynx with an intact palate, requiring intubation at birth for airway obstruction. In the first week of life, he underwent a transoral, transpalatal approach to resection of the meningocele. The second patient had the Sakoda complex, including a midline meningocele and midline cleft palate. At 7 months, a transoral resection of the meningocele was performed through his preexisting cleft palate, with repair of the skull base defect with calvarial bone graft.

**Conclusion:** Basal sphenoethmoidal meningoceles and encephaloceles are extremely rare entities. The traditional approach has been a transcranial subfrontal repair, which puts the olfactory bulbs, optic chiasm, and pituitary at risk.

An alternative is the transoral transpalatal approach to repair of the meningocele and skull base defect, which spares the morbidity of a craniotomy. The transpalatal approach has been reported in only three previous cases; we present two additional—one that required a palatal split and one that was done through a preexisting cleft palate. Emphasis will be on diagnosis, management options, and surgical technique, with the use of high-definition videos, images, and illustrations.

#### 148. Proposed Classification for Skull Base Reconstruction after Endoscopic Endonasal Surgery

Amir R. Dehdashti (presenter), (Danville, PA, USA)

**Introduction:** Endoscopic endonasal surgery has evolved over the last few years. The outcomes are considered at least similar to standard microscopic transsphenoidal surgery in the setting of sellar and selected midline skull base lesions. The reconstruction of the skull base defect, however, has been a challenging part of this novel approach. A simple practical classification of skull base reconstruction is proposed.

**Methods:** Between February 2009 and July 2011, 120 endoscopic endonasal procedures were performed for a variety of sellar and skull base lesions. The skull base was reconstructed based on the lesion type, size and extension, the size of the skull base defect, and intraoperative CSF leak. For sellar/suprasellar lesions with no intraoperative CSF leak, a simple closure with Surgicel, Gelfoam, and Evicel was performed (Type I reconstruction). If a minute CSF leak was observed during the surgery and subsided, an AlloDerm was added to the Type I reconstruction to cover the sellar defect (Type II reconstruction). If intraoperative CSF leak was more significant, a combination of Avitene, Surgicel, and fat graft was used for the intrasellar part, then AlloDerm and Evicel were added to cover the sellar defect (Type III reconstruction). For very large pituitary adenomas (>3 cm), all recurrent tumors (if feasible) and all expanded endoscopic procedures, a nasoseptal flap was harvested and added to the Type III reconstruction (Type IV reconstruction). Lumbar drainage was performed when there was an opening of the third ventricle. The rate of postoperative CSF leak was compared among the four reconstruction groups.

**Results:** Eighty-five patients had pituitary adenomas, 12 had Rathke's cleft cyst (or other benign cyst), and 23 underwent expanded endoscopic procedures for the following pathologies: craniopharyngioma (7), giant pituitary adenoma (6), meningioma (5), chordoma (2), CSF leak repair (2), and clival plasmocytoma (1). Type I reconstruction was performed in 54, Type II in 20, Type III in 14, and Type IV in 32. The rate of postoperative CSF leak was 0 in Type I, 3 in Type II (15%), 5 in Type III (35%), and 2 in Type IV (6%). Among the 10 patients with postoperative leak, 9 responded to lumbar drainage. One (with Type III reconstruction) had to undergo a second endoscopic repair followed by a craniotomy and skull base reconstruction due to persistence of CSF leak. Type III reconstruction was associated with higher rate of postoperative CSF leak.

**Conclusion:** As there is no standard consensus for reconstruction of the skull base after endoscopic endonasal surgery, this proposed classification may simplify the reconstruction type. Higher rate of CSF leak in Type III reconstruction warrants preoperative assessment and preparation for more generous use of Type IV reconstruction.

#### 149. Barrier-Limited Multimodality Closure for Reconstruction of Wide Sellar Openings

Aaron R. Cutler (presenter), Kai Xue, Jeffrey D. Suh, Marilene B. Wang, Marvin Bergsneider (Los Angeles, USA)

**Background:** Although the endonasal endoscopic approach (EEA) allows for increased bone removal and thus a wider dural exposure, it also presents the challenge of skull base reconstruction in the face of an intraoperative cerebrospinal fluid (CSF) leak. Obtaining a watertight reconstruction using a fat graft with wide sellar exposures can be

challenging, and with no barrier in place, carries the risk of reinstating mass effect. The alternative, a vascularized nasoseptal flap, may require several days to heal and has an approximate CSF leak rate of 6%.

**Objective:** The purpose of this study is to introduce and assess the efficacy of a barrier-limited multimodality (BLMM) closure technique for intraoperative CSF leaks obtained during an EEA, consisting of an autograft fat-based watertight seal, a limiting membrane barrier, and the vascularized nasoseptal flap.

**Methods:** Between 2008 and 2010, 196 patients underwent an EEA procedure for lesions involving the sellar, parasellar, and suprasellar regions at our institution. We performed a retrospective review of 27 consecutive patients who experienced an intraoperative CSF leak (Grade 1-11, Grade 2-9, and Grade 3-7) requiring repair with the BLMM technique. The membrane barrier is first created by securing a piece of absorbable collagen sponge to the dural edges with titanium clips. This is followed by an autologous fat graft that is typically buttressed in place using bone harvested during the exposure. The vascularized nasoseptal flap is then rotated to cover the entire construct. The results of 43 prior reconstructions with intraoperative CSF leaks repaired using a nasoseptal flap only were analyzed as a comparison group.

**Results:** There were no postoperative CSF leaks for the patients who underwent reconstruction using the BLMM closure technique. There were no complications attributable to the BLMM reconstruction. The CSF leak rate for the comparison group with nasoseptal flap repair only was 19%.

**Conclusion:** The BLMM closure may further decrease the incidence of postoperative CSF leaks compared with that obtained with a predominant reliance on a vascularized nasoseptal flap. The membrane barrier allows for a watertight inner closure and prevents herniation of the fat autograft into the resection cavity. An outer layer nasoseptal flap provides a living barrier for optimal long-term defense.

#### 150. Meta-Analysis of CSF Leak Rate Following Skull Base Reconstruction with and without Vascularized Local Pedicled Flaps

Jeffrey C. Bedrosian (presenter), Edward D. McCoull, Vijay K. Anand, Theodore H. Schwartz (New York, USA)

**Objectives:** Endoscopic techniques to repair CSF leaks, encephaloceles and skull base tumor defects have evolved rapidly over the past decade. Repair of the skull base is typically performed in a multilayer fashion in an effort to provide a durable repair and to avoid postoperative CSF leak. Within the past 5 years, the vascularized local pedicled flap has been introduced to aid skull base repair. It has been shown that living donor tissue will speed remucosalization of the skull base, and it has been postulated that a more robust mucosal flap will decrease the rate of postoperative CSF leakage. We performed a meta-analysis of published series of endoscopic skull base procedures to compare postoperative CSF leak rates using various reconstructive techniques.

**Methods:** We performed a MEDLINE (1948–2011) search of endoscopic skull base series, including those studies that described their method of skull base reconstruction and postoperative complications. Our meta-analysis of this data included postoperative complications, comparing vascularized pedicled flaps with nonvascularized multilayered reconstructions. We performed subgroup analyses of defect location, tumor type, and reconstructive method, where possible.

**Results:** We analyzed 24 published series. We performed subgroup analysis of primary CSF leak repair and skull base repair following tumor resection. Overall, vascularized pedicled flap reconstruction improved the rate of postoperative CSF leakage (6.2%) versus nonvascularized multilayered skull base repair (7.9%,  $P = 0.05$ ). For the spontaneous CSF leak and encephalocele subgroup, the rates were 1.9% and 5.7%, respectively ( $P = 0.05$ ). The results compared favorably to our own large series of 301 patients. After adoption of the nasoseptal flap, our overall leak rate decreased by nearly half, from 5.9% to 3.1% ( $P = 0.05$ ).

**Conclusions:** Vascularized pedicled mucosal flap reconstruction results in an improvement in postoperative CSF leak rates following endoscopic skull base reconstruction. This analysis also demonstrates a learning curve for these flaps, as leak rates have improved commensurate with case experience.

#### 151. Anteriorly Based Inferior Turbinate Flap for Endoscopic Skull Reconstruction

Ziv Gil (presenter), Nevo Margalit (Tel Aviv, Israel)

**Objective:** In the absence of the nasal septal flap, there is a limited ability to reconstruct the anterior skull base due to paucity of alternative intranasal vascularized flaps. In this paper, we describe for the first time the anterior pedicled inferior turbinate flap (AITF) as a method for endonasal reconstruction of anterior skull base defects.

**Study Design:** A prospective review was conducted of the demographic, clinical, surgical, and early follow-up data of five patients who underwent reconstruction of skull defects by the AITF approach.

**Methods:** The nature of the arterial blood supply of the inferior turbinate from the sphenopalatine artery, the anterior ethmoidal artery (AEA), and the lateral nasal artery was exploited to design an anteriorly pedicled flap. AITF survival, graft coverage, adequacy of the seal, and rate of complications were assessed.

**Results:** Five patients were suitable to undergo anterior skull base reconstruction using the AITF after tumor resections of CSF leak. Each had a high-flow intraoperative CSF leak. The reconstruction achieved full covering of the skull base defect from the frontal sinus to the planum sphenoidale in each case, with no postoperative CSF leaks or any other complications.

**Conclusion:** The AITF approach is simple to execute and can be safely and effectively used for endonasal reconstruction of anterior skull base defects, especially when traditional reconstruction techniques are not possible.

#### 152. Middle Turbinate Vascularized Flap: Applications in Skull Base Reconstruction

Bradley A. Otto, Ricardo L. Carrau (presenter), Danielle M. Prevedello, Matthew O. Old, Leo F. Ditzel Filho, Danielle de Lara, Rodrigo C. Mafaldo (Columbus, USA)

**Background:** The use of local vascularized flaps has had significant impact on postoperative cerebrospinal (CSF) leak rates following endoscopic endonasal skull base surgery (EESBS). The middle turbinate (MT) flap is one alternative for reconstruction of sphenoid and fovea ethmoidalis defects. In select cases, the MT flap is an excellent alternative to the nasoseptal flap.

**Objective:** We aim to describe our technique and utilization of the MT flap for skull base reconstruction and sinonasal optimization following EESBS.

**Methods:** We used the MT flap to cover sphenoid and fovea ethmoidalis defects. When necessary, modifications to the original description of the flap were made to tailor the reconstruction to the specific needs of the patient. To date, we have treated five patients with various conditions, including pituitary tumors and spontaneous CSF leaks associated with intracranial hypertension. No postoperative CSF leaks, complications, or crusting related to the flap have been identified.

**Conclusions:** The MT flap is a safe, effective alternative for skull base reconstruction. Especially for anterior sphenoid or posterior fovea ethmoidalis defects, the MT may offer sufficient repair with the least morbidity.

### 153. Triple-Layer Reconstruction Technique for Large Cribriform Defects after Endoscopic Endonasal Resection of Anterior Skull Base Tumors

Smruti K. Patel (presenter), Mickey L. Smith, Osamah J. Choudhry, Jean Anderson Eloy, James K. Liu (Newark, USA)

**Introduction:** Endoscopic endonasal transcribriform resection of anterior skull base tumors results in large skull base defects that extend the entirety of the cribriform plate, from the frontal sinuses to the tuberculum sellae anteroposteriorly, and from one medial orbital wall to the other horizontally. Endoscopic repair of these large cribriform defects can often be challenging. We describe our reconstruction technique for large skull base defects after endoscopic endonasal transcribriform resection of anterior skull base tumors. This triple-layer technique is comprised of autologous fascia lata, acellular dermal allograft, and a vascularized pedicled nasoseptal flap (NSF). The technique is described, and CSF leak rate is evaluated.

**Methods:** Retrospective review of a prospective database over a 2-year period identified nine patients who underwent a purely endoscopic endonasal transcribriform approach for resection of anterior skull base tumors. Patients who underwent combined craniofacial approaches and those treated for anterior skull base encephaloceles were excluded from this study. Lesions included two olfactory groove meningiomas, two esthesioneuroblastomas, one olfactory schwannoma, one sinonasal small cell neuroendocrine carcinoma, one melanoma, one adenoid cystic carcinoma, and one recurrent osteoblastoma. After tumor resection, all patients underwent triple-layer reconstruction using autologous fascia lata and acellular dermal allograft followed by a vascularized pedicled NSF to reconstruct a large cribriform skull base defect. No postoperative lumbar drainage was used in these cases.

**Results:** Postoperative CSF leak rate was 0% without the use of postoperative lumbar drainage. Overall mean follow-up period for all cases was 5.4 months (range, 1 to 13 months).

**Conclusion:** The triple-layer reconstruction technique using autologous fascia lata, acellular dermal allograft and a pedicled NSF is effective in reconstructing large anterior skull base defects after endoscopic resection of the cribriform plate. We feel that the use of postoperative lumbar drainage is not necessary when using this repair technique, which may result in earlier mobilization and shorter hospital stays.

## Poster Presentations

### 154. Endoscopic CSF Repair—Necessity of Fibrin Glue

Satyawati Mohindra (presenter), Sandeep Mohindra, Jagveer Yadav (Chandigarh, India)

**Objective:** To compare the results of CSF repair with and without fibrin glue in pediatric patients of CSF rhinorrhea treated endoscopically between December 2005 and July 2010 at our center.

**Methods:** This was a retrospective study carried out in the departments of Otolaryngology, Head and Neck Surgery, and Neurosurgery at the Postgraduate Institute of Medical Education and Research, Chandigarh, India.

**Results:** This study included 27 patients with CSF rhinorrhea divided into two groups: 13 patients underwent endoscopic endonasal CSF repair using fibrin glue (Tisseel, Baxter, Vienna, Austria) by an endoscopic rhinologist, and 14 patients underwent endonasal CSF repair without fibrin glue.

**Conclusion:** There was no statistically significant difference in endoscopic CSF repairs with or without fibrin glue ( $P = .48$ ). CSF repair without fibrin glue is more cost effective compared with repair with glue.

### 155. Anterior Cranial Fossa Meningioma, Outcome of Surgery Using Different Surgical Approaches

Sherif M. Elwatidy (presenter), Zain Jamjoom, Walid Murshid Riyadh (Saudi Arabia)

**Objective:** The aim of the work is to review patterns of clinical presentation, radiological features, and outcome of surgical excision of anterior fossa meningioma patients treated at King Khalid University Hospital (KKUH), College of Medicine, King Saud University.

**Patients and Methods:** Three hundred consecutive meningioma patients were treated at KKUH between 1990 and December 2010. Data of clinical presentation, radiological features, surgical procedure, and outcome of surgery were collected and analyzed.

**Results:** The patient population was 18% men and 82% women; the median age was 44 years. Forty percent of patients had olfactory groove, 32% had suprasellar, 20% had sphenoid wing, 6% had cranio-orbital, and 2% had multiple meningiomas. The tumor was <3 cm in 12%, 3–5 cm in 58%, and >5 cm in 30% of patients. Pterional approach was used in 52%, bifrontal approach in 32%, supraorbital approach in 6%, and combined approaches in 10% of patients. Total resection (Simpson I) was achieved in 74% of patients. Postoperative complications included CSF leak in two patients, severe brain swelling in two patients, infection in two patients, postoperative seizures in two patients, loss of vision two patients, visual deterioration in two patients, diabetes insipidus in two patients, EDH in one patient, and DVT in one patient. Follow-up period ranged from 6 months to 10 years (mean, 43 months), the outcome was 71% improved, 12% the same, 12% deteriorated, and 2% died. Tumor recurrence was seen in 10% of patients.

**Conclusion:** Surgical approach is tailored to tumor's size, location, and extension. Combined with microsurgical cranial base techniques, it allows complete removal with excellent neurosurgical outcome, minimal permanent morbidity, and low recurrence rates.

**156. Management of Pediatric Nasal Dermoids**

Jeffrey Cheng (presenter), Ken Kazahaya (Philadelphia, USA)

*Objective:* In this study, we review our experience with the management of pediatric nasal dermoids with a direct excision technique.

*Methods:* We performed a retrospective chart review at a tertiary care, pediatric hospital with patients younger than 18 years who were diagnosed with and surgically treated for nasal dermoid between January 1, 2000 and July 31, 2011. Adequate documentation of pathologic diagnosis, radiographic findings, operative notes, and follow-up examinations were necessary for inclusion in the study.

*Results:* Twenty-five patients were identified who met the inclusion criteria. The average age at the time of surgery was 45.7 months. Twenty-four (96%) of the patients were approached with direct excision of the lesion. In two of the cases, either an operating microscope or a rigid endoscope was used to aid in visualization of the dermoid tract to ensure adequate excision. Closure in all but two (4%) was achieved tension free with direct approximation. The other two cases required adjacent tissue transfer for adequate cosmetic closure. Only one case—the patient with the largest dermoid encountered in the study group, with prenasal and extracranial extent and largest dimension of 3.0 cm—was approached using an external rhinoplasty approach. Three cases (12%) were identified as having intracranial extension, but intraoperative, neurosurgical consultation was only required in one case for repair of a cerebrospinal fluid (CSF) leak. Complications occurred in two cases (4%). One was an immediate postoperative hematoma, which required wound re-exploration. The other complication was a CSF leak, which was identified and repaired intraoperatively by neurosurgery. The average length of hospital stay was 2.4 days. No recurrences were encountered with an average follow-up of 51.6 months.

*Conclusion:* Directed excision of nasal dermoids in pediatric patients affords excellent exposure and visualization, with or without the use of an endoscope or operating microscope. Reduced elevation and manipulation of surrounding tissues occurs, compared with other approaches, such as external rhinoplasty or craniotomy approaches. Short recovery times and minimal hospital stay can be expected. Complication rates, recurrences, length of hospital stay, and cosmetic outcomes are very favorable.

**157. Calcifying Pseudoneoplasm of the Neuraxis (CAPNON) of the Anterior Skull Base: Report of a Case**  
Aaron M. Fletcher (presenter), Patricia Kirby, Jeremy Greenlee, Erin K. O'Brien (Iowa City, USA)

Calcifying pseudoneoplasms of the neuraxis (CAPNON) are rare, benign, fibro-osseous lesions of the central nervous system. They can occur anywhere in the central nervous system, and arise with roughly equal frequency in the spine and brain parenchyma. The etiology of these lesions is uncertain, but they are thought to arise from a reactive as opposed to a neoplastic process. Treatment of these lesions is typically with surgical excision. Herein, we report a case arising in a 19-year-old man presenting with chronic headache, unilateral rhinorrhea, and epiphora. The lesion was located along the anterior skull base, with sinonasal and orbital extension. The lesion was resected using an endoscopic, transethmoidal approach.

**158. Isolated Orbital Plasmacytoma with Progression to Multiple Myeloma: A Case Presentation**

Vladimir Cortez (presenter), Blake Berman, Javed Siddiqi (Colton, CA, USA)

Extramedullary plasmacytoma is a subset of plasma cell tumors, and it accounts for 3% of all plasma cell tumors. Extramedullary plasmacytoma originate in the head and neck region and most commonly affect the extracranial nasal sinuses. The literature is scant of reports of extramedullary plasmacytoma to the orbit. Our institution reports a patient's clinical presentation, workup, pathological findings and postoperative course of an orbital extramedullary plasmacytoma.

A 62-year-old right-handed dominant man with known history of HIV was referred from ophthalmology with 3 months of progressive right eye symptoms including diplopia, proptosis, and diminished ocular motility. Clinical examination revealed a right 6th cranial nerve deficit with lateral gaze palsy, chemosis, proptosis, and diminished visual acuity of the right eye. Imaging of the brain showed an extra-axial lesion extending from the tip of the lesser wing of the sphenoid into the right orbit with mass effect. An additional extra-axial lesion in the left frontal anterior lobe of the brain appeared suspicious for an en plaque meningioma. The patient underwent a right cranio-orbitozygomatic craniotomy with orbital reconstruction for complete resection of the orbital mass. Intraoperative preliminary pathology was suggestive of a highly cellular neoplastic tumor, which was possibly a malignant meningioma or lymphoma. Final pathological diagnosis of the tumor was consistent with intraorbital extramedullary plasmacytoma. Immunohistochemistry of the tumor revealed sheets of neoplastic plasma cells with cytoplasmic IgG kappa light chain reaction. Standard multiple myeloma assessment identified elevated beta-2 microglobulin and protein electrophoresis levels. Nuclear body imaging and whole body skeletal survey revealed uptake of Technetium-99m in the left frontal skull and no obvious lytic or bony destructive processes, respectively. Postoperative treatment included an extended course of chemotherapy. A recent bone marrow biopsy of the left iliac crest revealed 2% monoclonal plasma cell population with cytoplasmic IgG kappa light chain restriction.

The literature is very scarce with reports of solitary extramedullary plasmacytoma of the orbit. This type of tumor is a rare subtype of plasma cell tumors. Isolated proliferation of plasma cell has a good chance of recovery, but conversion to multiple myeloma can worsen the prognosis with mean survival time of approximately 3 years.

**159. Cranial Repair of a Sternberg Canal Encephalocele Following Attempted Endoscopic Endonasal Repair Failure**

Regis Hoppenot (presenter), Andrew J. Fabiano, Nestor Rigual, Robert A. Fenstermaker (Buffalo, USA)

*Introduction:* Sphenoidal encephaloceles can occur secondary to a patent Sternberg canal. Such encephaloceles have traditionally been treated by intracranial repair; however, advances in endoscopic techniques have led some to advocate an expanded endonasal endoscopic repair of sphenoidal encephaloceles. This case demonstrates a failure of endoscopic endonasal repair, which led to craniotomy.

*Methods:* We present a case report.

*Results:* A 32-year-old woman presented with headaches and persistent cerebrospinal fluid (CSF) rhinorrhea. Brain MRI showed a sphenoidal encephalocele. The patient underwent expanded endoscopic endonasal repair, including a layered dural closure with fascia lata. One month postoperatively, the patient experienced a return of CSF rhinorrhea. She underwent ventriculoperitoneal shunt placement and repeat endoscopic endonasal repair. Again, she experienced a return of CSF rhinorrhea, confirmed by myelogram. The patient subsequently underwent pterional craniotomy, which allowed for intracranial identification of the defect. The dura was primarily sutured, and the patent bony canal was filled with hydroxyapatite. The patient has had no further CSF rhinorrhea or headaches in 5 months of follow-up.

*Conclusions:* Treatment of underlying hydrocephalus is imperative in encephalocele repair. Sphenoidal encephaloceles may be difficult to repair with an expanded endonasal approach; thus, direct, intracranial repair should be considered.

#### 160. Schwannomas of the Anterior Skull Base: Analysis of 41 Cases in the Literature

Peter Sunaryo (presenter), Osamah J. Choudhry, Leroy Sharer, Jean Anderson Eloy, James K. Liu (Edison, NJ, USA)

*Object:* Schwannomas of the anterior skull base (ASB) are extremely rare. In this study, the authors review the literature of reported cases of ASB schwannomas to analyze the clinical and radiographic presentations, as well as the surgical management of these rare lesions.

*Methods:* A MEDLINE/PubMed search was performed, revealing 40 cases of ASB schwannomas. The authors report an additional case in the study, making a total of 41 cases. Each case was analyzed for clinical presentation, anatomical location, radiographic features, and surgical treatment.

*Results:* In 41 patients with ASB schwannomas, 73% were exclusively intracranial, 22% were primarily intracranial with extension into the nasal cavity and/or paranasal sinuses, and 5% were primarily sinonasal and extended to the ASB. Headaches were the most common presenting symptom (51%), followed by olfaction impairment (50%), and seizures (41%). Computed tomography revealed calcifications in 19% and bone erosion in 56%. Magnetic resonance imaging typically showed a heterogeneously enhancing lesion. The majority of the patients underwent craniotomy (91%), the most common being a bifrontal craniotomy. Three patients underwent a purely endoscopic endonasal approach (9%). Gross total resection was achieved in all cases. There were no recurrences during an average follow-up of 16 months (range, 2 to 48 months). Postoperative complications included two cases of CSF leakage, two cases of bacterial meningitis, and one case of epidural hematoma.

*Conclusions:* ASB schwannomas are rare lesions and can mimic other extra-axial pathologies involving the ASB such as olfactory groove meningiomas, esthesioneuroblastomas, and other malignant ASB tumors. Gross-total resection of these lesions should be the goal of surgery. Although these have been traditionally treated with transcranial skull base approaches, an endoscopic endonasal approach can be considered in some cases.

#### 161. Primary Ewing's Sarcoma of the Ethmoid Sinus with Intracranial and Orbital Extension: Case Report and Literature Review

Mingsi Li (presenter), Aaron Hoschar, Thomas Budd, Samuel Chao, Joseph Scharpf (Cleveland, USA)

Ewing's sarcoma family of tumors (ESFTs) is a group of cancers that commonly arises in patients during their second decade of life. It frequently involves the trunk and long bones of the body with primary Ewing's sarcoma of the paranasal sinuses being exceedingly rare. We describe a case of a 39-year-old woman with primary Ewing's sarcoma (ES) originating from the ethmoid sinuses with intracranial extension into the anterior cranial fossa and the orbit. CT, MRI and histopathological findings will also be included. There are very few case reports on primary Ewing's sarcoma originating from the ethmoid sinuses, and to our knowledge, this is the second reported case with the involvement of the anterior cranial fossa. However, this is the only case where immunochemical staining and molecular genetic analysis are available for definitive diagnosis.

#### 162. Meta-Analysis of 75 Cases of Sinonasal Teratocarcinosarcoma: A Rare Neoplasm of the Anterior Skull Base

Poonam Misra (presenter), Peter Sunaryo, Ada Baisre, Neena Mirani, Jean Anderson Eloy, James K. Liu (Newark, USA)

*Object:* Sinonasal teratocarcinosarcoma (SNTCS) is a rare and highly malignant neoplasm that often involves the anterior skull base. Although the optimal treatment of these tumors is not well defined, the most common treatment method has included surgical resection and adjuvant radiotherapy. In this study, the authors perform a meta-analysis of SNTCS cases reported in the literature.

*Methods:* A MEDLINE/PubMed search revealed 74 cases of SNTCS in the English literature. The authors report an additional case in the study, making a total of 75 cases. Each case was analyzed for patient demographics, clinical presentation, tumor location, diagnosis, treatment, and outcome.

*Results:* The average age of the patients was 54.3 years, with a strong male predilection (6.5:1). The most common presenting symptoms were nasal obstruction (73.3%) and epistaxis (61.3%). Tumors presented mostly in the nasal cavity (64%) and ethmoid sinus (53.3%), followed by the maxillary sinus (22.7%). Eleven patients (14.7%) presented with intracranial extension, including our reported case. The most common treatment method was surgery with adjuvant radiation therapy (56%). Other treatments were surgery alone (14.7%), surgery with radiation and chemotherapy (9.3%), radiation alone (6.7%), surgery and chemotherapy (5.3%), and radiation and chemotherapy (2.7%). Of the 42 patients treated with surgery and radiation therapy, 18 (42.9%) showed no evidence of disease at the latest follow-up, and 10 (23.8%) patients showed tumor recurrence. Of the 11 patients treated with surgery alone, 3 (27.3%) showed no evidence of disease at latest follow-up, while 5 (45.5%) experienced recurrence or metastasis. Seven patients were treated with a combination of surgery, radiation, and chemotherapy. Four of these patients (57.1%) showed no evidence of disease at latest follow-up, while three (42.9%) experienced tumor recurrence. Of the five patients who were treated with radiation alone, four



(80%) developed recurrence. Treatment with surgery and chemotherapy was reported in four patients. Two remained disease free and two were alive with disease or with recurrence. Combination radiotherapy and chemotherapy was used in two patients. One showed no evidence of disease, the other developed metastases. Overall, surgery was used in 85.3% of cases, radiotherapy in 74.7%, and chemotherapy in 17.3%. At the most recent available reported follow-up (average, 40 months; range, 2 to 372 months), 40% were alive without disease, 32% were alive with disease (recurrence or metastasis), and 28% were dead.

**Conclusions:** SNTCS is a rare and aggressive malignant skull base tumor. Although a variety of treatment paradigms have been reported in the literature, radical surgical resection followed by radiation therapy appears to be the best treatment option. The role of chemotherapy is not well defined due to the limited number of cases.

### 163. Multimodality Treatment Outcomes of Sinonasal Undifferentiated Carcinoma of the Skull Base

Linda N. Lee (presenter), Stacey T. Gray, William Curry, Annie W. Chan, John Clark, Eric H. Holbrook, Daniel G. Deschler, Derrick T. Lin (Boston, USA)

**Objective:** To evaluate and update the clinical outcomes of a multimodality treatment approach for sinonasal undifferentiated carcinoma (SNUC) involving the anterior skull base.

**Methods:** Eleven patients with SNUC treated at the Massachusetts Eye and Ear Infirmary/Massachusetts General Hospital Cranial Base Center from 1995 to 2008 were analyzed retrospectively. All histologic specimens were reviewed by a single pathologist confirming the diagnosis of SNUC.

**Results:** Fourteen patients were originally diagnosed with SNUC between January 1995 and July 2008 by review of the medical records of the Massachusetts Eye and Ear Infirmary. After review of the histology by a single, blinded, pathologist, 11 patients were confirmed with SNUC. There were six men and five women in the study with a mean age of 55 years. Seven patients at initial presentation had extensive local disease and were deemed surgically unresectable due to radiographic involvement of either the cavernous sinus or internal carotid artery. Initial treatment for three patients involved chemotherapy and proton beam radiation. Four patients were treated initially with subtotal resection to facilitate postoperative proton beam radiation therapy and chemotherapy. Four patients that were deemed having resectable disease underwent traditional craniofacial resection followed by postoperative chemotherapy and proton beam radiation. All four of these patients had negative histologic margins. All patients received proton beam therapy at some point of their therapy at a dose of 70 to 76 Gy. Overall, 5 of the 11 patients are dead of disease. One patient died during the course of treatment. No patients are currently alive with known disease. Mean follow-up time is 53 months.

**Conclusions:** For patients with en bloc resectable disease, we recommend surgical resection followed by postoperative chemotherapy and proton beam radiation therapy. Patients with advanced disease who are deemed unresectable may benefit from combined chemotherapy and proton beam radiation therapy for locoregional control.

### 164. Endoscopic Endonasal Resection of a Groove Meningioma with Olfactory Preservation

Bradley A. Otto, Rodrigo C. Mafaldo, Danielle de Lara (presenter), Leo S. Ditzel Filho, Daniel M. Prevedello, Ricardo L. Carrau (Columbus, USA)

**Background:** There are few cases in the literature demonstrating resection of olfactory groove meningiomas with olfactory preservation. Although the standard treatment for olfactory groove meningiomas uses traditional transcranial routes, the endoscopic endonasal approach (EEA) has been used with increased frequency. One of the main benefits of the EEA is the lack of frontal lobe retraction required to access the lesion. Preservation of olfaction can be challenging using either approach, but especially so for the EEA, due not only to the location of the olfactory nerves in relation to the tumor, but also to the transgression of olfactory epithelium during the approach.

**Technique and Case Illustration:** A case of a large anterior fossa meningioma with olfactory function preservation is presented. The technique used is described.

**Conclusion:** The EEA is one option skull base surgeons have for accessing large anterior cranial fossa meningiomas. In our experience, the ability to preserve olfaction is dependent on both the size and location of the tumor. Chances of maintaining olfaction are greatest when at least one nerve and a portion of corresponding olfactory epithelium, usually at the anterior-most extent of the dissection, can be preserved.

### 165. Septal Transposition: A Novel Technique for Preservation of the Nasal Septum during Endoscopic Endonasal Resection of Olfactory Groove Meningiomas

Madeleine R. Schaberg (presenter), Christopher J. Farrell, Mindy Rabinowitz, James J. Evans, Marc R. Rosen (New York, USA)

**Introduction:** Endonasal resection of olfactory groove meningiomas may be indicated in select cases. The endoscopic approach requires resection of the superior nasal septum for access resulting in a large septal perforation. We describe an approach to the anterior cranial base that best preserves the normal nasal anatomy in a patient with an olfactory groove meningioma. Septal transposition allows for a wide exposure of the anterior cranial base, preserves a nasal septal flap, and eliminates a septal perforation.

**Case Report:** A 39-year-old woman presented with anosmia and a progressively enlarging olfactory groove meningioma on serial imaging. An endoscopic endonasal resection of the tumor was performed. A nasoseptal flap was raised on the left side in the standard fashion. As opposed to performing a large superior septectomy, a superior and an inferior tunnel was made raising the mucoperichondrium in narrow (10 mm) bands along the superior and inferior septum on the right side. Endoscopic scissors were then placed through these tunnels and used to detach the septum superiorly and inferiorly. This allowed the septum to be detached from the anterior skull base but remain adherent to the septal mucoperichondrium in the central portion. Thus, the septum with its attached mucoperichondrium was transposed off the maxillary crest and pushed into the right nasal corridor, remaining out of the surgical field. This was accomplished without destroying septal bone, cartilage, or mucosa. Once the tumor resection was completed, the septum and a

fully intact mucoperichondrium were returned to the midline. On outpatient follow-up, nasal endoscopy the right side of the nasal cavity had completely normal anatomy without septal perforation, and the left side had an intact mucosalized septum. There was no cerebrospinal fluid leakage, and the left-sided nasoseptal flap was well healed and adherent to the cranial base.

**Conclusion:** In select cases, it is possible to maximally preserve the nasal septum when approaching anterior cranial base tumors such as olfactory groove meningiomas. The septal transposition is a useful technique that allows a wide exposure of the anterior cranial base with preservation of the normal nasal anatomy and avoidance of a large septal perforation.

#### 166. The Unilateral Endoscopic Endonasal Transsphenoidal Approach to the Pituitary: A Return to the Beginning for Nasal Preservation

Madeleine R. Schaberg (presenter), Christopher J. Farrell, Mindy Rabinowitz, James J. Evans, Marc R. Rosen (New York, USA)

**Introduction:** The endoscopic endonasal transsphenoidal approach to the pituitary is currently widely employed using the “four-handed” technique, an endoscope positioned in one nasal cavity and the instruments in the opposite nasal cavity. This technique provides a wide working corridor to the sellar region, but it requires the sacrifice of the sphenopalatine artery bilaterally during the sphenoidotomy and precludes the ability to subsequently raise a nasoseptal flap for reconstruction at the time of surgery or during possible future surgeries. The unilateral approach, originally described by Carrau and Jho, can be performed using a single nasal corridor to access the pituitary. This allows not only for improved preservation of nasal anatomy but also preservation of one intact sphenopalatine artery–nasoseptal flap unit.

**Methods:** A retrospective chart review was performed of all patients who underwent skull base surgery over a 1-year period (8/1/10–8/1/11) by the authors.

**Results:** Ten patients were identified whose surgery was performed using only a unilateral nasal corridor. All patients underwent an endoscopic endonasal transsphenoidal approach using image guidance with unilateral entry into one sphenoid sinus and preservation of the contralateral nasal mucosa. All patients underwent preoperative computed tomography (CT) and magnetic resonance imaging (MRI), for surgical planning. The average tumor volume was 13 cm<sup>3</sup> (standard deviation  $\pm$  7cm<sup>3</sup>), and the mean age was 50 years (range, 22–76 years). Pathology included seven macroadenomas (two growth hormone secreting, two ACTH secreting, and three nonsecreting), two Rathke’s cleft cysts, and one meningioma. Immediate postoperative MRI scans demonstrated gross total tumor resection in 9/10 patients, with the sole exception being a planned biopsy of a cavernous sinus meningioma. Complications included one cerebrospinal fluid leak (managed with revision surgery) and one episode of self-limited epistaxis.

**Conclusion:** The endoscopic endonasal unilateral approach to the sphenoid enables improved maintenance of normal nasal physiology and unnecessary sacrifice of structures critical in skull base reconstruction. This approach should be revisited in appropriate cases that do not require extensive bimanual dissection or are anticipated to possi-

bly require a nasoseptal flap in the current surgery. Using this approach also allows for future use of a nasoseptal flap should further surgery be required.

#### 167. The Supraorbital Approach for Removal of Intra-Axial Frontal Brain Tumors: A Technical Note

Leo F. Ditzel Filho (presenter), Nancy McLaughlin, Damien Bresson, Domenico Solari, Amin B. Kassam, Daniel F. Kelly (Columbus, USA)

**Introduction:** The supraorbital (SO) “eyebrow” craniotomy is commonly used to remove extra-axial frontal fossa and parasellar tumors such as meningiomas and craniopharyngiomas. Herein we present the utility and selection criteria for the SO approach to resect intra-axial frontal lobe brain tumors.

**Methodology:** All consecutive patients who underwent a SO craniotomy for an intra-axial tumor were retrospectively analyzed for tumor location, pathology, extent of resection, and complications.

**Results:** Over 28 months, 10 patients (mean age, 67.6 years; 7 women) underwent 11 SO procedures to resect intra-axial brain tumors. Pathology included metastatic carcinoma ( $n = 07$ ), glioma ( $n = 02$ ), and radiation necrosis ( $n = 01$ ). The mean distance of the shortest trajectory to the lesion was 2.4 mm. Gross total or near total removal was achieved in 80% of the cases. There were no new neurological deficits, postoperative hematomas or CSF leaks.

**Conclusion:** The SO “eyebrow” craniotomy is a safe and effective keyhole method to remove intra-axial frontal lobe lesions. Tumors in the frontal lobe, for which the shortest distance is through a frontobasal or orbitofrontal trajectory, are ideal for this route, which allows for minimal disruption of normal brain parenchyma. Deeper intra-axial tumors can also be effectively accessed via this route with excellent clinical outcomes.

#### 168. Surgical Decompression of Skull Base and Orbital Prostate Metastasis

Miguel A. Lopez-Gonzalez (presenter), Gwynett Hughes, Benjamin Rosenbaum, Jorge A. Gonzalez-Martinez (Beachwood, OH, USA)

**Background:** Prostate cancer is the most frequently diagnosed cancer in men, and hormonal therapy has limitations, with prostate cancer cells becoming resistant after several years. Skull metastases from prostate are rare (around 6%), and even less frequent in the skull base.

**Case Report:** A 57-year-old man with history of prostate cancer had a minor head injury 2 months prior to our evaluation, was admitted to an outside institution and diagnosed with a right-sided subdural hematoma based on brain CT scan. The patient was managed with observation only and developed progressive visual loss for a week (right > left). He was found with bilateral papilledema. The brain MRI showed an extra-axial subdural mass with bone involvement and orbit extension. The patient underwent a right frontotemporal craniotomy with orbital decompression and exploration. He later underwent radiation treatment with 3750 cGy in 15 fractions with four fields prescribed to 95% IDL.

**Conclusion:** Prostate cancer frequently causes metastases to bone, but uncommonly to skull and the skull base. Any neurological symptoms or cranial nerve deficits in a

patient with history of prostate cancer will require further workup for prostate metastasis, given the fact that early detection can improve medical and surgical treatment, as well as provide functional recovery.

**169. The Combined Use of Pericranial Flap and Titanium Mesh in Reconstruction of Large Medial Orbital Defects**  
Homere Al Moullan (presenter), David Hiltzik, Priyam Vyas, Peter Costantino (New York, USA)

Large Nasoorbital defects are challenging defects to reconstruct. In the context of chronic infection and inflammation and postradiation exposure, these defects have a high rate of fistula and chronic drainage. Many techniques have been previously described, but none have completely solved this issue.

In our experience, the pericranial flap has been easy to implement and efficacious with the adjunction of titanium mesh in these contexts. In this paper, we present our experience using this technique in two cases of different pathologies where we used the combined pericranial flap and titanium mesh for reconstruction of large bony and soft tissue defects of the naso-orbital region. The first case was a complication of Wegner's granulomatosis of the nasal cavity with bilateral inferomedial large orbital wall defect. The second was a complication of endonasal endoscopic surgery with a unilateral large bony defect.

The vivid blood supply and the versatility of the flap are ideal in this setting. Also, its flexibility makes it suitable for use intraorbitally with no effect on vision, or on ocular movements. Combining this flap with titanium mesh provides more support, which prevents further herniation of any of the orbital contents into the nasal cavity. This combination also has the potential to be used in a myriad of repairs in the midface area.

**170. Endonasal Endoscopic Surgery for Anterior Skull Base Pathologies: A Single Center's Initial Experience**  
Gary L. Gallia (presenter), Douglas D. Reh, Masaru Ishii (Baltimore, USA)

*Introduction:* Over the past decade, there has been tremendous development in endonasal endoscopic approaches to anterior skull base pathologies. Here we review the first 3 years of our experience with purely endonasal endoscopic approaches in the treatment of a variety of benign and malignant pathologies of the anterior skull base.

*Results:* Between February 1, 2008 and February 1, 2011, 22 purely endoscopic procedures were performed for pathologies involving the anterior cranial base. The pathologies included malignant tumors, cephaloceles/CSF leaks, mucocele, meningioma, and hemangiopericytoma. The malignant tumors ( $n = 10$ ) included esthesioneuroblastoma ( $n = 9$ ), sinonasal undifferentiated carcinoma (SNUC) ( $n = 1$ ), and adenocarcinoma ( $n = 1$ ). In all, nine patients with esthesioneuroblastoma and the one patient with the SNUC, a negative margin resection was achieved. In the patient with the adenocarcinoma, this lesion extended intracranially and into the right orbit. Given the patient's age and morbidity associated with an orbital exenteration, a subtotal resection was planned. All 10 patients received postoperative radiotherapy; 3 patients also received adjuvant chemotherapy. The patient with adenocarcinoma developed a spinal metastasis that was treated with radiotherapy. With a

mean follow-up of 23 months, all patients remain without evidence of disease. All patients with cephaloceles/CSF leaks ( $n = 7$ ) underwent successful resection of the cephalocele and skull base reconstruction and perioperative intracranial (ICP) monitoring via a lumbar drain. Two patients had elevated ICP, one treated with diamox and the second with placement of a ventriculoperitoneal shunt (VPS).

With a median follow-up of more than 19 months, none have had a recurrent CSF leak. Three patients underwent endoscopic resection of benign tumors including two meningiomas and one hemangiopericytoma. In one of the meningioma patients, a gross total resection was achieved. In the other patient, a planned subtotal resection was achieved, given the patient's age and her preoperative performance score. Residual tumor was treated with fractionated radiotherapy. In the patient with the hemangiopericytoma, an en bloc resection was achieved. There has been no recurrence or progression in this group of patients. Complications were noted in four patients. Postoperative pneumocephalus occurred in one patient and resolved spontaneously. Two patients developed complications following radiotherapy; one patient developed sinusitis requiring an endoscopic sinusotomy and one patient developed worsening dysosmia compared with her preoperative symptoms. One patient with a very anterior meningocephalocele required additional surgery with an external approach for recurrent frontal sinusitis. There were no cases of postoperative CSF leaks or meningitis.

*Conclusion:* Our series adds to the growing experience of endonasal endoscopic surgery in the treatment of skull base tumors. Additional studies on larger numbers of patients will help define the utility of this approach for patients with anterior skull base tumors.

**171. Study of the Nasoseptal Flap for Endoscopic Anterior Cranial Base Reconstruction**

Carlos D. Pinheiro-Neto (presenter), Henrique F. Ramos, Peris-Celda Maria, Alessandro Paluzzi, Juan C. Fernandez-Miranda, Paul A. Gardner, Carl H. Snyderman, Luiz U. Sennes (Pittsburgh, USA)

*Objectives:* The purposes of this study were to (1) measure the dimensions of the nasoseptal (NS) flap and the anterior skull base (ASB) defect, (2) verify whether the flap is sufficient to cover the defect, and (3) study the anatomy of the septal artery (SA).

*Methods:* After endoscopic craniofacial resection, sufficiency of the flap to cover the ASB defect was assessed. The SA was dissected. The number of branches in the pedicle and the distance between the artery and the sphenoid ostium were noted. Radiologic study analyzing computed tomography scans of 30 patients for comparison among measurements of the NS flap and the ASB defect was performed.

*Results:* In all cases, the flap was sufficient to cover the ASB. Two branches of the SA were found in the pedicle in 71.4%. The distance between the SA and the sphenoid ostium was 9.3 mm. The reconstruction area of the flap (17.12 cm<sup>2</sup>) was larger than the defect area (8.64 cm<sup>2</sup>) ( $P < .001$ ). The difference between the superior length of the flap and the anterior-posterior distance of the defect was <5 mm in 26.7%. Comparison between the anterior flap width and the anterior defect width revealed that in 33% the difference was <5 mm.

*Conclusions:* The dimensions of NS flap are sufficient to completely cover the ASB defect. The anterior edge of the defect presents increased risk for failure in coverage.

Additional width adding the nasal floor mucosa to the flap is important to decrease the risk of gap in the anterior orbit-orbit defect. It is more common to find two branches of the SA in the pedicle.

### 172. Combined Surgical Approaches for Skull Base Chordomas

Maria Koutourousiou (presenter), Stephanie L. Henry, Matthew J. Tormenti, Alexandro Paluzzi, Juan Fernandez-Miranda, Carl H. Snyderman, Paul A. Gardner (Pittsburgh, USA)

**Objective:** Gross total resection (GTR) is the goal of surgery for skull base chordomas. For extensive, invasive chordomas, a single approach is sometimes not enough to achieve this goal.

**Methods:** Among 71 patients with skull base chordomas who underwent endoscopic endonasal surgery (EES) in our Department (period: April 2003–September 2011), 12 were treated with combined open and endoscopic approaches. Medical records and radiologic images were retrospectively analyzed and evaluated.

**Results:** Eight patients were initially treated with combined approaches, while four underwent craniotomy for recurrence after EES. Patients selected for initial management with combined approaches presented with extensive chordomas (mean tumor volume, 66.38 cm<sup>3</sup> vs. 31.58 cm<sup>3</sup> of the whole cohort) and with tumor located in the lower clivus with lateral extension (in six out of eight patients), which is one of the most challenging areas for endoscopic surgery. The eight patients were treated either with a single ( $n = 3$ ) or staged surgery ( $n = 5$ ). EES was combined with transcervical approach ( $n = 4$ ), far lateral ( $n = 3$ ) approach, extreme lateral/transcondylar ( $n = 1$ ) approach, or orbitofrontal approach ( $n = 1$ ). Despite the tumor size, GTR was achieved in three cases, near total (>95%) in four, and subtotal (>85%) in one. Patients who underwent craniotomy for recurrence had initially presented with extensive chordomas (mean volume, 55.67 cm<sup>3</sup>) and had an unsuccessful EES (resection <85% of tumor in three out of four patients). As expected, after a midline approach, residual was located at the most lateral aspects of the tumor; recurrence was then accessed with a lateral approach. The recurrent cases underwent a retromastoid ( $n = 2$ ), subtemporal ( $n = 1$ ), extreme lateral/transcondylar ( $n = 1$ ), or orbitofrontal ( $n = 1$ ) approach. GTR was not possible in these aggressive chordomas.

**Conclusion:** Disease control is related to the extent of chordoma resection. EES, like any other skull base approach, represents a vital part of the neurosurgical armamentarium for the treatment of skull base chordomas. In selected cases, a combined open and endoscopic approach is mandatory to achieve the maximum degree of resection.

### 173. Treatment of a Clival Chordoma Using Magnetic Resonance–Guided, Laser-Induced Thermal Therapy (LITT): Case Report

James C. Barrese (presenter), Pinakin R. Jethwa, Eric L. Hargreaves, Anil M. Shetty, Shabbar F. Danish (Jersey City, USA)

**Introduction:** Chordomas are rare tumors that are difficult to treat and have high recurrence rates despite aggressive therapy. The authors present the first case of a patient with a newly diagnosed clival chordoma in which tumor

ablation was achieved with magnetic resonance–guided laser-induced thermal therapy (LITT). The purpose of this report is to demonstrate the feasibility of this technique and describe the response of this pathology to thermal energy.

**Methods:** A 54-year-old woman presented with difficulty swallowing and changes in her voice. Workup included an MRI that showed an enhancing clival mass extending into the nasopharynx. The diagnosis of chordoma was made after a needle biopsy. After a detailed discussion of treatment options, the patient elected MRI-guided LITT. She underwent placement of the laser catheter into the chordoma via an endoscopic endonasal approach. With real-time MR thermometry monitoring, 12 watts of laser-generated thermal energy was delivered to the tumor for 311 seconds. The patient remained neurologically intact during and after the procedure and was discharged on postoperative day 1. Response to treatment was assessed using serial contrast enhanced MRI scans.

**Results:** The initial volume of the tumor was 1.65 cm<sup>3</sup>. Periprocedural MRI demonstrated a complete thermal ablation of the mass radiographically. The volume of the tumor increased on day 1 to 2.47 cm<sup>3</sup> due to swelling, but then began to retract to 1.34 cm<sup>3</sup> by day 25. At most recent follow-up (136 days postprocedure) the mass is now 0.35 cm<sup>3</sup>. The patient tolerated the procedure well and has had resolution of her symptoms since surgery.

**Conclusions:** The endoscopic endonasal approach to MR-guided laser ablation is both technically feasible and safe. Chordoma cells seem to be sensitive to thermal energy as reflected by the substantial decrease in the size of the tumor post LITT. As a result, this therapy may be a useful alternative in hard-to-reach chordomas, or in recurrent cases that have failed other conventional treatment modalities. Further follow-up will be needed to assess the long-term outcome after LITT and the role for this novel technology in the treatment of chordomas and other CNS neoplasms.

### 174. Concurrent Pituitary Adenoma and Chordoma

Stephen Y. Kang (presenter), Matthew E. Spector, Stephen E. Sullivan, Erin L. McKean (Ann Arbor, USA)

**Objective:** To describe a patient with multiple recurrent pituitary macroadenoma and concurrent skull base chordoma.

**Method:** In a tertiary care academic medical center, a 64-year-old man underwent transnasal transsphenoidal removal of a nonsecretory pituitary macroadenoma. Five months later, he presented with intermittent diplopia, and imaging confirmed extensive recurrent disease. He subsequently underwent transnasal transsphenoidal removal of the mass, and pathology confirmed recurrent pituitary adenoma. One year later, he developed severe headache and diplopia. Imaging revealed a heterogeneous appearing mass in the sella and sphenoid sinus. Retrospectively, two distinct masses could be seen with different MR imaging characteristics, one mass in the suprasellar space and one involving the sphenoid and ethmoid air cells, eroding the clivus. He was again taken to the operating room and no tumor was found in the sella itself via a revision right-sided transsphenoidal approach. Blood and clots were identified in the sella and sphenoid sinus and were removed. These were not sent for pathology. One year later, the patient developed progressive diplopia and progressive left visual loss, and MR imaging showed a large, aggressive pituitary fossa lesion filling the

sphenoid and posterior ethmoid sinus air cells with suprasellar, parasellar, and anterior cavernous involvement, affecting the optic chiasm. He was subsequently referred to the University of Michigan multidisciplinary cranial base team for consideration of further resection. He presented to the operating room for expanded endoscopic radical resection of the recurrent disease.

**Result:** An intraoperative frozen section of the mass favored chordoma. On final analysis, the majority of the specimen contained pathologic findings consistent with chordoma. There also was a small intrasellar fragment consistent with residual pituitary adenoma. Imaging and histopathologic slides are available for presentation.

**Conclusion:** This report highlights the possibility of concurrent skull base neoplasms. Though rare, this possibility should be entertained when the clinical course differs from the natural history of the original pathologic diagnosis.

### 175. Role of Diffusion-Weighted MRI in Clival Chordoma

Robert M. Lober (presenter), Kristen W. Yeom, Nancy Fischbein, Michael S. Edwards, Griffith R. Harsh, Hannes Vogel, Bret Mobley (Stanford, USA)

**Purpose:** Chordoma is a rare notochordal tumor with a proclivity for the skull base and sacrococcygeal region. Poorly differentiated chordoma (PDC), as reported in the pediatric literature, displays more aggressive behavior compared with classic chordoma (CC). We investigated the role of diffusion-weighted imaging (DWI) MRI in evaluating these chordoma types.

**Methods:** Nine patients with clival chordoma (median age, 9.5 years; range, 22 months to 60 years) who had pretreatment DWI MRI (echo planar imaging technique,  $b = 1000$  s/mm<sup>2</sup>, 3 directions) were retrospectively reviewed, after IRB approval. The apparent diffusion coefficient (ADC) of the solid portions of the tumor, exclusive of hemorrhage or cyst, was measured using the region of interest method. Immunohistochemical staining for nuclear Brachyury was performed to confirm chordoma diagnosis. Staining with SMARCB1/INI-1 was performed to distinguish chordoma types. The ADC values of clival chondrosarcoma were assessed in two patients for comparison.

**Results:** All cases of PDC ( $n = 3$ ) were seen in children. The diagnosis of CC ( $n = 6$ ) was made in 4 adults and 2 children. There was a significant difference between ADC values of PDC ( $891 \pm 127$  mm<sup>2</sup>/s) and CC ( $1491 \pm 167$  mm<sup>2</sup>/s) ( $P = 0.001$ ). Chondrosarcoma showed the highest ADC ( $1756 \pm 47$  mm<sup>2</sup>/s), but statistical significance was not assessed due to low sample size. Enhancement characteristics did not distinguish these tumor types.

**Conclusions:** Diffusion MRI may serve as a useful adjunct in assessing clival tumors, particularly in identifying poorly differentiated chordoma. A larger series incorporating diffusion MRI of clival tumors may further define its role in evaluating other tumors such as chondrosarcoma.

### 176. Endoscopic-Assisted Supraorbital Retroinfundibular Approach to the Interpeduncular Fossa: A Cadaveric Operability Study

Chi-Tun Tang, Nishanta B. Baidya (presenter), Mohamed A. Ragae, Mario Ammirati (Columbus, USA)

**Background:** Surgical approaches to the retroinfundibular area (mainly anterosuperior and lateral parts of the anterior incisural space) are challenging; recently, few reports have described endoscopic-assisted approaches to this area.

**Objective:** The purpose of this study is to investigate and evaluate the exposure and operability of these areas provided by an endoscopic-assisted supraorbital approach through the infrachiasmatic window and optical-carotid triangle. We also tested a simulated clipping procedure to assess the surgical maneuverability.

**Materials and Methods:** Six alcohol-immersed cadaveric heads injected with pigmented silicone rubber were prepared for bilateral dissections. After a standard  $3 \times 1.5$ -cm craniotomy was performed at the supraorbital forehead, we advanced the dissection through the following steps: (1) creating the intradural subfrontal corridor, (2) performing the endoscopic anterior clinoidectomy, (3) mobilizing the clinoid segment of internal carotid artery, and (4) drilling the tuberculum sellae. Two angled (0 and 30°) rigid endoscopes with outer diameters of 4 mm (Aesculap, Pennsylvania, USA) were introduced. We compared the exposure and surgical maneuverability of the approach using the microscopic mode alone with the endoscopic-assisted mode. We used an evaluation scale to assess exposure and operability that was developed by our laboratory.

**Results:** We evaluated the exposure and the surgical maneuverability of key anatomical structures of the retroinfundibular area. The structures evaluated included the diaphragma sellae, the dorsum sellae, the posterior clinoid process, the pituitary stalk, the mammillary bodies, the tuberculum cinereum, the oculomotor nerves, the basal pons, the upper trunk of the basilar artery, the superior cerebellar arteries, the posterior cerebral arteries, the posterior communicating arteries, and the basilar bifurcation. The exposure and the surgical maneuverability were significantly higher in the endoscopic-assisted mode ( $P = 0.03$ ).

**Conclusion:** Based on our study, the endoscopic-assisted supraorbital retroinfundibular approach is associated with better performance than the pure microscopic approach. Further clinical information is required to verify the value in practice.

### 177. Intradural Endoscope-Assisted Anterior Clinoidectomy: A Cadaveric Study

Nishanta B. Baidya (presenter), Chi-Tun Tang, Mario Ammirati (Columbus, USA)

**Introduction:** The anterior clinoid process (ACP) is critically related to the clinoidal portion of the internal carotid artery (ICA). The deep location of the ACP makes treatment of vascular and neoplastic lesions related to the ACP challenging. Removal of the ACP is advocated to facilitate treatment of such lesions. However, injury to the clinoidal ICA remains a potential and dreadful complication of ACP removal.

**Purpose:** The aim of this study was to demonstrate an endoscopic-assisted technique to perform intradural removal of the ACP via a pterional approach with continuous visualization of the clinoidal ICA.

**Methods:** Sixteen bilateral pterional dissections were performed in eight glutaraldehyde-embalmed, colored silicone-injected, adult cadaveric heads. Using a standard pterional approach, we performed drilling of the ACP in two stages. Stage 1 consisted of extradural microscopic removal of the sphenoid ridge to gain access to the origin of the ACP. Stage 2, the endoscopic stage, consisted of intradural endoscopic removal of the ACP and mobilization of the clinoidal segment of the ICA. We used 2.7 mm, 0°, and 30° angled endoscopes.

**Results:** In all the specimens, we were able to remove the ACP while at the same time continuously visualizing the clinoidal ICA. The exposure of the clinoidal ICA and of adjoining neurovascular structures was excellent and was accomplished with minimal frontal lobe retraction. Mobilization of the clinoidal ICA led to unhindered exposure of the parasellar region.

**Conclusions:** Endoscopic-assisted ACP removal with continuous ICA visualization was feasible in our model. Continuous visualization of the clinoidal ICA should theoretically decrease the risk of inadvertent ICA injuries. Clinical studies to validate this laboratory study are necessary.

### 178. Endoscopic, Transnasal, Transclival Resection of a Pontine Cavernoma

Matthew R. Sanborn (presenter), Philip B. Storm, Nithin D. Adappa, James N. Palmer, Jason Newman, John Y. Lee (Philadelphia, USA)

**Introduction:** Recent advances in endoscopic technique have made it feasible for surgeons to access vascular lesions of the skull base through the endoscopic, endonasal corridor. Although this approach represents a significant departure from traditional open surgery, the central tenets of vascular surgery remain unchanged. We present our experience with endoscopic endonasal resection of a pontine cavernoma, and we review the growing literature on this topic.

**Clinical Presentation:** A 17-year-old male patient presented with acute onset of headache and facial numbness. Magnetic resonance imaging demonstrated an enhancing lesion presenting to the ventromedial pons consistent with a cavernous malformation. The patient subsequently experienced acutely worsening neurological deficits progressing to complete left hemiparesis and gaze palsy. A purely midline ventral endoscopic, transnasal, transclival approach was used to resect the cavernoma. Postoperatively, he had transient worsening of his left-sided motor function and restricted horizontal gaze. He developed a cerebrospinal fluid leak requiring temporary CSF diversion and a revision of the skull base closure. At last follow-up his hemiparesis had improved, and his MRI demonstrated a radiographic cure.

**Review of the Literature:** Although craniotomy remains the gold standard approach for vascular lesions, a subset of these lesions may lend themselves to endoscopic midline ventral approaches. Endonasal endoscopic approaches have been described in five published case reports—paraclinoid, superior hypophyseal, anterior communicating, vertebral artery, and PICA aneurysms—as well as one report of an intraosseous arteriovenous malformation of the skull base. The chief limitation of this approach remains the need to obtain adequate exposure and hemostasis and to limit postoperative CSF leaks.

**Conclusions:** The endoscopic, transnasal, transclival approach is a novel approach to select vascular lesions of the skull base. A pontine cavernous malformation presenting to the ventral surface can be a safe and effective option for patients, providing the most direct surgical corridor to pontine cavernomas. Recently developed techniques for closure and repair of the skull based defect have minimized, but not eliminated, the risk of CSF leak in these procedures.

### 179. A Composite Mucochondral Flap for Skull Base Repair

Michael Friedman, Christian G. Samuelson (presenter), Craig S. Hamilton (Chicago, USA)

Radical base of skull surgery and aggressive and expanded endoscopic sinonasal procedures have contributed to the need for repair of skull base defects. Current techniques for the repair involve the use of skeletal grafts, soft tissue on a vascular pedicle, and postoperative buttressing with Gelfoam and nasal packing. We describe a modified technique for treating skull base defects using a composite mucochondral flap from the nasal septum.

In this technique, an island of cartilage from the nasal septum is harvested, maintaining its attachment to the overlying mucosa and mucoperichondrium as well as a vascular pedicle. The cartilage is sculpted to snap into the defect and be self-locking while the mucosal segment is kept larger and covers the cartilage. A fat graft may be placed to obliterate dead space. The composite flap is then rotated into position to plug the defect.

A major advantage of this technique is that it provides a solid vascularized skeletal support as opposed to a graft covered by mucoperichondrium. In addition, because the flap is constructed with attached mucosa, there is no need for further tacking, and postoperative buttressing is not typically necessary. Our group has successfully treated five patients with this technique without complication, and all septal donor sites fully healed without issue.

### 180. Deliberate Design of the Posterior Septectomy during Transsphenoidal Endoscopic Skull Base Surgery to Harvest Septal Tissue for Potential Skull Base Reconstruction

Devayani Lal (presenter), Naresh P. Patel (Phoenix, USA)

**Background:** The use of autologous free bone and mucosal grafts in reconstructing small skull base defects not requiring the nasoseptal flap is well described. A posterior septectomy is routinely performed during transsphenoidal endoscopic skull base surgery. However, formal planning of the septectomy to harvest septal tissue (free mucosal and bone grafts) for skull base reconstruction has not been described.

**Objective:** The purpose of this study is to describe a modified technique of posterior septectomy with septal tissue harvest for skull base reconstruction.

**Study Design:** Surgical technique modification was examined.

**Methods:** We describe our modified technique during transsphenoidal skull base approaches.

A nasoseptal flap is not routinely harvested at the outset. Instead, prior to sphenoidotomy, the pedicle is preserved by incising the anterior sphenoid face mucosa inferior to the ostium and reflecting it inferiorly.

The septectomy is planned next, primarily based on required exposure. Within limits, it can be enlarged to harvest larger grafts. The anterior margin is cut, usually 1–1.5 cm, from the sphenoid rostrum, but may extend to the anterior aspect of the middle turbinate. The inferior border is level with the sphenoid floor, preserving the nasoseptal flap pedicle. Superiorly, the limb is cut below the sphenoid roof, preserving olfactory epithelium. A needle tip Bovie is

used for septectomy, cutting through mucosa, bone and contralateral mucosa. The posterior attachment to the sphenoid rostrum is then carefully detached. Septectomy in this fashion yields trilaminar septal tissue harvested en bloc (two free mucosal grafts and one free bone graft, approximately 1–2 × 1–2 cm in size). Small sellar defects can be repaired with this bone, and mucosal grafts can be used to line the sphenoid, bone graft, or an exposed carotid artery to assist with early mucosalization.

**Conclusions:** A simple modification, with deliberate planning of the posterior septectomy and harvest of septal tissue, expands skull base reconstructive options. Free mucosal and bone grafts can be obtained without adding additional morbidity to transsphenoidal endoscopic skull base surgery. It can potentially be used for cases without large defects or high-pressure high-volume CSF leaks, sparing the need for nasoseptal flap or other grafts. With this modification, a nasoseptal flap can still be harvested for reconstruction if needed.

### 181. Anterior Pedicle Lateral Nasal Wall Flap: A Novel Technique for the Reconstruction of Anterior Skull Base Defects

G. Hadad, C. Rivera-Serrano, L. Bassagasteguy, R. L. Carrau (presenter), D. M. Prevedello, J. Fernandez-Miranda, A. B. Kassam, B. A. Otto (Columbus, USA)

**Objectives:** Expansion of the clinical indications for ablative endoscopic endonasal approaches has behooved us to search for new reconstruction alternatives. We present the anatomic foundations of a novel anterior pedicled lateral wall flap (Hadad-Bassagaisteguy 2 [HB2] flap) for the vascularized reconstruction of anterior skull base defects.

**Study Design:** The study consists of an anatomical description, feasibility study, and technical report.

**Methods:** Using a cadaveric model, we investigated the feasibility of harvesting an anteriorly based mucoperiosteal flap from the lateral nasal wall. We then applied the techniques developed in the anatomical laboratory to reconstruct four patients with extensive defects of the anterior skull base. Our experience included two patients with defects resulting from the endoscopic endonasal resection of esthesioneuroblastomas, one patient with an extensive meningoencephalocele of the anterior cranial fossa, and one patient with a large defect of the anterior skull base secondary to closed head trauma. Two of these reconstructions were combined with a Hadad-Bassagaisteguy nasoseptal 2 (HB2) flap.

**Results:** HB2 flaps were harvested and transposed to reconstruct anterior skull base defects in cadaveric specimens, and, subsequently, in four patients. The HB2 flap provided adequate coverage in the cadaveric model, as well as clinically in our four patients. Their postoperative healing was uneventful.

**Conclusions:** The HB2 flap is a feasible alternative for the reconstruction of anterior skull base defects in select patients.

### 182. Posterior Pedicle Lateral Nasal Wall Flap: A New Reconstructive Technique for Large Defects of the Skull Base

G. Hadad, C. Rivera-Serrano, L. Bassagaisteguy, R. L. Carrau, J. Fernandez-Miranda, A. B. Kassam, B. A. Otto (presenter), (Columbus, USA)

**Objectives:** During the last decade we have seen a rapid expansion in the indications for expanded endoscopic

approaches, resulting in larger and more complex skull base defects. Reconstructive developments, however, have lagged behind our extirpative capabilities. As complex clinical scenarios continue to challenge current reconstructive strategies, we are compelled to develop alternative techniques. In this project, we demonstrate the anatomical basis for a new posterior pedicled lateral wall flap (Carrau-Hadad [C-H] flap) for the reconstruction of median skull base defects, and present our early clinical experience.

**Study Design:** The study consists of an anatomical description, technical report, and feasibility study.

**Methods:** Using a cadaveric model, we designed and harvested a posterior pedicle mucoperiosteal flap from the inferolateral nasal wall and nasal floor. We applied the information gained in the anatomical laboratory to reconstruct four patients with transmural defects of the skull base resulting from the endoscopic endonasal resection of one extrasellar pituitary adenoma and three recurrent chordomas.

**Results:** Using a cadaveric model, C-H flaps were designed, harvested, and transposed into various defects of the planum sphenoidale, sella turcica, clivus, and nasopharynx. We were able to use the C-H flap to adequately reconstruct all surgical defects at the clivus ( $n = 3$ ) and sella ( $n = 1$ ). All patients healed uneventfully.

**Conclusions:** Our anatomical dissections and early clinical experience support the use of the posterior pedicle lateral nasal wall flap to reconstruct large ventral cranial base defects in properly selected patients.

### 183. Preservation of Olfactory Function Following Endoscopic Resection of Select Malignancies of the Nasal Vault

Y. K. Ong, A. Solares, R. L. Carrau (presenter), D. M. Prevedello, A. B. Kassam, B. A. Otto, M. Old (Columbus, USA)

**Objective:** The purpose of this study is to elucidate the feasibility of preserving olfactory function in patients undergoing oncologic anterior skull base resection via an endoscopic approach.

**Method:** This is a retrospective case series. All patients underwent a standardized smell identification test.

**Results:** From January 2002 to July 2011, we attempted to preserve olfactory function in nine patients, who required endoscopic resection of various malignancies involving the ipsilateral anterior skull base (six esthesioneuroblastomas, one squamous cell carcinoma, one adenocarcinoma, and one hemangiopericytoma).

In seven patients, the resection included a unilateral endoscopic craniectomy that preserved the contralateral middle and superior turbinates. Two patients underwent resection of the ipsilateral olfactory epithelium as the superior margin of resection. Six patients received adjuvant radiotherapy.

Postoperatively, olfaction was documented in seven patients (three normosmic, four microsmic). All patients are free of recurrence at the original site at a mean follow-up period of 55.7 months (range, 21–101 months). One patient developed metastatic esthesioneuroblastoma to the cervical lymph nodes 4 years after surgery.

**Conclusion:** In select patients, it is feasible to preserve olfactory function without apparent compromise of oncologic outcomes. The success rate depends largely on the extent of the resection, which, in turn, is dictated by the extent of the tumor.

#### 184. Endoscopic Harvest of Fascia Lata Free Flap in a Cadaveric Model

Peter S. Amenta (presenter), Michael Lynn, Tyler Kenning, Troy J. DeRose, Marc Rosen, James Evans (Philadelphia, USA)

Advances in technology and surgical technique have expanded the breadth of pathology amenable to endonasal resection. The avoidance of cerebrospinal fluid (CSF) leaks and adequate repair of skull base defects are critical to the ultimate success of any endoscopic procedure. Traditionally, the fascia lata free flap is harvested during the endonasal procedure through a 10-cm incision. The fascia lata closure has demonstrated a high success rate; however, the harvest may result in a painful and cosmetically unappealing surgical site. As a result, we have developed a minimally invasive endoscopic suprafascial technique for fascia lata harvest in a cadaveric model.

A 2-cm incision was made in the lateral thigh of a cadaver approximately one third of the distance between the femoral greater trochanter and lateral epicondyle. An endoscopic port (endoport) was advanced over a 7-mm high-definition endoscope, and CO<sub>2</sub> insufflation was used to improve visualization in the suprafascial plane. Blunt dissection was performed under direct visualization through the endoport. An endoscopic bipolar scissor was used to make two 1-cm incisions in the fascia lata at the proximal and distal margins of the flap. Taking care to preserve the integrity of the underlying muscle, the scissor was used to connect the incisions, thereby creating a 10 × 4-cm elliptical graft. The graft was removed with standard toothed forceps, and the incision was closed with absorbable suture.

We report our experience with endoscopic fascia lata harvest in a cadaveric model. Our results show that a large graft suitable for the vast majority of dural repairs can be harvested endoscopically through a small incision. Furthermore, the procedure appears to be less traumatic to the surrounding tissue and results in a more cosmetically suitable final appearance. Future investigation is necessary to establish the feasibility of the procedure in live models where active bleeding may complicate the harvest. Long-term follow-up of the cosmetic results and postoperative pain are also needed.

#### 185. Transnasal Completely Endoscopic Resection of Pituitary Tumors Using a Binostril, Four-Handed Technique While Preserving the Potential for Nasoseptal Flap Reconstruction: The Subseptal Approach

Justin M. Sweeney (presenter), Majestic Tam, James T. May, Rohit Vasan, Harry R. van Loveren, Mark H. Tabor (Tampa, USA)

Completely endoscopic transnasal resection of sellar and parasellar lesions is rapidly becoming commonplace. Experienced centers have extended this technique to approach increasingly complex disease. Concomitant improvements in endonasal skull base reconstruction with vascularized nasoseptal flaps have proven invaluable in reducing the associated risk of cerebrospinal fluid (CSF) rhinorrhea. These flaps are pedicled on the posterior septal artery, a terminal branch of the sphenopalatine artery. Traditional approaches to the sella transect this artery during the posterior septectomy, necessitating that the flap be harvested prior to tumor dissection to preserve it as a viable closure option. However, the most

pituitary cases are straightforward and have a low incidence of intraoperative CSF leak. The routine early raising or harvest of nasoseptal flaps in every case seems excessive and is not without morbidity. The authors describe a novel technique for a binostril, four-handed approach to the sella, which preserves the nasoseptal flap and allows for its harvest and use at the time of closure only in the presence of an intraoperative CSF leak. Early results in 15 patients are presented.

#### 186. Impact of Chemotherapy and Radiotherapy on the Success of Cerebrospinal Fluid Leak Repair after Transnasal Endoscopic Resection of Skull Bases Tumors

Marcus V. Ortega Alves (presenter), Nicholas B. Levine, Franco DeMonte, Ehab Y. Hanna, Michael E. Kupferman (Houston, USA)

**Background:** Transnasal endoscopic resection (TER), whether purely endoscopic or endoscopic-assisted, has become the treatment approach of choice for many skull base tumors. Potential benefits of TER include decreased morbidity and improved cosmetic results. One of the major limitations of TER is the management of large dural defects and the need for repair of cerebrospinal fluid (CSF) leaks. This is a major consideration for patients who are treated with neoadjuvant or adjuvant chemotherapy (CTX) and radiotherapy (RTX), as these modalities can impair wound healing and exacerbate surgical complications. With limited studies in the published literature, it is unclear whether TER is associated with an increased risk of failed CSF leak repair.

**Objective:** The objective of this study is to determine the impact of CTX and RTX on the success of CSF leak repair after TER.

**Methods:** We conducted a retrospective chart review of a single institution's experience with TER from 1992–2011.

**Results:** Twenty-eight patients were identified to have CSF leak after TER for malignant skull base tumors. Of these, 18 patients underwent RTX and 9 patients were treated with CTX. All patients required CSF leak repair after cribriform and/or dural resection with mucosal flaps or pericranial flaps. Failed CSF leak repair was noted in three patients (10.7%). These patients showed an increased risk of other neurological sequelae, including altered mental status, seizure, and meningitis ( $P = 0.017$ ). A prior history of RTX or CTX (28.57%) was not associated with the risk of failed CSF leak repair.

**Conclusion:** Adjuvant or neoadjuvant CTX or RTX is not associated with an increased risk of failed CSF leak repair. Our 10% incidence compares favorably with currently published literature. Careful selection of the appropriate candidate for TER can limit the devastating neurological sequelae associated with a failed repair. Moreover, failed repairs can delay the initiation of adjuvant therapies. Successful CSF leak repair can be performed in patients with malignant skull base tumors with an acceptable risk profile.

#### 187. An Institutional Workflow Model for Anatomical Segmentation in Advanced Image-Guided Skull Base Surgery

Stephan K. Haerle (presenter), Michael J. Daly, Harley Chan, Allan D. Vescan, Gelareh Zadeh, Ian J. Witterick, Jonathan C. Irish (Toronto, Canada)

**Introduction:** Advanced navigation systems incorporating augmented reality and critical structure proximity



alerts hold considerable promise for guidance of skull base surgery. However, these approaches face the challenge of being able to provide reliable anatomical segmentation methods that can be efficiently integrated into the clinical workflow. This study evaluates various contouring software methods, imaging data, and technical devices available for the image-guided surgeon.

**Material and Methods:** Preoperative and postoperative image data (CT, MR) from anterior skull base patients (University Health Network) were retrospectively reviewed. Anatomical segmentation was performed using both manual slice-by-slice delineation and semiautomatic segmentation software.

**Results:** Different parameters such as volumetric analysis of a semiautomatic method or the role of proximity alerts were reviewed in this institutional analysis.

**Conclusions:** This study elucidates a potential institutional guideline for workflow in a clinical setting using image-guided surgery, virtual endoscopic visualization and real-time proximity alerts for tracked ablative instruments.

### 188. Combined Endoscopic Endonasal Transorbital Approach with Transconjunctival-Medial Orbitotomy for Excisional Biopsy of the Optic Nerve—a Technical Note

Maria Koutourousiou (presenter), Susan T. Stefko, Alexandro Paluzzi, Matthew J. Tormenti, Juan C. Fernandez-Miranda, Carl H. Snyderman, Joseph C. Maroon, Paul A. Gardner (Pittsburgh, USA)

**Objective:** The fronto-orbitozygomatic (FOZ) approach is traditionally employed for access to the entire orbital cavity from the globe to the orbital apex. The endoscopic endonasal approach (EEA) combined with transconjunctival-medial orbitotomy represents an alternative, minimally invasive technique to achieve the same goal.

**Methods:** A patient with rapidly progressive, asymmetric vision loss underwent EEA for optic nerve biopsy. Due to the undetermined histopathological diagnosis and complete unilateral vision loss, complete resection of the nerve was indicated for diagnostic purposes. A combined endoscopic endonasal transorbital approach with transconjunctival-medial orbitotomy was selected to remove the entire intraorbital length of the optic nerve. Following endoscopic sphenoidectomies, medial orbital decompression, and optic nerve decompression, the orbital cavity was entered through the incised periorbita of the medial orbital wall. The optic nerve was identified and mobilized between the medial and inferior rectus muscles. Through the transconjunctival approach, the medial rectus muscle was isolated and detached from the globe to facilitate globe rotation, optic nerve visualization and optic nerve transection at its attachment to the globe. Through the transorbital EEA, the annulus of Zinn was visualized and transected between the medial and inferior rectus muscle attachments. The optic nerve was identified at the orbital apex and optic canal and was transected. The 2-cm intraorbital segment of the optic nerve was subsequently removed en bloc endonasally through the defect of the medial orbital wall.

**Results:** The patient maintained normal extraocular movements and experienced no complications from the surgery. The postoperative course was uneventful, and the patient was discharged the next day.

**Conclusion:** The transorbital EEA combined with a transconjunctival-medial orbitotomy can be considered the endoscopic equivalent of the traditional FOZ approach with less bone removal, no cutaneous incisions and cosmetic problems, shorter surgical time, faster recovery, and potentially decreased trauma to the orbital structures.

### 189. Endoscopic Transsphenoidal Endonasal Approach for Large Pituitary Adenoma with Extraparasellar Extension

Ali Ayyad (presenter), Jens Conrad (Mainz, Germany)

**Objective:** The transsphenoidal route is a direct and rapid extracerebral approach to the sellar region; therefore, it is the most widely used technique for the processes involving this area. Since its introduction in 1907, it has been subjected to tremendous developments. The endoscope is the latest innovation in the field of optical instrumentation; it allows the “surgeon’s eye” to penetrate the depth and width of the access route.

**Methods:** Over 4 years, from December 2003 to December 2010, we operated on 97 patients (51 men, 46 women) with large pituitary adenomas, 18 with giant adenomas. Fifteen patients had hormone-active tumors (10 GH, 4 prolactinoma, 1 ACTH), and most patients presented with visual disturbances.

**Results:** Total excision was achieved in 86 patients. Of the 15 patients with active adenoma, 11 were cured. Six patients developed recurrence, two developed postoperative bleeding, and four had postoperative CSF rhinorrhea. Eighty percent of patients with visual disturbances showed improvement.

**Conclusion:** The minimum traumatization of the nasal cavity without nasal retractor, the optical advantages of the endoscopic visualization in anatomical orientation and tumor removal, and the early postoperative improve of the patients without nasal packing are obvious advantages of the endoscopic binostril technique.

### 190. Incidence and Management of Epistaxis after Endoscopic Skull Base Surgery

Jeffrey D. Suh (presenter), Marvin Bergsneider, Marilene B. Wang (Los Angeles, USA)

**Objective:** The purpose of this study is to assess the incidence and causes of postoperative epistaxis after endoscopic skull base surgery.

**Setting:** This study was conducted at an academic tertiary care medical center.

**Patients and Methods:** A total of 305 consecutive endoscopic endonasal skull base surgeries were performed at a single tertiary care institution from 2007 to 2011. Surgery was performed for a wide variety of benign and malignant pathologies including sellar tumors (245), meningiomas (17), clival chordomas (9), craniopharyngiomas (5), and others (29). Patient-related characteristics (age, sex, diagnosis, comorbidity level, medical history, medications), operative data, and the incidence and management of postoperative epistaxis were recorded over a 4-year period.

**Results:** The incidence of postoperative epistaxis was 2.5% (eight episodes) in five patients (1.6%). Two patients had a history of hypertension. Median time to epistaxis was 8 days (range, 4–13 days). Three patients were managed

successfully with repeat nasal packing alone, one required cauterization of the sphenopalatine artery, and one patient was taken to the operating room for diffuse mucosal bleeding. The site of bleeding was identified in 2/8 episodes (25%). No patient required blood transfusion or embolization.

**Conclusions:** Epistaxis after endoscopic skull base surgery is infrequent, with an incidence similar to endoscopic surgery for inflammatory conditions. Despite a potential for severe postoperative hemorrhage, the current study demonstrates that bleeds are generally mild, can be treated with nasal packing or simple cauterization, and usually occur in the early perioperative period.

### 191. Evolution of a Microsurgical to Endoscopic Practice for Treatment of Pituitary Tumors and Skull Base Lesions: Importance of Multidisciplinary Team Approach and Learning Curve

Mickey L. Smith (presenter), Smruti K. Patel, Osamah J. Choudhry, Jean Anderson Eloy, James K. Liu (Newark, USA)

**Introduction:** Transnasal surgery for parasellar lesions has existed for nearly a century. With the introduction of the microscope in 1967, Hardy revolutionized microsurgical transsphenoidal surgery, which became standard practice over the next 30 years. More recently, the endoscope has been used to treat pituitary tumors and other skull base pathologies. The advancement of endoscopic skull base surgery has allowed surgeons to gain access to lesions beyond the confines of the sella. In this report, we describe the evolution of our endonasal transsphenoidal practice from primarily a microsurgical to an endoscopic practice over the course of 4 years.

**Methods:** We retrospectively reviewed a prospective database of endonasal cases performed by the senior author from July 2007 to September 2011. In total, 171 patients were divided into two groups. Group A patients ( $n = 73$ ) were operated on prior to July 2009; Group B patients ( $n = 98$ ) were operated on after July 2009. We evaluated the type of technique used (microscope vs. endoscope), types of pathology treated, and CSF leak rates.

**Results:** Over the 4-year course, there was a significant shift from using a microsurgical technique to primarily a fully endoscopic technique (fourfold increase). Microsurgical technique was used in 76.7% in Group A and 6.1% in Group B ( $P < 0.05$ ). A purely endoscopic technique was used in 23.3% in Group A and 93.9% in Group B ( $P < 0.05$ ). There were significantly more pituitary tumors treated in Group A (75.3%) than Group B (40.8%,  $P < 0.05$ ). However, in Group B, there was a significant increase in the number of extrasellar pathologies treated (59.2% vs. 24.7%,  $P < 0.05$ ), including craniopharyngiomas, meningiomas, and sinonasal tumors. There were no significant differences in postoperative CSF leaks between Groups A and B (2.7% vs. 2.0%, respectively).

**Conclusion:** This data represents a significant change in practice patterns from a microsurgical to an endoscopic approach. This is largely due to the senior author's adoption of the endoscopic technique because of its advantages of better illumination, panoramic visualization, and increased access to pathologies beyond the sella. There appears to be a learning curve with endoscopic skull base surgery. With increased experience and using a multidisciplinary team approach, more complex extrasellar lesions can be readily removed with low complication rates.

### 192. Modified Hemi-Lothrop Procedure for Supraorbital Ethmoid Lesion Access

Mark E. Friedel, Shawn Li, Paul D. Langer, James K. Liu, Jean Anderson Eloy (presenter) (Newark, USA)

**Background:** The supraorbital ethmoid (SOE) cell is an accessory ethmoid cell in the frontal area that extends into and pneumatizes superolaterally along the orbital plate of the frontal bone. The outflow pathway of the SOE cell can become obstructed, leading to a SOE mucocele. Given their lateral location, SOE lesions are traditionally treated through external approaches, although some authors have advocated treatment through standard endoscopic routes. We present a case of a large supraorbital ethmoid mucocele treated with a novel modified hemi-Lothrop procedure (MHLP). This technique provides the benefit of an angulated approach to increase lateral visualization and bimanual binostrial instrumentation through a superior septectomy window.

**Methods:** Case report and review of the literature are presented.

**Results:** A 43-year-old gentleman presented with a 5-year history of progressive diplopia and right-eye proptosis. Oculoplastic examination revealed 6 mm of right proptosis, 7 mm of right hypoglobus, and diplopia on upward gaze with slight hypotropia. Nasal endoscopy revealed a rightward deviated nasal septum. CT scan showed a large right SOE mass with significant proptosis of the right eye with marked inferior displacement and minimal lateral displacement. MRI showed a right SOE mass consistent with a SOE mucocele. The patient underwent endoscopic drainage of the SOE mucocele using a MHLP technique. The procedure consisted of a right anterior ethmoidectomy/maxillary antrostomy and an endoscopic Draf IIB with a superior septectomy to gain access from the contralateral nasal cavity and allow bimanual binostrial dissection. The wall between the right frontal sinus and the SOE cavity was resected to combine and enlarge the drainage pathway of these adjacent cavities. Postoperatively, the patient's proptosis was significantly decreased. He maintained full extraocular movement and reported resolution of diplopia. His postoperative CT scan showed widely patent right frontal sinus and SOE cavities.

**Conclusions:** The SOE cell can be difficult to access endoscopically. The modified hemi-Lothrop procedure represents a novel and feasible way to access this area from the contralateral nasal cavity through a superior septectomy window. This approach is useful in addressing difficult-to-access supraorbital ethmoid lesions that may otherwise require more extensive endoscopic or external approaches.

### 193. Endonasal Access to the Upper Cervical Spine—Cadaveric Analysis

Harminder Singh, Robert M. Lober (presenter), Hector Lopez, Marc Rosen, James Evans (Stanford, USA)

**Objectives:** The factors that limit endonasal access to the upper cervical spine have not been fully described. We sought to determine whether endoscope position or patient positioning could augment endonasal exposure of the cervical spine.

**Setting:** In the cranial base dissection laboratory, we used fluoroscopy and endoscopy to determine whether cadaver neck flexion or extension could affect maximal visualization of the upper cervical spine during the endonasal approach.

**Participants:** Ten cadavers without evidence of fracture, severe spondylosis, or previous instrumentation were studied.

**Main Outcome Measures:** Descriptive zones were assigned to cervical spine levels, and endoscopic visualization was simulated with projected lines at 0 and 30 degrees from the endoscope to the cervical spine with various endoscope positions and with the head in neutral, flexed, and extended positions.

**Results:** Flexion or extension of the head alone did not have a statistically significant effect on the extent of endonasal exposure of the upper cervical spine when using our criteria of cervical spine zones. There was, however, a trend correlating the extended position with further endonasal access down the cervical spine. The greatest impact was the concurrent use of a 30° endoscope and neck extension. In addition, more caudal cervical spine levels can potentially be visualized by tilting the endoscope against the piriform aperture.

**Conclusions:** Maximum endonasal exposure of the upper cervical spine was obtained by maneuvering instruments at the fulcrum of the posterior hard palate and the nares rather than changing the position of the head alone. These results complement radiographic morphometric data in our previous study for preoperative assessment and surgical planning.

#### 194. Transorbital Neuroendoscopic Management of Sinogenic Complications Involving the Frontal Sinus, Orbit and Anterior Cranial Fossa

Jae H. Lim (presenter), Maya Sardesai, Manuel Ferreira, Kris Moe (Seattle, USA)

Sinogenic complications involving the frontal sinus, orbit and anterior cranial fossa are often life-threatening and require prompt surgical intervention. Transnasal endoscopic surgery has remained at the forefront of surgical management of sinogenic complications involving these anatomical regions. However, certain areas involved in pathology of the sinuses either cannot be accessed in this fashion, or endanger critical neurovascular structures when transnasal pathways are employed. Therefore, transorbital neuroendoscopic surgery (TONES) was recently introduced to transgress the limits of the transnasal endoscopic surgery. The access that it provides could add additional surgical pathways for treating sinogenic complications involving the frontal sinus, orbit, and anterior cranial fossa. We describe a prospective series of 13 patients who underwent TONES for the management of various sinogenic complications, including epidural abscess, orbital abscess, fronto-orbital mucocele or mucopyocele, as well as subperiosteal abscess presenting with orbital apex syndrome. The primary outcome measurement was the efficacy of TONES in treating these pathologies with single or multiportal technique. TONES provided effective access to the frontal sinus, orbit, and the anterior cranial fossa. All patients demonstrated postoperative resolution of initial clinical symptoms with well-hidden surgical scars. There were no ophthalmologic complications or recurrence of pathology. Based on our experience, TONES appears to provide a valuable addition to current surgical armamentarium for treating selected complications of sinusitis.

#### 195. The Role of Endoscopic Endonasal Surgery in Petroclival Chondrosarcoma

Matthew J. Tormenti (presenter), Alessandro Paluzzi, Maria Koutoutousiou, Juan C. Fernandez-Miranda, Carl H. Snyderman, Paul A. Gardner (Pittsburgh, USA)

**Introduction:** The endonasal corridor has gained popularity as a means for accessing midline pathologies of

the anterior skull base. Its use as a primary treatment modality, as well as in conjunction with open approaches, has led to improved surgical outcomes for some of these. The purpose of this study was to evaluate its use in the resection of petroclival chondrosarcomas.

**Methods:** The charts and radiographs of 16 consecutive patients who underwent an endonasal skull base approach for resection of chondrosarcoma were reviewed. Attention was paid to extent of resection and the need for further therapy.

**Results:** The mean age of the 16 patients was 45.5 years. Four (25%) of the tumors were recurrent tumors that had been previously operated on via craniotomy. Two of these patients also had prior radiation therapy.

Gross total resection was achieved in eight patients (50%), and near total resection was achieved in six (37.5%). One surgery was aborted due to carotid perforator avulsion and significant blood loss. In patients who did not have a gross total resection, the most common place for residual tumor was the inferolateral margins of the resection. Of patients with a residual tumor, one (6.2%) patient required an open operation for recurrence in the parapharyngeal space.

**Conclusion:** The endonasal corridor can safely enable the removal of some select chondrosarcomas of the skull base. In cases where complete removal of tumor is not possible, other surgical corridors, adjuvant radiotherapy, or observation are reasonable treatment options.

#### 196. Endoscopic Endonasal Expanded-Kawase's Approach: Surgical Technique and Outcome

Daniel M. Prevedello, Rodrigo C. Mafaldo, Danielle de Lara, Leo F. S. Ditzel Filho (presenter), Bradley A. Otto, Ricardo L. Carrau (Columbus, USA)

**Background:** Petroclival meningiomas are a challenge in neurosurgery. Multiple approaches have been described to safely remove these lesions. These tumors can engulf many vital structures in the three fossae. The risks of these approaches are discussed extensively in the literature and are associated with hearing loss, facial nerve injury, and spinal fluid leakage.

**Objectives:** The aim of this study is to show the feasibility of endonasal endoscopic expanded approaches to reach multiple skull base compartments, including sella, petrous bone, clivus, and middle and posterior fossae.

**Case Illustration:** A 58-year-old woman had two previous surgeries for resection of a right cavernous sinus tumor at another facility. The first procedure was a pterional craniotomy with biopsy; partial resection of the tumor was followed by radiation.

Unfortunately the tumor recurred, and she had radical resection of the tumor through a combined approach for middle fossa and posterior fossa, with ICA sacrificing by supraclinoid ICA clipping and petrous ICA coiling. The pathology at that time proved it was an atypical meningioma grade II. After that surgery, she ended up with third, fourth, and sixth cranial nerve palsy as well as partial seventh cranial nerve palsy and complete hearing loss on the right side. After 2 years, she had a new recurrence causing brainstem compression. We describe a radical endoscopic endonasal procedure performed to resect this recurrent atypical petroclival-cavernous meningioma.

**Conclusion:** This is an opportunity for a new route to be considered in cases of recurrence after standard approaches. This option represents an alternative approach with less brain retraction.

### 197. Transorbital Neuroendoscopic Surgery of the Middle Cranial Fossa by Lateral Retrocanthal Approach

Robert Oxford (presenter), Randy Bly, Louis Kim, Kris Moe (Seattle, USA)

Transorbital neuroendoscopic surgery (TONES) offers extended lateral endoscopic access to the anterior and middle cranial fossae. It can be used in multiportal combination with transnasal endoscopic approaches to access regions that might otherwise require an open craniotomy. To increase access to the middle cranial fossa, we investigated the use of TONES through the lateral retrocanthal (LRC) approach with ultrasonic bone aspiration (UBA). A cadaver study using five heads with bilateral analysis was undertaken to investigate the feasibility of the approach. Based on the favorable results of this study, we undertook a clinical evaluation of the technique in five patients with middle cranial fossa pathology using TONES and UBA through the LRC pathway. All procedures were successful; the LRC pathway was found to be highly efficacious, with ample room for target manipulation. UBA under endoscopic visualization was found to be highly effective, providing simultaneous irrigation and aspiration with the same instrument. TONES takes full advantage of recent advances in instrumentation and intraoperative navigation, and the LRC approach affords excellent exposure for en face visualization for treatment of lateral skull base lesions and defects of the middle fossa. The use of UBA appears to be rapid, and may provide increased safety over the use of a rotating drill near critical neurovascular structures.

### 198. The Naso-Axial Line: A New Method of Accurately Predicting the Inferior Limit of the Endoscopic Endonasal Approach to the Craniocervical Junction

Philipp Aldana (presenter), Emanuele La Corte (Jacksonville, USA)

**Background:** Endoscopic approaches to anterior pathology of the craniocervical junction (CVJ) have arisen as alternatives to open approaches. Understanding and predicting the limits to the endoscopic approach to CVJ is important in surgical planning. The endoscopic endonasal approach (EEA) is commonly used, thus we sought to develop a method that accurately predicts the inferior limit of this to the CVJ. The method developed was compared with methods currently used to predict the same.

**Methods:** Nine fresh-frozen adult cadaver heads were used for anatomical dissection. Preoperative and postoperative volumetric computerized tomographic scans were performed to compare the naso-axial line (NAL) vs. naso-palatine (NPL, or Kassam, line) used to predict the inferior limit of the EEA to the actual extent of surgical dissection.

**Results:** The mean differences between the NAL and the actual inferior surgical exposure of EEA at the C2 cortex (anterior and posterior) were both 0.3 mm. Anatomically, the actual inferior surgical limit ranged from the dens to the upper half of the C2 body, which matched

that predicted by the NAL. The NPL predicted an inferior EEA limit at a much lower range than the actual—from the lower half of the C2 body to the superior endplate of C3. Using the least squares means (LSM) method to estimate the deviation from postsurgical measurements, we found no difference between the NAL and the actual inferior surgical limit (LSM, 0;  $P = 1.0$ ). In contrast, the NPL predicted a significantly lower EEA limit than the actual surgical limit (LSM, 13.3;  $P < 0.001$ ).

**Conclusion:** The naso-axial line accurately predicts the inferior limit of the EEA, which ranges from the dens to the upper half of C2. This new method can be used in presurgical planning to assess the suitability of the EEA to craniovertebral junction pathology.

### 199. Frontal Sinus Window for Minimally Invasive Access to the Frontal Sinus and Anterior Skull Base

Bradley A. Otto, Ricardo L. Carrau (presenter), Daniel M. Prevedello, Matthew O. Old, Danielle de Lara, Leo F. Ditzel Filho, Rodrigo C. Mafaldo (Columbus, USA)

**Background:** Minimally invasive approaches to the skull base continue to evolve. Although endoscopic endonasal approaches can be used to access the anterior skull base and frontal sinus, lesions in the lateral frontal sinus may be inaccessible. Additionally, lesions located in the lateral confines of supraorbital ethmoid cells may be difficult to reach via traditional endonasal approaches. In these situations, an alternative approach using a frontal sinus anterior table window may provide the most direct, least invasive access.

**Objectives:** Describe the technique and our experience using an anterior table frontal sinus window for minimally invasive access to lateral frontal sinus and anterior skull base lesions.

**Methods:** The anterior table of the frontal sinus is exposed using either a brow incision or blepharoplasty type incision. Dissection is carried down to the periosteum preserving the supraorbital and supratrochlear neurovascular bundles. Using a drill, a 1-cm oval window is created in the anterior table of the frontal sinus. This window can be enlarged as necessary depending on the dissection required. Then, two- to three-handed endoscopic techniques can be implemented to address lesions in the lateral frontal sinus or anterior skull base.

**Results:** We used this technique to address lesions located in the lateral frontal sinus including benign tumors and encephaloceles. We also repaired skull base defects in supraorbital ethmoid cells using this approach. In each case, we were able to preserve normal sinonasal physiology based on clinical examination and postoperative imaging. The location of the window was different in each patient to provide the most direct access to the lesion and address the lesion with the smallest possible window size. To date, we have not had any permanent complications or cosmetic complaints except transient forehead numbness in one patient.

**Conclusions:** The frontal sinus window can provide access to lesions in the lateral frontal sinus and anterior skull base, including supraorbital ethmoid cells. In select cases, this approach may offer the most direct route to the lesion of interest with the least morbidity. Strategically placed incisions minimize visible scars.

### 200. A Visual Introduction to the Adaptation of the Pedicled Flap in Endoscopic Reconstruction of Cranial Base

Houman Pebdani, Soroush Larijani, Idara Edem, Boris Krischek (presenter), Al Vescan, Fred Gentili, Gelareh Zadeh (Toronto, Canada)

The transsphenoidal approach provides a well-established route for ventral skull base surgery and in particular intrasellar pathology. The use of the vascular pedicled flap has effectively countered the complications previously associated with the bone and dural defect produced by this procedure. The purpose of this article is to introduce the various steps of this technique from a surgical perspective with the addition of an interactive video.

Videos and still images obtained from 100 different endonasal endoscopic transsphenoidal procedures, for standard sella pathology and an expanded approach for parasellar and anterior fossa tumors, were used and edited to create step-by-step interactive videos of surgical approach and its surgical nuances.

Teaching of endoscopic techniques is challenging, and simulation models are not readily available at most institutions.

We believe the implementation of this video provides greater insight to the technique and provides an invaluable education tool for residents, fellows, and neurosurgeons who wish to acquire this technique and approach.

### 201. Endoscopic Infratemporal Resection as an Adjunct to Open Middle Fossa Approach for Residual Grade 2 Infratemporal Fossa Meningioma

Sarah Burgin (presenter), Stephen E. Sullivan, Erin L. McKean (Ann Arbor, USA)

Transnasal approaches to the lateral skull base and infratemporal fossa are rapidly evolving, and recently these approaches have been used adjunctively with open approaches to the lateral skull base. Compared with open lateral approaches to the infratemporal fossa, transnasal approaches do not require manipulation of the temporomandibular joint and facial nerve, or retraction of the temporal lobe. Tumors medial and inferior to the critical neurovascular structures in the infratemporal fossa are most amenable to resection through this approach.

A 40-year-old gentleman previously underwent a middle cranial fossa approach for resection of a meningioma of the middle fossa, extending into the epitympanum. A subtotal resection was achieved. Anaplastic elements were noted on pathology, and he was followed with serial imaging over the next 8 years. The tumor grew very slowly, and the patient subsequently developed a near complete facial nerve paralysis. He then underwent a revision middle cranial fossa and transzygomatic approach, but visualization of the tumor was limited inferiorly. Total resection could not be obtained. Six weeks later, a staged endoscopic expanded transnasal approach was used to obtain a gross total resection of his recurrent tumor. Now 6 months out, imaging shows no residual or recurrent disease. He has no persistent nasal crusting, quality-of-life surveys show high scores, and smell testing remains normal.

### 202. Endoscopic Resection of Solitary Fibrous Tumor of the Anterior Skull Base

Phillip Chaffin (presenter), Mathew Hunt, Emiro Caicedo-Granados (Minneapolis, USA)

Sinonasal glomangiopericytomas, formerly called sinonasal hemangiopericytomas, are rare, vascular tumors with predilection for the sinonasal tract. These soft tissue tumors with hemangiopericytoma-like growth patterns are now divided into three categories: (1) solitary fibrous tumors, (2) lesions showing evidence of myoid/pericytic differentiation, and (3) neoplasms that occasionally display hemangiopericytoma-like features (e.g., synovial sarcoma).

Solitary fibrous tumors are tumors of CD34-positive fibroblasts that often show a prominent hemangiopericytoma-like vascular pattern. They are very uncommon in the sinonasal tract, comprising less than 0.1% of all neoplasms. These tumors can be easily misdiagnosed as sinonasal glomangiopericytomas. Here we describe a patient with sinonasal solitary fibrous tumor eroding and extending into the anterior cranial fossa. The patient had previously undergone transnasal endoscopic resection of a tumor described as a glomangiopericytoma, reportedly confined to the middle turbinate. Ten months later, he presented with an intracranial hemorrhage, and MRI demonstrated a mass eroding into the anterior cranial fossa from the nasal cavity with overlying hemorrhage into the left frontal lobe. The patient was treated with a purely endoscopic endonasal anterior craniofacial resection, including the intracranial portion. Complete resection was obtained with negative margins. The skull base was reconstructed using dural substitutes and nasal septal flaps. No postoperative complications were observed. The patient was discharged at postoperative on day 3. Per our knowledge, this is the first reported skull base solitary fibrous tumor treated with a purely endoscopic approach.

### 203. Management and Treatment of Orbital Fungal Sinusitis with Intracranial Involvement

James K. Fortson (presenter), Paul King, Vijaykumar Patel, Gillian E. Lawrence (Tucker, GA, USA)

Fungal sinusitis is being reported more now in the literature than it was previously. Even with increased data and information, the intracranial involvement is still infrequent, but it can be fatal. As such, it is crucial that there is early diagnosis and treatment. Fungal sinusitis can be divided into two main groups, invasive and noninvasive, and the treatment is not the same for both groups. This case report will discuss in detail the presentation of our patient with a careful look at imaging, diagnosis, treatment, and management. It will be shown that the involvement of neurosurgery is critical in cases where there is intracranial extension. Early detection and diagnosis along with medical therapy and surgical techniques, such as endoscopy, have decreased the morbidity and mortality. Prognosis is dependent on the degree of invasiveness of the fungus.

### 204. MRI FLAIR Changes in Total Resection of Olfactory Groove Meningiomas through Expanded Endonasal Endoscopic Approaches

Leo F. Ditzel Filho (presenter), Juan Carlos Fernandez-Miranda, Danielle de Lara, Bradley A. Otto, Amin B. Kassam, Ricardo L. Carrau, Daniel M. Prevedello (Columbus, USA)

*Background:* olfactory groove meningiomas can grow insidiously and significantly compress the adjacent

cerebral structures. One of the main challenges in their surgical management is achieving complete removal without further damage to the frontal lobes.

**Objective:** The purpose of this study is to analyze and describe cerebral edema and FLAIR signal changes in MR imaging of olfactory groove meningiomas totally resected through EEA.

**Methods:** Pre- and postoperative films of 20 consecutive olfactory groove meningiomas completely removed through EEA were reviewed. Tumor volume as well as pre- and postoperative FLAIR signal change volumes, was assessed using the DICOM image viewer OsiriX.

**Results:** Mean tumor volume was 26.2 cm<sup>3</sup> ( $\pm 22.7$ ), mean preoperative FLAIR change volume was 39.1 cm<sup>3</sup> ( $\pm 44.9$ ), and mean postoperative FLAIR change volume was 4.2 cm<sup>3</sup> ( $\pm 5.9$ ). In 1 of the 20 cases analyzed (5%) there was increase of signal changes postoperatively, all other patients demonstrated image improvement.

**Conclusions:** EEA appears to be a safe and effective method for total removal of olfactory groove meningiomas. FLAIR signal changes tend to resolve after tumor resection and do not seem to worsen with this operative technique. Further comparative studies are necessary to determine whether this feature differs from open approaches.

### 205. Jugular Foramen Syndrome as Initial Presentation of Metastatic Lung Cancer

D. M. Hayward (presenter), C. Morgan, J. Biller, B. Emami, V. C. Prabhu (Maywood, IL, USA)

Metastatic involvement of the cranial base and jugular foramen generally presents with headache and lower cranial neuropathy but may escape early diagnosis. In this report, a patient developed a jugular foramen syndrome as the initial presentation of metastatic lung cancer soon after being diagnosed and treated surgically for extracranial atherosclerotic internal carotid artery disease. With the appropriate diagnosis established, he underwent local fractionated radiation therapy and systemic chemotherapy but succumbed to the disease. This presentation analyzes metastatic disease affecting the cranial base and in particular, the jugular foramen, with a discussion of the clinical syndromes that accompany this rare condition.

### 206. Diagnosis and Management of Nasopharyngeal Branchial Cysts

Richard O. Wein (presenter), (Boston, USA)

Nasopharyngeal branchial cysts (NBCs) have been discussed in the literature in only a limited number of publications. Differing from Thornwaldt cysts, NBCs present laterally and arise from the fossa of Rosenmüller and may track superiorly within the bony confines of the eustachian tube. Initially, patients are asymptomatic but may present with aural fullness, unilateral conductive hearing loss, and serous otitis media as the cystic mass grows. Two of our three patients had the lesion incidentally identified at the time of assessment for another diagnosis. In this case series, imaging characteristics and response to treatment are reviewed. A literature search will be performed to summarize the management options for this entity, in addition to reviewing the differential diagnosis for cystic masses on the nasopharynx in the adult population.

### 207. Inflammatory Pseudotumor Involving the Parapharyngeal Space and Skull Base

Sherief H. Garrana (presenter), Erin L. McKean, Lawrence J. Marentette (Oklahoma City, USA)

Inflammatory pseudotumor (IP) is a nonspecific, non-neoplastic inflammatory mass that has been reported to occur in multiple areas of the body. Histologic findings demonstrate varying degrees of inflammatory cellular infiltrates and fibrotic changes. Numerous classification systems exist, although the main groupings are lymphoid, granulomatous, and sclerosing. In the head and neck, it most commonly occurs in the orbit and occasionally will extend to other areas of the skull base. Very rarely do these lesions arise primarily in the skull base and temporal bone without orbital involvement. Treatment options include steroids, surgical resection, and radiation therapy. We report a case of IP involving the left parapharyngeal space; the jugular and hypoglossal foramina; cranial nerves X, XI, XII; the internal carotid artery; and the jugular vein, with bony destruction of the clivus. Oropharyngeal and nasopharyngeal biopsies failed to demonstrate neoplastic process. Subsequent transpalatal transpharyngeal biopsy with subtotal resection also only showed evidence of chronic inflammation. The patient was treated with radiation therapy, with a total of 40 Gy delivered in 20 fractions to the left skull base. Radiation course was completed in November 2009. No change in tumor extent was noted during irradiation. Imaging has not demonstrated any evidence of disease progression following the completion of radiation, and most recent follow-up in August of 2011 with MR imaging continued to show no progression of disease. Given the success of our treatment approach, we conclude that radiation therapy may be a good therapeutic approach for inoperable IPs of the skull base.

### 208. Management of the Nasolacrimal Apparatus in Patients Undergoing Anterior Craniofacial Resection (ACFR) or Maxillectomy

Rahmatullah Rahmati (presenter), Gary Linkov, Jatin P. Shah, Mark Bilsky, Dennis H. Kraus (New York, USA)

**Background:** Patients with tumors involving the anterior skull base, paranasal sinuses, and oral cavity (hard palate and alveolar ridge) often require surgical management that involves the disruption of the nasolacrimal duct. There is limited information in the literature on the management of the nasolacrimal system and its functional outcome in this patient population.

**Methods:** A retrospective chart review was conducted on 129 patients (mean age, 56 years; range, 14–92 years) who underwent an ACFR or maxillectomy with transection of the nasolacrimal tract at Memorial Sloan-Kettering Cancer Center between 1992 and 2010. Patient and tumor characteristics, surgical management, and outcomes were examined.

**Results:** Of the 129 patients, 74 (57%) were men, and 15 (12%) presented with the symptom of epiphora. The tumor site of origin was the nasal cavity or ethmoid sinus in 88 (68%), maxillary sinus in 25 (20%), and other in 16 (12%) patients. Tumors were malignant in 113 (88%) cases and staged as follows: T1–12 (11%), T2–23 (20%), T3–18 (16%), T4a–44 (39%), and T4b–17 (15%). ACFR was performed in 44 (34%) patients, maxillectomy in 64 (50%) patients, and both in 21 (16%) patients, with a mean follow-up time of 51 months (4–178 months). A nasolacrimal stent was placed at the time

of initial surgery in 80 (62%) patients. Subsequent dacryocystorhinostomy (DCR) was performed in 16 (12%) patients. Epiphora at any point postoperatively occurred in 49 (38%) cases, with a mean time to epiphora of 11 months (0–74). Only six patients (5%) reported epiphora on last follow-up. The placement of a nasolacrimal stent was not statistically significant in reducing the incidence of epiphora or the need for DCR. The main complications related to nasolacrimal stenting included infection in 11 patients and stent dysfunction in 8 patients.

**Conclusions:** Surgical management of tumors via an ACFR and maxillectomy may involve transection of the nasolacrimal duct, and postoperative epiphora can occur in a substantial number of patients. Although nasolacrimal stenting did not show reduction in epiphora rates or need for DCR, only a few patients experienced persistent epiphora, and stent-related complications were relatively minor.

### 209. Middle Cranial Fossa Approach: Pathologies and Complications

Kimon Bekelis (presenter), Ziev Moses, Symeon Missios, Jim Saunders, Kadir Erkmen (Lebanon, NH, USA)

**Introduction:** The middle cranial fossa approach is an established surgical technique used mainly for vestibular schwannoma resection. We present our institution's experience with the approach, including the range of pathologies treated and the morbidity associated with it.

**Methods:** The electronic records of all the patients that have undergone a craniotomy with middle fossa approach in our institution from 2005 to 2010 were retrospectively reviewed.

**Results:** Forty-one patients (22 men) with a mean age of 51.7 years (range, 21–74 years) underwent middle fossa approaches in our institution. Immediately preoperatively 36 patients (88%) underwent lumbar drain placement for brain relaxation. Eight patients additionally had orbitozygomatic craniotomies and seven had extended middle fossa approaches (with drilling of the petrous apex) to enhance exposure. Pathologies treated include vestibular schwannomas, tegmen tympani defects with spontaneous CSF leaks, petroclival meningiomas, middle fossa meningiomas, nasopharyngeal carcinomas, trigeminal schwannomas, chordomas, giant pituitary adenoma with cavernous sinus extension, myopericytoma, cholesterol granuloma, synovial sarcoma, temporal bone fracture with facial nerve compression, basilar apex aneurysm, facial nerve schwannoma, and epidermoid. There were no postoperative CSF leaks or GSPN injuries. Two patients had complications related to the postoperative approach, with one developing an epidural hematoma necessitating reoperation and evacuation, and one requiring laminectomy for removal of a retained lumbar drain fragment. The mean hospital stay was 7.1 days (range, 3–23 days).

**Conclusions:** The middle fossa approach, with orbitozygomatic extension or drilling of the petrous apex, when needed, can be used to provide exposure to a wide range of pathologies with acceptable morbidity and complication rate.

### 210. Anatomic Causes for Trigeminal and Facial Nerve Dysfunction in Patients with Vestibular Schwannomas

Albert D. Tu (presenter), Ryojo Akagami (Vancouver, Canada)

**Background:** Vestibular schwannomas are relatively common intracranial neoplasms with a range of clinical

presentations. Most patients complain of cochlear and vestibular dysfunction; however, a proportion will also demonstrate neuropathies of other cranial nerves. The most frequent non-vestibular-cochlear nerves affected are the trigeminal and facial nerves. The cause of has never been clearly delineated. These cranial nerve symptoms have, however, been shown to be a significant source of morbidity and detriment on quality of life.

**Objective:** The purpose of this study was to determine specific anatomical causes for trigeminal and facial nerve dysfunction in patients with vestibular schwannoma.

**Methods:** A retrospective chart review of patients with a surgically resected vestibular schwannoma in 2007 was carried out from a single surgeon's database. All patients were reviewed for clinical presentation and imaging findings on presentation. Only patients with high resolution MRI studies that were available for review were included in the analysis. Patients with evidence of neurocutaneous syndromes were excluded.

**Results:** A total of 64 patients were included in the study. Evidence of trigeminal and facial nerve dysfunction was found in 41% and 35%, respectively, and 23% had evidence of both. Patients were much more likely to present with sensory rather than autonomic or motor dysfunction of each nerve. Patients with lesions larger than 2.60 cm in maximal diameter and a predominantly cisternal location of their lesion were more likely to present with trigeminal nerve dysfunction, whereas patients with lesions predominantly in the internal auditory canal were more likely to present with facial nerve dysfunction, regardless of size.

**Conclusions:** These findings would suggest that the trigeminal nerve undergoes a stretch neuropraxia as it contacts the tumor in the subarachnoid space, whereas the facial nerve appears to undergo a compressive neuropraxia at the level of the IAC. Furthermore, differences in motor and sensory function sensitivity to tumor contact may reflect perceptible differences in dysfunction, or a primary difference in sensitivity of neuronal fibers to extrinsic trauma.

### 211. Microvascular Decompression Surgery: National Trends, Outcomes, and Complications

Anand Veeravagu (presenter), Bowen Jiang, Robert Arrigo, Paul Kalanithi, Melanie Hayden, Chirag Patil, Maxwell Boakye, Shivanand Lad (Palo Alto, USA)

**Objectives:** The purpose of this study was to explore national trends, outcomes, and complications associated with microvascular decompression (MVD) surgery for neuralgias of cranial nerves V, VII, and IX using the Nationwide Inpatient Sample (NIS) data from 2003 to 2008.

**Introduction:** MVD has become a well-accepted and standard surgical technique for the treatment of various cranial neuropathies. Low mortality and morbidity rates have been associated with high-volume hospitals and with high-volume surgeons. Few national database studies have been published about the trends, outcomes, and complication patterns associated with MVD over the past decade.

**Methods:** The NIS database was used to identify MVD procedures in the United States from 2003 to 2008. Patients were grouped by demographics, cranial nerve indications, comorbidity score, insurance type, and hospital size.

**Results:** The national sample included 2,311 MVD procedures with 1,923 performed for trigeminal neuralgia,

349 for hemifacial spasm, and 39 for glossopharyngeal neuralgia. National demographics for the procedure included 71% younger than 65 years of age; 62% women; 60% White; and comorbidities, measured by Elixhauser score, of 0 = 42%, 1–2 = 50%, 3 or more = 8%. Mortality and complication rates were 0.26% and 6.77%, respectively. Complications included neurologic (1.3%), wound infection/leak (1%), vascular injury (0.5%), dysphagia (0.6%), and hearing loss (1.8%). MVD for glossopharyngeal neuralgia was associated with higher complication rates, hospital charges, and length of stay. Overall, hospital charges averaged \$48K with a 3.3-day length of stay.

**Conclusion:** This study summarizes national estimates of indications, outcomes, and complications associated with MVD procedures.

## 212. Expanded Endonasal Endoscopic Approaches to Skull Base Lesions in Pediatric Patients

Vafi Salmasi (presenter), Xuewei Xia, Masaru Ishii, Douglas D. Reh, Gary L. Gallia (Cleveland, USA)

Skull base tumors are uncommon in pediatric patients and account for less than 10% of all skull base pathologies. These lesions have traditionally been approached via transcranial or transfacial corridors. Over the past decade, however, there has been a dramatic increase in endoscopic approaches in the treatment of skull base pathologies, including those in pediatric patients. Over the past 3 years, the authors have treated six patients under the age of 21 with an expanded endonasal endoscopic approach. Pathologies included a juvenile nasopharyngeal angiofibroma in two patients and an aneurysmal bone cyst, leiomyoma, CSF leak, and chordoma, each in one patient. Given the size of the lesion, a staged resection was performed in two patients. All patients tolerated the procedures well. The patient with the chordoma had third and sixth cranial nerve palsies postoperatively, which have been improving. A gross total resection was achieved in 4/5 tumor cases and a near total resection was achieved in the patient with the chordoma. There has been no recurrence noted in the four tumor cases in which a gross total resection was achieved. The patient with the chordoma is currently undergoing proton beam radiotherapy for his residual tumor remnant. There were no postoperative CSF leaks and no episodes of meningitis. Our series contributes to the growing body of literature supporting the role of expanded endonasal endoscopic procedures in selected pediatric patients with skull base pathologies.

## 213. Klippel-Feil Syndrome in Association with a Craniocervical Arachnoid Cyst: A Unique Case Report

Imad S. Khan (presenter), Osama Ahmed, Jai D. Thakur, Cedric Shorter, Bharat Guthikonda (Shreveport, USA)

**Introduction:** Klippel-Feil syndrome, or Brevicolis, is a complex congenital disorder caused by the improper segmentation of the cervical vertebrae. We present a very rare case of a patient with Klippel-Feil syndrome who presented with an intradural arachnoid cyst at the craniocervical junction.

**Clinical Presentation:** A 46-year-old woman presented to our clinic in April 2010 with complaints of progressively worsening headaches and dizziness for 18 months. She also demonstrated mild upper extremity weakness bilaterally. MRI revealed fused cervical vertebrae and a dorsal intradural

arachnoid cyst at the craniocervical junction, extending down to the second cervical level. Due to worsening symptoms, the patient was scheduled for surgery.

A midline skin incision extending from the superior aspect of theinion to the level of C4 was made, and subperiosteal dissection exposed the posterior suboccipital region and the upper cervical spine. A defect was found between the lower occipital bone and the fused upper cervical vertebrae. To minimize bony destabilization, the dura was opened through this defect without removing any bone from the upper spine or the lower occipital bone. On opening the dura, a large cystic fenestrated mass draining a clear fluid was encountered. The adhesions between the cyst, the lower brainstem, fourth ventricle, and vertebral artery were carefully excised under direct visualization by a 0-degree endoscope that was introduced through the defect. Partial excision of the cyst wall was performed. There were no complications intraoperatively, and the patient has remained symptom free for over a year postoperatively with good radiological decompression.

**Conclusion:** We report a unique association between a craniocervical arachnoid cyst and Klippel-Feil syndrome. To our knowledge, no other cases of this association have been reported in the literature. Arachnoid cysts should be part of the differentials in the presence of worsening myelopathic symptoms or pain in patients with Klippel-Feil syndrome.

## 214. Custom-Tailored Anterior Petrosectomy within Surgical Approaches to the Petroclival Region

Aikaterini Patrona (presenter), Robert Behr (Fulda, Germany)

**Objective:** This study analyzes the use of anterior petrosectomy in approaches to the petroclival area.

**Methods:** Eight cases of petroclival meningiomas and one case of a petrous apex cholesterol granuloma, which were all operated on via an anterior petrosectomy in combination with anterior or posterior approaches to the petroclival region, were retrospectively analyzed. All cases underwent surgery under electrophysiologic monitoring of cranial nerves and brainstem function. The basis of this approach selection, its benefits, and its risks were assessed.

**Results:** Anterior petrosectomy was performed via a middle fossa subtemporal or frontotemporal approach in five cases and combined with a posterior presigmoid approach in four cases. Simpson grade I-II resection was achieved in six cases. Simpson grade III resection was achieved in two cases. The cholesterol granuloma was completely removed. No mortality or decrease in Karnofsky performance score was observed at the time of the last follow-up examination (mean follow-up, 4 years).

Four patients presented preoperatively with abducens palsy, and three patients presented with a trigeminal neuralgia combined with sensory deficit. Gait disturbance was seen in four patients with brainstem compression, which resolved after surgery. Before the operation, all patients were House-Brackmann facial nerve function grade I. At the last follow-up examination, there were no patients with persistent abducens palsy, two patients had a persistent slight trigeminal affection, and facial nerve function was grade I in 6 patients and grade II in three patients. There was one case of delayed hypacusis.

In the five cases of subtemporal or frontotemporal approach, a custom-tailored anterior petrosectomy was performed intradurally and facilitated reaching Meckel's cave



and the upper and middle clival region. The vein of Labbé was preserved in all cases. There were two cases of minor hemorrhage in the temporal lobe and one case of meningitis via a preexisting mastoiditis. There were no cerebrospinal fluid fistulas.

**Conclusions:** Performing a custom-tailored anterior petrosectomy enhanced petroclival exposure and the degree of tumor resection, especially in the area of the petroclival junction, apical petrous bone, posterior cavernous sinus, and Meckel's cave without a higher rate of intraoperative risks and complications.

### **215. Middle Cranial Fossa Approach for Repair of Tegmen Tympani Defects and Temporal Encephalocele**

John A. Braca (presenter), Vikram C. Prabhu, Sam Marzo (Maywood, IL, USA)

Defects in the floor of the middle cranial fossa (MCF) are commonly reported in cadaveric studies and encountered in surgical practice. Dehiscence of the bone overlying the petrous internal carotid artery (ICA), greater superficial petrosal nerve (GSPN), or geniculate ganglion is reported in 15–20% of cadaveric studies. Defects in the tegmen, if accompanied by dural defects, can result in MCF encephaloceles or cerebrospinal egress into the middle ear, with the risk of seizures, hearing loss, or meningitis. We have adopted an MCF approach to the repair of these dural and tegmen defects with excellent results.

This series of seven individuals presented with middle ear fluid collections associated with subjective hearing loss confirmed by audiometry. Cranial CT or MR imaging demonstrated defects in the tegmen tympani. The average age was 56 years (range, 26–67 years) with a M:F ratio of 6:1. Most defects occurred on the left side. The most common presenting symptoms were ipsilateral hearing loss with ipsilateral otorrhea. All patients were treated via a standard MCF approach and repair of the dural defect with a Durepair (Medtronic) graft and synthetic polymer glue (DuraSeal, Covidien). All cases but one had successful resolution of the CSF otorrhea and improvement in hearing. One patient developed a recurrent CSF otorrhea requiring a repeat surgery and developed delayed staphylococcus aureus meningitis that improved with steroids and antibiotic therapy. Facial nerve monitoring was universal, and there were no instances of facial nerve injury or malfunction. Prophylactic lumbar drain placement was used in the first four patients of the series and was eventually abandoned due to its non-use postoperatively and also to allow a CSF cushion under the temporal lobe during surgery. The middle cranial fossa approach allows for optimal exposure and treatment of CSF leaks due to tegmen defects with excellent outcomes.

### **216. Jacques Benignus Winslow (1669–1760): Unlocking the “Jewel Box” of the Skull Base**

Jai D. Thakur (presenter), Ashish Sonig, Imad S. Khan, Anil Nanda (Shreveport, USA)

What drew accolades for Dwight Parkinson in the 20th century was originally meticulously dissected over 200 years ago by Jacques Benignus Winslow (JBW) at the anatomical theaters of Jardin du Roi, Paris. Ironically, Jacques Benignus Winslow's claim to remembrance is strongly critiqued for coining the epochal misnomer “Sinus Cavernofi,” known as the Cavernous Sinus. However, acknowledging his uniquely

descriptive treatise on the human anatomy, published as *Exposition Anatomique de la Structure du Corps Humain* in 1734, redeems the misplaced nomenclature.

Following the work of the medieval anatomists Galen and Vesalius, the duplicature of dura (sinus) around the sphenoid bone was for the first time explored in a human. Explicitly, JBW stated in his treatise that the cavernous sinus is “of a very particular kind,” known to contain numerous vessels and nerves apart from blood; it was a novel documentation. Additionally, the Danish-born French anatomist precisely documented the relationship of the trigeminal nerve with the folds of dura overlying cavernous sinus. Other highlights of his contribution to the neurosurgical anatomy include his description of the cervical portion of the sympathetic nervous system and first effective anatomical study on spine for mobility and function.

Surprisingly, what became a point of criticism in the 20th century modern microneurosurgery era was his analogy of the cavernous sinus to the spongy substance in “spleen and corpora cavernosa of the urethra,” henceforth, the name Cavernous Sinus. This vignette directs to elucidate the remarkable work of the Professor of Anatomy, Physiology, and Surgery who sparked a transformation into the evolution of neurosurgery.

### **217. Symptomatic Adult Chiari I Malformation: Posterior Fossa Morphometric Analysis and Clinical Outcomes**

Jai D. Thakur (presenter), Rishi Wadhwa, Ashish Sonig, Shihao Zhang, Imad S. Khan, Josh Martin, Anil Nanda, Bharat Guthikonda (Shreveport, USA)

**Introduction:** The data on correlation of posterior fossa morphometric analysis (PFMA) in adult Chiari I Malformation (CIM) with the extent of tonsillar herniation (EOTH), syrinx formation, and clinical outcomes are lacking. The objective of this study is to elucidate the same and, additionally, assess the role of EOTH and syrinx formation on clinical outcomes.

**Methods:** Symptomatic adult patients ( $\geq 21$  years old) who underwent surgery for CIM from 2001 to 2010 were retrospectively analyzed ( $n = 23$ ). Adults with acquired CIM or having EOTH  $< 5$  mm were excluded from the study. Comparative posterior fossa morphometric analysis (PFMA) was done with normal adult controls ( $n = 23$ ). The patients were further divided into four groups; Group 1(syrinx), Group 2(no syrinx), Group 3 (EOTH  $< 15$  mm), and Group 4 (EOTH  $\geq 15$  mm) for intergroup analysis. Good outcome was defined as improvement in preoperative KPS score at follow-up (mean, 10 months).

**Results:** The mean age of the patients was 38 years. In the comparative PFMA, length of the supraocciput was shorter in CIM patients than control (35 mm vs. 41 mm,  $P = 0.0004$ ), whereas the anteroposterior diameter (APD) of foramen magnum was larger in CIM patients than controls (41 mm vs. 37.5 mm,  $P = 0.02$ ). In the intergroup analysis, no variable, including EOTH, was significantly different between Groups 1 and 2. The angle between the supraocciput and the cerebellar tentorium was significant in the patients who underwent posterior fossa decompression with duraplasty. Postoperative CSF leaks were seen in 13%. Good outcomes were noted in 55% of patients, although no patient showed deterioration in KPS score. EOTH and presence of syrinx were not associated with clinical outcomes.

*Conclusion:* Significant difference in length of the supraocciput and APD of foramen magnum in our study suggests altered bone development in adult CIM patients. The cohort of patients having tonsillar herniation  $\geq 15$  mm had higher angle between the supraocciput and cerebellar tentorium. EOTH and presence of syrinx were not associated clinical outcomes.

### 218. Harvey Cushing's Treatment of Skull Base Infections at the Johns Hopkins Hospital, 1896–1912 Aravind Somasundaram, Shaan M. Raza, Courtney Pendleton, Alfredo Quinones-Hinojosa (presenter), (Baltimore, USA)

*Introduction:* Harvey Cushing began his career in a time period when strict surgical protocols were evolving, which allowed new avenues of surgical procedures, enabling him to apply the concept of sterility to develop safe and effective methods in neurosurgery. This is the first report of Harvey Cushing's management and treatment of skull base infections while he was at Johns Hopkins.

*Methods:* Through the courtesy of the Alan Mason Chesney Archives, the Johns Hopkins surgical records from 1896 to 1912 were reviewed.

*Results:* Twelve patients underwent operative intervention for infections of the skull base. The mean age was 28.5 years (range, 5 to 63 years). Seven patients (58%) were female. Infections involving the skull base were acquired from the following initial diagnoses: empyema antrum (3), cerebral abscess from infected skull fragments (1), cerebral lobe abscess from spread of a tooth abscess (1), frontal sinusitis (2), mastoid defect (2), necrosis (2), and a compound depressed fracture (1). The mean length of stay was 15.8 days (range, 4 to 34 days). Postoperatively, nine patients were discharged in "well" or "good" condition, two patients died, and one patient remained the same.

*Conclusion:* Cushing used meticulous irrigation technique in treating skull base infections, stemming from his laboratory research regarding appropriate irrigation fluid in physiological experiments. In this series, Cushing used postoperative drainage in only four patients, demonstrating his understanding that unnecessary drainage could potentially lead to infection or other problems. His careful evaluation of patients, application of laboratory findings, and adherence to sterility helped Cushing create a foundation in successfully treating skull base infections.

### 219. Effect of Previous Sinonasal Surgery on Long-Term Radiographic Incidence of Sinus Disease in Patients Following Endoscopic Skull Base Surgery Darshni Vira (presenter), Adam S. DeConde, Marilene B. Wang, Marvin Bergsneider, Jeffrey D. Suh (Los Angeles, USA)

*Objective:* The purpose of this study was to determine whether prior history of sinonasal surgery affects the incidence of long-term radiographic sinus disease after endoscopic skull base surgery.

*Study Design:* A retrospective review was conducted at a university medical center.

*Methods:* All patients that underwent a transnasal transsphenoidal endoscopic approach to the skull base with both preoperative and postoperative imaging greater than 6 months after surgery were identified. Lund-Mackay

scores for CT images and an analog scoring system for MRI were used to stage all images. Change in preoperative and postoperative imaging scores were calculated and compared between patients with and without a history of a previous sinonasal intervention (i.e., septoplasty, transnasal transsphenoidal skull base surgery, or endoscopic sinus surgery).

*Results:* Eighty-five patients were included in the study, 37 patients without a history of prior surgery and 20 patients with a history of prior surgery. Patients with a history of prior surgery had worse mean preoperative imaging scores compared with the group undergoing primary surgery in the left maxillary sinus (difference = 0.5 vs. 0.1,  $P = <0.01$ ), left frontal (difference = 0.1 vs. 0.0,  $P = 0.05$ ), and left sphenoid (difference = 0.2 vs. 0.0,  $P = <0.01$ ), and right sphenoid sinuses (difference = 0.3 vs. 0.0,  $P = <0.01$ ). The mean postoperative changes in radiographic scoring of sinusitis differed between patients with prior surgery and those undergoing primary surgery in the right anterior ethmoid (difference = -0.05 vs. 0.3,  $P = 0.02$ ), left posterior ethmoid (difference = -0.3 vs. 0.1,  $P = 0.01$ ), right posterior ethmoid (difference = -0.3 vs. 0.2,  $P = 0.03$ ), and left sphenoid sinus (difference = -0.05 vs. 0.2,  $P = 0.04$ ). Patients with a prior sinonasal surgery showed no increase in incidence of radiographic sinusitis in the postoperative MRIs. In contrast, patients with no history of prior sinonasal surgery had worse radiographic scores in the right anterior ethmoid, right posterior ethmoid, left and right maxillary, and left and right sphenoid sinuses ( $P \leq 0.01, 0.03, 0.02, < 0.01, 0.02$ , respectively).

*Conclusion:* Patients with a history of sinonasal surgery show no increased incidence of radiographic evidence of sinusitis after endoscopic transnasal transsphenoidal skull base surgery.

### 220. Isolated Meckel's Cave and Cavernous Sinus Amyloidomas Mimicking Central Skull Base Tumors W.W. Chang (presenter), M. E. Jentoft, J. J. Van Gompel, J. E. Hammack, T. J. Sebo, M. J. Link (Rochester, USA)

*Objective:* Rarely, non-neoplastic pathologies can mimic tumors of the skull base. Increased morbidity could result if empiric treatment is undertaken based on a radiographic presumed diagnosis alone.

*Methods:* We present the case of a 39-year-old woman who presented with a 10-year history of slowly progressive left facial numbness with associated trigeminal neuralgia. Four years prior to her presentation, she developed right facial numbness and neuralgic pain, which became intractable and severe. In addition, she reported intermittent diplopia that eventually prompted imaging, which revealed abnormal enhancement and fullness involving bilateral Meckel's caves and cavernous sinuses. Imaging of the entire neural axis was otherwise normal. CSF analysis and systemic workup for cancer or inflammatory or infectious etiologies were unrevealing. Preoperatively, the differential diagnosis included inflammatory and neoplastic processes.

*Results:* The patient underwent a right frontotemporal craniotomy and subtemporal exploration of the right Meckel's cave. Firm, avascular tissue was discovered adherent to the trigeminal nerve and ganglion and surrounding dura. Histopathological studies showed entrapment of the ganglia by amyloid and amyloid deposition within the microvasculature with characteristic apple-green birefringence.

Mass spectroscopy detected a peptide profile that was consistent with light chain amyloid, kappa subtype. Hematologic workup was subsequently pursued and showed no evidence for underlying myeloma, lymphoma, or systemic amyloidosis.

*Conclusion:* We present a very rare case of amyloidomas of bilateral Meckel's caves and cavernous sinuses causing progressive neurologic deficits. Although extremely rare, primary amyloidoma should be considered in the differential diagnosis of central skull base tumors.

### 221. Identification of MRI Biomarkers and Histopathological Alterations in Response to Combination Therapy with Antiangiogenic Agents and Radiation in a Murine Model of Glioma Tumor

Shahzad Jalali, Warren Foltz, Kelly Burrell, Caroline Chung, Gelareh Zadeh (presenter), (Toronto, Canada)

*Introduction:* Combinatorial therapy using radiation therapy (RT) and antiangiogenic agents (AA) holds great promise in treatment of gliomas; however, the timing, sequence, and duration of the combination therapy has yet to be established. As a result, there is a growing need to develop noninvasive, reproducible, and quantitative biomarkers of response to therapy. This study aims to identify multi-parametric MRI biomarkers that can effectively determine tumor vascular changes in response to AA and RT.

*Methods:* We compared results between two AAs (Sunitinib and VEGF-Trap) in combination with RT in pre-clinical glioma models. Intracranial murine glioma models were generated by injection of human glioma cell line into NOD/SCID mice. Mice were treated with AA alone, RT alone, or AA+RT, and some received no treatment for control. Serial multi-parametric MRI analysis included (1) T2-weighted RARE, (2) diffusion-weighted imaging (DWI), (3) DCE-MR, (4) T1 quantification using a saturation recovery RARE (SR-RARE), and (5) contrast-enhanced T1-weighted RARE anatomical imaging at baseline and treatment day 3, 7, 10, and 14. Data analysis included the measurement of initial area under the signal intensity curve at 60 seconds (iAUC60); Ktrans, Kep, and Ve for dynamic contrast-enhanced (DCE) MRI; and apparent diffusion coefficient (ADC) maps for diffusion-weighted imaging. Correlative immunohistochemical analysis was performed using proliferation, hypoxia, and endothelial markers.

*Results:* We demonstrated a significant reduction in Ktrans (an index of vascular permeability) in the RT and RT+AA groups. This finding is corroborated by a reduction in tumor vascular density and vascular diameter. We found that ADC (reflective of tumor cellularity and extracellular water content) is significantly increased in RT versus non-RT groups and paralleled by diminished tumor cell proliferation and increased intercellular space. VEGF-Trap treatment had a greater effect on tumor growth, tumor vessel density, and tumor vessel permeability compared with Sunitinib. Combination treatment showed a prolonged effect on reducing tumor growth and vascular density compared with RT or AA alone.

*Conclusion:* The results of this study identify novel biomarkers of response to combination therapy that can be used efficiently to schedule the sequence and extent of AA and RT. Future work will focus on validating these biomarkers in clinical trials for patients with gliomas.

### 222. Jugular Foramen Schwannomas: Single Institutional Experience of 28 Cases

Ashish Suri (presenter), Sumit Bansal, Manmohan Singh, Ashok K. Mahapatra (New Delhi, India)

*Background:* Jugular foramen schwannomas are rare. Only a couple of series involving a large number of cases have been reported.

*Objective:* In the present study, we aimed to analyze the clinical characteristics, surgical approaches, and outcomes for patients undergoing treatment for jugular foramen schwannomas via retrospective analysis of departmental records.

*Methods:* Data for 28 patients treated for jugular foramen schwannomas in the Department of Neurosurgery at the All India Institute of Medical Sciences between January 2001 and December 2010 were analyzed.

*Results:* Most patients were in the fourth decade of life, with the duration of symptoms ranging from 1 month to 13 years. A skull base approach was used in every surgically treated case. Of the 19 patients for whom radiological follow-up data were available, complete tumor excision was achieved in 17 cases. Follow-up ranged from 3 months to 59 months (mean, 32 months). One patient died and three had permanent morbidity in the form of facial nerve palsy.

*Conclusion:* We conclude that jugular foramen schwannomas are best treated by total surgical resection, which yields acceptable results with low rates of mortality and permanent morbidity.

### 223. Endoscopic Approach to Malignant Tumors of the Skull Base

Brian W. Rotenberg, Jason Franklin (presenter), (London, ON, Canada)

*Introduction:* Endoscopic skull base surgery has for the most part focused on treatment of benign tumors where benefits of endoscopic surgery over open approaches have been well established. Specifically, improved visualization of benign tumors such as inverted papillomata allows for more directed excision with less morbidity. Malignant tumors of the sinonasal tract and skull base have often been considered not amenable to endoscopic resection due to the inability to obtain adequate resection margins. However, this notion is being challenged in the current study.

*Methods:* Retrospective cases of malignant tumors removed via endoscopic technique were reviewed.

*Results:* Over a 2-year period, six malignant tumors were resected using a fully endoscopic technique from various anatomical subsites in the nose. The case histories, surgical approaches, complications, and outcomes are reviewed and compared with historical literature.

*Conclusion:* With appropriate selection of patients and tumors, a fully endoscopic technique can safely be used to resect sinonasal and skull base malignancies.

### 224. Utility of 18-FDG-PET in the Initial Diagnosis and Workup of Sinonasal Malignancy

Vijay R. Ramakrishnan (presenter), Alexander G. Chiu, James N. Palmer, David W. Kennedy, Bert W. O'Malley (Aurora, CO, USA)

*Introduction:* The utility of 18-FDG-PET has been gradually defined for most head and neck cancers, and is

frequently used for surveillance after therapy for sinonasal malignancies. PET scanning has not been extensively studied in the initial diagnosis of sinonasal malignancy, but may prove helpful for diagnosis and treatment planning. The aim of this study is to determine if PET scanning can accurately diagnose malignant sinonasal lesions and identify the presence of regional or distant metastasis.

**Methods:** A retrospective chart analysis was conducted of 36 cases of sinonasal malignancy in patients who underwent PET scan at the time of diagnosis. Maximum standard uptake values (SUV<sub>max</sub>) were recorded for the primary site as correlated with CT and/or MRI, and the detection of metastasis was documented.

**Results:** Thirty-six patients with sinonasal malignancies underwent diagnostic whole-body PET or PET-CT scans; 30/36 had a mean SUV<sub>max</sub> of 13.9 (range, 3.2–58.0). Three patients were found to have intensely avid uptake in which the SUV<sub>max</sub> was not documented, and three had no uptake in the region of their malignancies. Whole-body PET scan at tumor presentation detected metastasis in 25% (9/36).

**Conclusions:** The use of PET scanning has become more prevalent in head and neck cancer. For diagnosis of sinonasal malignancy, it appears to be quite reliable, although false-negatives may occur. Metastasis was detected in 25% of patients, suggesting a role for PET scanning in the diagnosis and treatment planning of malignant sinonasal lesions.

### 225. Late-Term Presentation of Metastatic Renal Cell Carcinoma to the Sinonasal Cavity

Aaron K. Remenschneider (presenter), Stacey T. Gray, Peter Sadow (Boston, USA)

Renal cell carcinoma is a relatively rare tumor, accounting for 3% of all adult malignancies. Metastatic disease is theorized to occur through hematogenous spread and to occur most often to bone, lung, and liver. However, the head and neck area has been reported as a site of metastasis in up to 15% of patients. Metastatic disease tends to present at or near the time of initial diagnosis, with only a handful of cases reporting metastatic disease greater than 10 years after primary tumor treatment. Sinonasal metastases often present with nasal obstruction and epistaxis, and these symptoms should raise concern for metastatic disease in any patient with a nasal mass and history of renal cell carcinoma. Workup should include pre-biopsy imaging. As these lesions are highly vascular, biopsy should be performed in a controlled setting. Pathologic specimens will demonstrate clear cytoplasm and show cells arranged in nests. AE1, AE3, and CAM 5.2, as well as RCC antigen staining, are positive. Once the diagnosis is established, local radiation therapy has been the treatment of choice, with or without concurrent chemotherapy. Surgical resection of the mass has been controversial, and usually reserved for debulking after primary radiotherapy.

We present the case of a 53-year-old gentleman with a 4-month history of left-sided nasal congestion and facial pressure without epistaxis. Greater than 10 years prior to presentation, he had undergone a right nephrectomy for a T1 renal cell carcinoma that required no further therapy. On examination, nasal endoscopy was remarkable for a mass in the left nasal cavity. A CT scan revealed a vascular, expansile polypoid soft tissue mass within the region of the left superior turbinate and sphenoid recess, extending into the sphenoid sinus and choana. It measured 4×3×2 cm and exhibited bony remodeling along the medial maxillary wall.

The initial biopsy resulted in extensive bleeding, and pathology was suggestive of a benign process, such as hemangioma. Therefore, preoperative embolization and subsequent excision of the mass was performed. The entirety of the mass was removed endoscopically en bloc with minimal intraoperative bleeding. The final pathology was consistent with renal cell carcinoma. The patient received postoperative radiation therapy and is completely disease free 1 year after resection of the metastasis.

As a rare entity, renal cell carcinoma metastatic to the sinonasal cavity has been traditionally treated with radiation with or without chemotherapy. We report a patient who underwent preoperative embolization, complete surgical resection of the mass, and postoperative radiation, who is currently free of disease.

### 226. Ganglioneuroma of the Skull Base Presenting with Multiple Cranial Nerve Deficits: A Case Report and Review of the Literature

Peter C. Revenaugh, Joseph Scharpf (presenter), (Cleveland, USA)

**Objective:** With this study, the authors aim to present a case of skull base ganglioneuroma presenting with cranial nerve deficits and to review the current literature regarding head and neck ganglioneuromas.

**Methods and Results:** A 60-year-old gentleman was admitted to an academic institution for sudden onset of neck pain, hoarseness, and dysphagia. He had deficits of both cranial nerves X and XII at presentation. A gadolinium-enhanced MRI revealed a 5 by 1.4 cm fusiform-enhancing lesion enlarging the right jugular foramen extending along the upper cervical spine and along the posterior aspect of the carotid sheath. A CT-guided biopsy was nondiagnostic, and systemic evaluation including PET imaging was negative for a primary malignancy. The patient underwent serial imaging, and then, due to persistent symptoms, a combined transmastoid and transcervical approach to the jugular foramen with complete resection of the parapharyngeal space lesion located on the sympathetic chain. His postoperative course was uneventful with a return of swallowing ability but without reconstitution of his presenting cranial nerve functional loss. Histopathologic examination was consistent with a ganglioneuroma. His serial preoperative imaging studies and intraoperative photo documentation are presented.

**Conclusions:** Ganglioneuromas are benign neurogenic tumors arising from autonomic ganglia. They commonly occur within the posterior mediastinum, retroperitoneum; they rarely occur on the neck. There are a limited number of reports of parapharyngeal ganglioneuromas at the skull base in the English language literature, and none to our knowledge presenting with these cranial nerve deficits. It is important to consider tumors derived from the sympathetic nervous system when approaching parapharyngeal lesions.

### 227. Transcervical Double Mandibular Osteotomy Approach to the Infratemporal Fossa

Stewart I. Adam, Ketan R. Bulsara, Roger Lowlicht, Benjamin L. Judson (presenter), (New Haven, USA)

**Objective:** In this study, we propose an alternative to the traditional transmandibular lower lip and chin splitting approach for transcervical exposure of high infratemporal

fossa and parapharyngeal space tumors involving the carotid canal and jugular foramen. The proposed osteotomy configuration allows improved rotation of the mandible and transcervical access to high skull base lesions.

**Methods:** We present two cases of high skull base tumors removed transcervically with anterior and posterior segmental mandibulotomies preserving the mental nerve and without a lip or chin incision.

**Results:** Making the posterior osteotomy in an inverted “L” configuration is necessary so that the coronoid process does not prevent rotation of the mandible out of the visual field. Both patients had complete tumor resection with access to the carotid canal and jugular foramen and functional preservation of the mental nerve and marginal branch of the facial nerve. Neither patient had malocclusion or other dental complications from the approach.

**Conclusions:** This modification on a double osteotomy technique is useful for providing transcervical access to high infratemporal fossa or parapharyngeal space tumors. It avoids the traditional chin or lip incision and preserves the mental and facial nerves.

### 228. Factors Contributing to Delay in Diagnosis of Sinonasal Natural Killer/T-Cell Lymphoma

David Jung (presenter), Stacey T. Gray (Boston, USA)

Extranodal natural killer/T (NK/T)-cell lymphoma is an aggressive disease that frequently presents in the sinonasal cavity. NK/T-cell lymphoma is much more common in Asia than the United States. As the disease frequently presents with nasal obstruction and mucosal inflammation, in its early stages NK/T-cell lymphoma may mimic chronic rhinosinusitis and other inflammatory disorders. We present two cases, one of a 30-year-old Mexican woman and one of a 34-year - Vietnamese man, where the diagnosis of NK/T cell lymphoma was initially delayed because the patients were being treated for chronic rhinosinusitis. Both patients were subsequently treated with radiation and have no evidence of recurrence. We discuss the potential factors contributing to the delay in diagnosis in these two cases. Although NK/T-cell lymphoma is rare in the United States, early referral to an otolaryngologist and low threshold for biopsy in suspicious cases may facilitate rapid diagnosis of this and other less common inflammatory and neoplastic diseases involving the nasal cavity and paranasal sinuses.

### 229. Schwannomas of the Nasopharynx and Pterygopalatine Fossa

Michael Shohet, Shira Koss (presenter), (New York, USA)

We report a rare case of nasopharyngeal schwannoma in a 40-year-old Japanese woman that was successfully excised completely using an endoscopic approach. For contrast, we report a large pterygopalatine fossa schwannoma excised completely using an endoscopic approach in a 73-year-old woman. Schwannomas are benign, well-encapsulated peripheral nerve sheath tumors. They can occur throughout the body with 45% of cases occurring in the head and neck and less than 4% of cases arising in the nasal cavity and paranasal sinuses. Only a handful reportedly originates in the nasopharynx. Nasal schwannomas can have a highly variable presentation and variable histologic and cranial nerves findings, with the most common symptom being progres-

sive unilateral nasal obstruction. Schwannomas are classically radioresistant with treatment based on total tumor excision. The nasopharynx is, however, a notoriously difficult area to access surgically due to its central location, surrounding facial skeleton and skull base, great vessels, and cranial nerves. The traditional surgical approach for this region has been open, including anterior, lateral, and inferior approaches with the anterior approach of lateral rhinotomy as the most common. These approaches, however, provide limited access or significant morbidity, including fistulas, trismus, and cosmetic deformities. Minimally invasive endoscopic resection of this region has been increasingly used as it offers comparable efficacy to open approaches with better visualization, cosmesis, safety, and more rapid healing. In this presentation, the signs and symptoms of nasopharyngeal masses will be reviewed, cranial nerve findings will be discussed, and the varying histologies of schwannoma of the nasal cavity and paranasal region will be detailed.

### 230. Metastatic Disease to the Clivus Mimicking a Clival Chordoma

Adam S. DeConde (presenter), Darshni Vira, Marvin Bergsneider, Marilene B. Wang (Los Angeles, USA)

**Objective:** This study presents two cases of clival metastases, which presented as clival chordomas, and reviews the literature of this rare phenomenon.

**Study Design:** Two cases from a university medical center are reported, as well as a review of the literature.

**Methods:** The history, radiology, and pathology of two patients with clival metastases are presented and the literature is reviewed for this rare clinical entity.

**Results:** Case 1: A 52-year-old woman with no significant past medical history presented with diplopia and was found to have a right sixth cranial nerve palsy. Imaging was obtained and demonstrated a clival tumor measuring 1.8 × 2.2 × 2.3 cm with MR imaging consistent with a chordoma. The patient was taken for endoscopic resection via a transnasal transsphenoidal approach, and the tumor was resected successfully without complication. Intraoperative frozen section analysis showed findings consistent with olfactory neuroblastoma, but metastatic carcinoma could not be ruled out. Final pathology demonstrated mucinous colloid type adenocarcinoma. A postoperative PET/CT scan revealed left breast and axilla hypermetabolism as well as numerous metastatic foci throughout the axial skeleton. A biopsy of the lesion on the breast revealed invasive mammary carcinoma with mucinous colloid features.

Case 2: A 62-year-old woman with a history of a leiomyosarcoma and clival chordoma, which were both treated with surgical resection and radiation 4 years prior, presented to the neurosurgical department with an intermittent right sixth nerve palsy. MR imaging was obtained that showed a clival mass consistent with a clival chordoma. The patient was taken to the operating room and underwent an uncomplicated endoscopic resection of the clival mass. Final pathology revealed metastatic leiomyosarcoma.

**Conclusion:** To date, there are only 34 previously reported cases of metastatic disease to the clivus. Although clival metastases are extremely rare, they are an important part of the differential diagnosis of clival masses. Clival metastases can occur in the context of a known history of a distant malignancy; however, clival metastases can be the

presenting symptom of a distant malignancy and must be maintained in the differential diagnosis regardless of past medical history.

### **231. Intraoperative Hypertensive Crisis Due to a Catecholamine-Secreting Esthesioneuroblastoma**

Vafi Salmasi (presenter), Adam Schiavi, Brent A. Orr, Douglas W. Ball, Zev A. Binder, Masaru Ishii, Gary L. Gallia (Cleveland, USA)

*Objective:* The authors report the case of a patient with a catecholamine-secreting esthesioneuroblastoma who developed an intraoperative hypertensive crisis.

*Clinical Presentation and Management:* A 56-year-old man with a past medical history significant for hypertension was referred to our center for a residual esthesioneuroblastoma. A staged expanded endonasal endoscopic approach for a craniobasal resection was planned. At the conclusion of the first surgical procedure and following amputation of the tumor from the skull base, a hypertensive crisis occurred. Additional workup revealed elevated levels of blood and urinary catecholamines. The patient was pretreated with an alpha adrenoceptor blocker. The second stage of surgery was performed 4 weeks later, which resulted in a negative margin resection of the tumor. Serum levels of catecholamines following this resection were normal. On immunohistochemical analysis of the tumor, the tumor cells were found to be positive for tyrosine hydroxylase.

*Conclusion:* Although uncommon, esthesioneuroblastomas may produce clinically significant catecholamine secretion. This case highlights a patient who developed an intraoperative hypertensive crisis due to a catecholamine-secreting tumor. Catecholamine production should be considered in the differential diagnosis of unexpected extreme hypertension during surgical resection of esthesioneuroblastoma.

### **232. Giant Proliferating Pilar Tumor of the Scalp: A Minimal Risk Approach**

Christopher H. Rassekh (presenter), Kelly M. Malloy, Tom Thomas, Jason Brandt, Xiaowei Xu, Ara A. Chalian (Lafayette Hill, PA, USA)

A 61-year-old man presented with a large scalp mass of more than 30 years duration. He reported recent rapid growth, leading him to seek medical attention. On examination the lesion was approximately 20 cm in diameter with a wide base and a bulky protuberant appearance; the patient described himself as having a horned or "Viking helmet" appearance. CT imaging showed no abnormality of the underlying calvarium but was suggestive of extension of tumor through the galea in some areas. Biopsy was suspicious for proliferating pilar cell tumor. Given this rare but benign neoplasm diagnosis, the size of the disfiguring tumor, and the patient's comorbid status (anticoagulation for cardiac disease), we decided to resect the mass with limited margins to rule out malignancy definitively and treat the bulky lesion. Raney clips proved instrumental to maintaining hemostasis during the resection in this anticoagulation-requiring patient. The periosteum was preserved except for a few small areas where the tumor appeared to be very close to it. Because we needed to finalize the tumor type and assess margin status, we opt-

ed to avoid committing to a definitive flap or skin graft reconstruction and reconstructed the large scalp wound with an INTEGRA dermal regeneration template (Plainsboro, NJ) as a temporizing measure. Ultimately, all margins were negative, the diagnosis confirmed to be benign, and the patient was counseled regarding definitive reconstruction. In the short interim between the resection and his postoperative visit, remarkable wound healing had occurred and the decision was made to observe the wound without further reconstruction. Indeed, the patient opted to forgo additional reconstructive procedures as he was pleased with his result and did not want to miss further time at work.

The unique aspects of managing this case are presented in keeping with the theme of the meeting, Minimizing Risk. Our management of this high comorbidity patient with a massive rare neoplasm led us to investigate other conservative measures in such patients with scalp lesions and various lesions at other sites in the head and neck.

### **233. Sinonasal Adenocarcinoma: A Single Surgeon's Experience.**

Sachin Gupta (presenter), Homere Al Moutran, Priyam Vyas, David Hiltzik, Peter Costantino (New York, USA)

*Background:* Malignant sinonasal neoplasms are rare, and most tumors are diagnosed at an advanced stage. Treatment is primarily surgical, whether through an anterior craniofacial resection or a minimally invasive endoscopic approach. Given the rarity of sinonasal adenocarcinoma, there are no established management guidelines. The aim of this study was to review a surgeon's experience with sinonasal adenocarcinoma.

*Methods:* A retrospective chart review of patients with head and neck adenocarcinoma from 1/1/03–8/1/2011 was performed. Nine patients with sinonasal adenocarcinoma who underwent primary surgery through an anterior craniofacial resection or transnasal endoscopic resection were included in the study. Data regarding recurrence, salvage surgery, adjuvant therapy, and current evidence of disease were reviewed.

*Results:* Of the nine patients with sinonasal adenocarcinoma, six (67%) underwent anterior craniofacial resection and three (33%) underwent transnasal endoscopic resection. All patients underwent adjuvant therapy, with four (44%) undergoing only radiotherapy, and five (56%) undergoing both radiotherapy and chemotherapy. Recurrence was found in four patients (44%). There was no statistically significant correlation between the extent of primary surgery and rate of recurrence. All patients were followed up with alternating PET scans and MRIs every 3 months for the first 2 years. All four patients with recurrent disease were diagnosed early, underwent salvage surgery, and are clinically free of disease at a mean follow-up time of 22.5 months (range, 3–40 months).

*Discussion:* Sinonasal adenocarcinoma is a rare tumor and there are no established management guidelines. Depending on the extent of disease, surgical therapy can be effectively performed through either an anterior craniofacial approach or endoscopic approach. The high rate of recurrence, which is found in the literature, highlights the tumor's aggressive behavior and the need for careful surveillance.

**234. Primary Cranial Angiosarcoma: Long-Term Survival Is Feasible with Multidisciplinary Management**

Bharat Guthikonda (presenter), Osama Ahmed, Cedric Shorter, Imad Khan, Jai Thakur, Majed Jeroudi, Anil Nanda (Shreveport, USA)

*Introduction:* Angiosarcomas are high-grade endothelial tumors remarkable for their rarity and malignant behavior. Central nervous system involvement with angiosarcoma has rarely been described and arises from mesenchymal elements of the cranium. Cranial angiosarcoma is extremely rare and appears to have an extremely poor overall prognosis. We describe a multidisciplinary approach to managing cranial angiosarcoma that has led to a good neurological outcome and survival greater than 3 years in a pediatric patient. We supplement this with a review of the existing literature regarding this rare and usually highly aggressive tumor.

*Methods:* We present a 16-year-old male who was first noted to have a right-sided parietal subgaleal and cranial mass that was biopsied in 2008. Pathology was initially thought to be a Kaposiform hemangioendothelioma. The patient subsequently underwent chemotherapy with vincristine. The patient did well until early 2010 when he suffered a right-sided intraparenchymal intratumoral hemorrhage. At this time, the original pathological diagnosis was revisited and, on further review and consultation, the biopsy from 2008 was upgraded to the more malignant diagnosis of angiosarcoma. The patient recovered from this hemorrhage and subsequently underwent a second round of chemotherapy using vincristine, cyclophosphamide, and actinomycin. The tumor continued to progress despite this treatment, and he developed extensive skull deformity with massive bilateral fronto-temporoparietal angiosarcoma.

At this point, more definitive surgical intervention (which was previously thought to be too risky due to the extent and vascularity of the tumor) was reconsidered. Preoperative embolization of a large portion of the blood supply of the mass was performed. Total removal of bilateral subgaleal and cranial tumor was performed the day following embolization. The patient tolerated the extensive surgery well and was discharged on POD 6.

The patient is currently in the process of completing radiation therapy to the entire tumor bed. This will be followed by a monoclonal antibody-based chemotherapy regimen to which the patient is naive. He has clinically done very well with no neurologic deterioration and long-term survival.

*Conclusion:* We highlight the successful management of cranial angiosarcoma in the pediatric population using a multidisciplinary approach. With the combined efforts of pediatric oncology, radiation oncology, interventional neuroradiology, and neurosurgery, long-term survival (>3 years) is possible with this aggressive pathology

**235. Analysis of 223 Brain Tumor Patients Treated at a Level 1 Trauma County Medical Center**

Daniel T. Nagasawa (presenter), Marko Spasic, Winward Choy, Heather M. Garcia, Andy Trang, Bob Shafa, Duc Duong, James Ausman, Marvin Bergsneider, Linda Liao, Duncan McBride, Isaac Yang (Los Angeles, USA)

*Introduction:* Modern brain tumor therapy requires multidisciplinary teams for effective treatment. County-directed Level 1 Trauma medical centers are specifically

geared to care for acute trauma and indigent populations. In this unique study, we compare the brain tumor characteristics and follow-up data at Harbor-UCLA Medical Center.

*Methods:* A retrospective chart review was performed for every brain tumor treated with neurosurgery between July 2006 and December 2010. All patients had their gender, age, tumor pathology, follow-up, and outcome survivals aggregated for analysis. Inclusion criteria were: (1) follow-up data reporting survival and tumor recurrence, (2) documented brain tumor outcomes, and (3) adequate mortality follow-up data.

*Results:* In total, 271 patients met the inclusion criteria and had quantifiable outcome data following brain tumor treatment. The mean age at time of surgery was 46.9 years, with an average follow-up time of  $1.5 \pm 0.8$  years. Common skull base tumors included meningiomas (22.4%), pituitary adenomas (22.4%), and acoustic neuromas (5.1%). Average Karnofsky Performance Score (KPS) was slightly improved in the immediate postoperative interval versus preoperative (71.1 vs. 68.0) assessment, but this difference was not statistically significant. A significantly greater proportion of Hispanic (11%) and African American (3.4%) brain tumor patients were treated when compared with the local population ( $P = 0.001$ , and  $P = 0.035$ , respectively).

*Conclusion:* Our data suggest that skull base brain tumor neurosurgery is an essential need, even at County Medical Centers targeting trauma care. Our analysis indicates that neurosurgical intervention for skull base brain tumors may be effectively and safely used with good follow-up within this population, and that ethnic disparities within this setting may be an important topic for further investigation.

**236. Rare Skull Base Benign Tumors**

Mihaela Cristiana Tatu (presenter), (Bucharest, Romania)

Many different tumor types originate from or extend into the base of the skull, which is the sloped area behind the eyes and nasal cavities that forms the “floor,” or base of the skull. The spinal cord, multiple nerves, and the major blood vessels of the brain and head and neck pass through holes (foramina) in the skull base. Not all tumors in the skull base are malignant, but even benign tumors can cause symptoms or threaten the health and well-being of the patient.

Because of their location and proximity to other vital structures, skull base tumors present unique challenges for surgeons. Recent advances in diagnostic and surgical techniques have made the area more accessible to surgery, providing new treatments for these patients.

The author presented a rare case of a benign tumor of a skull base in an elderly male patient without clinical symptoms.

**237. Neuronavigation in Endonasal Pituitary and Skull Base Surgery Using an Auto-Registration Mask without Head Fixation: An Assessment of Accuracy and Practicality**

Nancy McLaughlin (presenter), Ricardo L. Carrau, Amin B. Kassam, Daniel F. Kelly (Santa Monica, USA)

*Introduction:* Intraoperative navigation is an important tool used during endonasal surgery that typically requires rigid head fixation. Herein, we describe a navigational technique using an auto-registration mask without head fixation.

**Methods:** Prospective evaluation of a surface auto-registration mask used without rigid head fixation in 12 consecutive endonasal skull base procedures was performed with patients positioned in a horseshoe head holder. We assessed the accuracy by recording the surface registration error (SRE) and target registration error (TRE). The time required for installation and the occurrence of system failure were noted. The system's accuracy was validated using a deep target viewed with the endoscope.

**Results:** We evaluated this technique in 12 consecutive endonasal cases performed by a neurosurgeon and ENT team. The surgeries treated macroadenomas (9), a chordoma (1), a craniopharyngioma (1), and a sinonasal melanoma (1). Median time required for registration and accuracy verification was 84 seconds (interval, 64 to 129 seconds). The mask stayed on the patient throughout the procedure. The mean SRE was 0.8 mm (interval, 0.6 to 0.9). The mean TRE was  $0.9 \pm 0.7$  mm and  $1.0 \pm 0.8$  mm, measured respectively at the beginning and end of each case. In every case, the system was judged accurate by the surgeons using the sphenoid keel or an intrasphenoidal bony septation as a deep target for internal validation. No system failure occurred.

**Conclusion:** A facial surface auto-registration mask maintained in place throughout surgery without rigid head fixation allows excellent operational accuracy in endonasal pituitary and skull base surgery. This navigational technique is practical, reliable, and noninvasive.

### 238. Applications of Transoral, Transcervical, Transnasal, and Transfacial Corridors for Robotic Surgery of the Skull Base

R. L. Carrau (presenter), E. Ozer, D. M. Prevedello, B. A. Otto, M. Old (Columbus, USA)

**Background:** Robotic surgery has emerged as an important tool that affords excellent three-dimensional (3D) visualization and two- to three-handed surgery (robotic arms) most commonly through the natural transoral corridor (transoral robotic surgery [TORS]). TORS has facilitated the performance of highly complex surgeries in areas of the upper aerodigestive tract that are relatively difficult to access, including the oral cavity, oropharynx, hypopharynx, nasopharynx, supraglottis, glottis, parapharyngeal space, and infratemporal fossa. Morbidity, operative time, and time of hospitalization are superior to those associated with open approaches. Similarly, several feasibility studies have suggested the utility of robotic-assisted surgery for skull base surgery. Early clinical experiences with removal of nasopharyngeal and parapharyngeal space tumors have been reported.

**Objective:** Our goals were to design a cadaveric model that identified surgical landmarks and advantages and limitations of each currently reported robotic corridor and to establish the feasibility of new ports.

**Material and Methods:** Cadaveric specimens were dissected using a da Vinci surgical robot at the Robotic Skills Laboratory of The Ohio State University Medical Center. We designed our laboratory environment to be similar to that of our operating room.

**Results:** Current robotic corridors are adequate to expose and remove the soft tissues adjacent to the posterior skull base, infratemporal fossa, and craniocervical junction. Newly proposed corridors provide similar capabilities to tackle lesions of the anterior skull base. All corridors are

limited by the current lack of a drill to control and extirpate lesions within the skull base or cranial cavity. Endoscopic and microscopic techniques are adjunctive to the robotic surgery in this regard.

**Conclusions:** A thorough understanding of the anatomy from the endoscopic and robotic perspectives (ventral) is critical for the planning and safe oncologic resection of tumors in this area. The surgical team must be versed in both robotic and endoscopic techniques before embarking in such a procedure. Our model provides the opportunity to acquire anatomical familiarity; however, clinical experience is mandatory as anatomical models fall short of real clinical scenarios. Coupling of robotics with computer navigation and the addition of drills and suction, as well as "uniport" technology, will spearhead greater changes that may minimize the morbidity and increase the efficacy of current skull base approaches.

### 239. Innovative Use of the O-Arm for Skull Base Resection in a Sphenoorbital Meningioma

Edward E. Kerr (presenter), Kiarash Shahlaie, Brian Dahlin, Rudolph J. Schrot (Sacramento, USA)

**Introduction:** Bone-invasive sphenoid wing meningiomas are typically associated with hyperostosis of adjacent bone. Gross total resection is the standard operative goal, and reoperation is often considered if postoperative imaging demonstrates incomplete resection or persistent neural compression. We report our experience with intraoperative computed tomography (iCT) using the Medtronic O-arm to evaluate the extent of resection of hyperostotic bone secondary to an en plaque sphenoorbital meningioma.

**Case Report:** A 43-year-old woman presented with a right-sided sphenoid wing meningioma causing proptosis secondary to hyperostosis of the sphenoid bone. We performed an orbitozygomatic craniotomy for resection of the hyperostotic bone at the skull base with the patient placed in standard metallic head holder and cranial fixation pins. The superior orbital fissure, foramen rotundum, and foramen ovale were decompressed. An iCT of the skull base was then obtained after initial decompression using the O-arm, and the images were used to guide further decompression of the lateral orbital wall prior to closure.

**Discussion:** Using iCT for intracranial pathology has been reported since 1987. However, its availability has grown substantially since then with the widespread implementation of portable, much more practical iCT devices. Portable iCT use has mostly been reported in spine surgery, although more recently it has been reported in use for functional neurosurgery. The majority of reported intracranial applications have involved electrode placement verification for deep brain stimulation. Various iCT devices have been developed; however, limitations in the gantry size necessitate specialized radiolucent head holders. The larger open-ring gantry configuration of the widely available O-arm allows more flexibility in obtaining the scan intraoperatively.

**Conclusion:** We used iCT to intraoperatively evaluate the adequacy of bony decompression of hyperostosis secondary to an en plaque sphenoorbital meningioma. This case illustrates an innovative intracranial application of a device most frequently used in spine surgery. The O-arm is ideal for tailoring skull base resections intraoperatively, and a standard metallic head holder can be used. Furthermore, this device may be more widely available in hospitals than other



devices capable of three-dimensional intraoperative imaging. In the future, soft tissue optimization for the O-arm may expand its intracranial imaging applications.

#### **240. Detection and Management of Skull Base Cerebrospinal Fluid Leaks Using HRCT-MRI Fusion Imaging**

Satish Govindaraj, Bradley Delman, Abib A. Agbetoba (presenter), Joshua B. Bederson (New York, USA)

**Background:** Endoscopic repair of cerebrospinal fluid (CSF) leaks has been well described in the literature as an effective method for the treatment of sinonasal skull base defects. However, despite the ongoing evolution of the endoscopic techniques for repair, site localization is a diagnostic challenge. The limitations and morbidity associated with diagnostic imaging studies such as high-resolution computer tomography (HRCT), magnetic resonance imaging (MRI), and computed tomography (CT) cisternography in detecting CSF leaks has created a need for more accurate and less invasive radiographic imaging modalities. In our study, we evaluate a novel technique of fusing HRCT and MRI imaging for the detection of CSF leaks, as well as its ability to aid in intraoperative localization of skull base defects through computer-assisted image guidance.

**Methods:** We retrospectively reviewed 17 cases of patients who underwent HRCT-MRI fusion studies with intraoperative fluorescein localization for the evaluation and repair of CSF leaks during a 3-year period between 2008 and 2011 at the Mount Sinai Medical Center.

**Results:** Seventeen HRCT-MRI fusion studies were evaluated from 17 different patients suspected of having anterior skull base CSF leaks. The etiology of the CSF leaks was spontaneous in seven, postpartum in two, and iatrogenic in one. Ten out of the 17 subjects had a confirmed diagnosis of CSF leaks on intraoperative nasal endoscopy. HRCT-MRI fusion imaging accurately identified the CSF leak and its location in each of the 10 subjects, yielding a sensitivity of 100%. Six of the 17 patients were found to have no signs of active CSF leak or skull base defect on intraoperative nasal endoscopy; 4 of these correlated with negative findings on fusion imaging. One patient is currently awaiting surgical intervention.

**Conclusion:** HRCT-MRI fusion is an excellent imaging modality that not only provides accurate identification and localization of CSF leaks but also acts as a great adjunct for intraoperative localization and repair. HRCT-MRI fusion can be incorporated into the diagnostic algorithm in the management of CSF leaks.

#### **241. Vestibular Monitoring via Abducens EMG: Observations on a Single Case**

Matthew Hanson (presenter), Christopher Mascarinas, Nicholas Post, John Miller (Brooklyn, NY, USA)

Advancement in skull base surgery has occurred due to the improved ability to remove larger and less accessible tumors while minimizing morbidity. Petroclival meningiomas represent a particular challenge due to their proximity to and involvement with multiple cranial nerves. Intraoperative neural monitoring has become routine in assisting the surgeon to avoid injury to these structures. We present a case of a large petroclival meningioma removed by a transpetrosal approach with intent of hearing preservation in which an

interesting finding was obtained from neural monitoring. In addition to facial, trigeminal, SSEP, and BAER monitoring, continuous EMG monitoring of the abducens nerve was performed. During the transmastoid approach, an opening was inadvertently made in the lateral semicircular canal. With the membranous labyrinth intact, it was decided to pack the canal to prevent further injury. The cupular deflection caused by the packing resulted in a rhythmic repeated firing of the ipsilateral abducens, representing the correcting saccades of the induced nystagmus. This confirmed that the vestibular apparatus, local brainstem, and nerve were intact and functional, as ablative nystagmus would have been in the opposite direction. This was confirmed further by there being no change in the wave I or V of the BAER. For the remainder of the case, the rhythmic firing of the abducens nerve served as a monitor of the health of both the VI and VIII nerves. Tumor involvement at the brainstem insertion of the VIII nerve eventually resulted in the loss of this phenomenon, mirroring the findings on BAER. It is felt that this phenomenon may be exploited in future selected cases to provide real-time feedback on the health of the vestibular nerve during skull base surgery.

#### **242. Comparative Analysis of FIESTA versus Conventional Imaging for Assessment of Cerebellopontine Angle Epidermoid Tumors**

Osamah J. Choudhry (presenter), Pratik Shukla, Resha Soni, Maureen Barry, Shira Slasky, James K. Liu (Elizabeth, NJ, USA)

**Introduction:** Conventional MR imaging sequences used for cerebellopontine angle (CPA) epidermoid tumors, including T1, T2, fluid attenuated inversion recovery (FLAIR), and diffusion-weighted imaging (DWI), are unable to adequately delineate the cranial nerves and blood vessels of the CPA from the lesion and surrounding cerebrospinal fluid (CSF). Fast imaging employing steady-state acquisition (FIESTA) is a newer MR sequence that provides superior contrast between CSF and cisternal structures.

**Methods:** Five patients undergoing resection of CPA epidermoid tumors with preoperative and postoperative FIESTA and conventional MR imaging were selected. Qualitative analysis was performed using two observers who evaluated preoperative and postoperative MR sequences for visualization of tumor extension and relationship to cranial nerves, as well as vascular structures. Quantitative analysis was performed using contrast-to-noise ratio for T2 and FIESTA studies to assess for tumor differentiation from CSF. One-tailed paired t-tests were used to compare groups in qualitative and quantitative analyses.

**Results:** On qualitative analysis, FIESTA was more accurate than conventional MR sequences in visualizing cranial nerves and blood vessels within the tumor vicinity and detecting residual tumor on postoperative sequences ( $P < 0.05$ ), but not for visualization of tumor extension. Mean contrast-to-noise ratio (CNR) was significantly higher ( $P < 0.05$ ) in all FIESTA sequences compared with T2-weighted sequences.

**Conclusion:** FIESTA imaging is superior to conventional MRI sequences for visualization of cranial nerves and vessels in relation to the tumor and in detecting residual tumor for postoperative assessment. FIESTA is a useful adjunct for preoperative planning and postoperative assessment of CPA epidermoid tumors.

### 243. Is Retrosigmoid Approach Adequate for Resection of Petroclival Meningiomas?

Sherif M. Elwatidy (presenter), Zain Jamjoom (Riyadh, Saudi Arabia)

**Background:** Petroclival meningiomas (PCMs) remain one of the most challenging intracranial tumors to treat surgically due to their deep location in the skull base and critical relation to vital neurovascular structures. Different skull base approaches are described in the literature for resection of these tumors. The retrosigmoid (RS) approach remains a standard approach to cerebellopontine angle (CPA) lesions including petroclival meningiomas.

**Objective:** The purpose of this study is to find out whether the retrosigmoid approach is adequate for excision of petroclival meningiomas.

**Results:** Out of 300 meningiomas operated on at KKUH during the period from 1990–2010, there were 100 skull base meningiomas, 17 of them were PCM. There were 10 women and 7 men, whose ages ranged from 20–69 years (mean, 44 years). The mean duration of symptoms was 22 months, and the common presenting features were headache in 70%, cranial nerve palsy in 53%, ataxia in 47%, raised ICP in 0.6%, motor weakness in 17.6%, and reduced sensation in the face in 17.6%. Tumor size was large (3–5 cm) in 11 patients (64.7%), greater than 5 cm in 4 patients (23.5%), and small (<3 cm) in 2 patients (11.7%). Total resection was achieved in 10 patients (59%). Postoperative complications included bulbar palsy in 5 patients (29.4%), facial nerve palsy in 4 patients (23.5%), hemiparesis in 2 patients (17.6%), and CSF collection in the wound in 2 patients (11.7%). The follow-up period ranged from 2–15 years (mean, 72 months). The outcome was good in 10 patients (58.8%), fair in 3 patients (17.6%), and poor in 2 patients; 2 patients died (11.8%). Tumor recurred in 23.5% at 4, 5, 6, and 8 years; all of them had STR, and 1 of the patients had multiple meningioma.

**Conclusion:** Total resection of petroclival meningioma is feasible through the retrosigmoid approach, and its morbidity is comparable to other extensive and lengthy skull base approaches.

### 244. Combined Supra-Infratentorial Microsurgical Approach for Petroclival and Tentorial-Incisureal Extra-Axial Lesions

Hamad I. Farhat (presenter), Michael Schinners, Jin C. Zhao, Richard Wiet, Ivan Ciric (Evanston, IL, USA)

**Background:** Microsurgical removal of extra-axial lesions in the petroclival region is one of the most challenging procedures in neurosurgery.

**Objective:** The objective of this report is to describe the fundamental anatomic concepts, surgical principles, and strategies as well as results in a series of 24 patients who underwent the supra-infratentorial petrosal approach for removal of petroclival and tentorial-incisureal lesions

**Material and Methods:** Thirteen petroclival meningiomas, 3 tentorial meningiomas, 6 vestibular schwannomas, and 2 trigeminal schwannomas underwent microsurgical removal using the supra-infratentorial approach in conjunction with petrosectomy (22 translabyrinthine, 2 retrolabyrinthine). The surgical principles and strategies followed were: (1) translabyrinthine or retrolabyrinthine petrosectomy that opens the surgical corridor anteriorly, (2) mobilization of the sigmoid sinus that opens the surgical corridor posteriorly,

(3) excision of the tentorium that provides additional space in the depth, (4) avoidance of vascular (arterial and venous) and neural injury, (5) adequate initial tumor decompression that opens the tumor-arachnoid interface, and (6) attention to detail (hemostasis/closure).

**Results:** Simpson grades 1 and 2 removal was accomplished in 16 patients. There were no operative mortalities. Complications included ipsilateral hearing loss (22), House-Brackmann II facial paresis (4), trigeminal sensory loss and CSF rhinorrhea (2 each), and worsened hemiparesis (1). There were three recurrences. The median follow-up period was 85 months (range, 6–164 months).

**Conclusion:** Adequate exposure is necessary for a meaningful and safe resection of petroclival tumors. We feel that sacrificing ipsilateral hearing was justified in order to access and safely remove these life-threatening tumors.

### 245. Anterior Skull Base Rhabdoid Meningioma Masquerading as Esthesioneuroblastoma

Sriram V. Eleswarapu, Darrin J. Lee (presenter), Arthur B. Dublin, E. Bradley Strong, Quang Luu, Kiarash Shahlaie (Folsom, CA, USA)

**Introduction:** Radiographic diagnoses of high-grade meningiomas can be complicated by unusually aggressive anatomy. This is particularly true for lesions exhibiting expansile extracranial growth or cystic structures, findings that are often characteristic of rarer tumors. We report for the first time a giant anterior fossa meningioma exhibiting anatomy classically suggestive of esthesioneuroblastoma.

**Case Report:** A 32-year-old man with a 3-year history of bilateral headaches and progressive nasal obstruction presented after a tonic-clonic seizure. Imaging revealed a giant skull base tumor involving the right frontal lobe, anterior fossa floor, frontal and ethmoid sinuses, and nasopharynx. The lesion had an extensive exophytic growth pattern, a nonenhancing peritumoral cyst, bony destruction of the cribriform plate, and absence of hyperostosis. Together, these findings were highly suggestive of an esthesioneuroblastoma. Combined endonasal and open cranial resection with skull base reconstruction were performed.

**Results:** The tumor was identified histopathologically as a WHO grade III rhabdoid meningioma. Postoperative imaging demonstrated complete tumor resection but persistence of the peritumoral cyst. The patient received adjuvant radiotherapy (59.4 Gy IMRT). Follow-up at 12 months revealed partial resolution of the cyst and stable postsurgical changes; the patient has had no postoperative seizures and remains neurologically intact.

**Conclusion:** Skull base meningiomas may present with deceptive imaging characteristics and may mimic a variety of lesions including esthesioneuroblastomas. Even in cases for which radiography restricts the differential diagnosis, aggressive anatomy should not necessarily be considered pathognomonic for rare skull base tumors.

### 246. Clinical Characteristics and Surgical Management of Atypical Meningiomas of the Skull Base

Joshua W. Osbun (presenter), Michael R. Levitt, Manuel Ferreira, Laligam N. Sekhar (Seattle, USA)

**Background:** Atypical grade II meningiomas represent a more aggressive form of meningiomas that possess a higher risk of brain invasion and recurrence after

surgical resection. We report our experience with these WHO grade II lesions with regards to patient characteristics and outcome and their surgical management.

**Methods:** We reviewed 219 consecutive patients undergoing craniotomy for resection of histopathologically proven meningioma from 2007 to 2011. Of these, 32 patients were identified with atypical WHO grade II meningiomas (14.6%). Pathologic grading was based on WHO criteria since 2009. Data were collected regarding the presentation, radiographic characteristics, and long-term follow-up of these patients.

**Results:** Thirty-two atypical meningiomas were resected in 30 patients (16 women and 14 men). Thirteen tumors (40.6%) were in a skull base location, and 19 were in a non-skull base location (59.4%), with an average size of 5.01 cm. Simpson grades of resection were grade I in 14 cases (43.8%), grade II in 3 cases (9.38%), grade III in 2 (6.3%), and grade IV in 12 cases (37.5%). Eight patients (25.0%) required staged surgery to achieve adequate resection due to a complex skull base location. The most common reasons for planned residuals (13 cases) were dural sinus involvement in 9 (28.1%) and brain invasion into eloquent cortex in 4 (12.5%). In an average follow-up of 2.63 years, four tumors (12.5%) recurred or had significant residual growth requiring a repeat surgery.

**Conclusions:** Our experience with atypical WHO grade II meningiomas demonstrates an increased incidence in skull base locations compared with previous reports that used pre-2009 grading criteria. We advocate aggressive surgical management for atypical WHO grade II lesions with staged procedures, when necessary, in skull base locations to achieve maximal resection, reduce recurrence, and improve patient outcome.

#### **247. Delayed Malignant Transformation of Petroclival Meningioma to Chondrosarcoma after Stereotactic Radiosurgery: Case Report and Review**

Rohan R. Lall (presenter), Omar Arnaut, James P. Chandler (Chicago, USA)

**Background:** Microsurgical resection of recurrent petroclival and cerebellopontine angle meningiomas carries significant morbidity to adjacent critical neurovascular structures. Recent interest has arisen regarding stereotactic radiosurgery as a tool to prevent growth and progression of these lesions.

**Case Presentation:** A 58-year-old woman underwent transpetrosal, transtentorial resection of a left petroclival meningioma in 1996 at Northwestern, with a small postoperative remnant in the cavernous sinus. Pathology was consistent with grade 1 meningioma. Follow-up MR brain imaging in 1998 showed growth, prompting gamma knife radiosurgery with a dose of 14 Gy. Follow-up MRIs were stable until 2004, when she again experienced progression of this lesion. Repeat radiosurgery was performed, at a dose of 12 Gy. The lesion was subsequently stable between 2004 and 2010.

She returned in September 2011 with gait difficulties, left facial hemi-anesthesia, hearing loss, and sixth nerve palsy. An MR brain scan showed massive tumor progression with compression of the pons and spread into the middle fossa and cavernous sinus. She was taken to surgery for debulking of this lesion. Intraoperatively, it was found that the substantial portion of the lesion was grossly consistent with meningioma. However, a tough, darker segment remained

partially adherent to the pons. Pathology review showed two different tissue components. One was a high-grade chondrosarcoma, with positive S-100 staining and EMA negativity. The other component was consistent with atypical meningioma.

**Discussion:** Recent series have shown greater than 90% rates of long-term control for posterior fossa meningiomas after stereotactic radiosurgery. Progression to anaplastic meningioma has been described in the literature and is considered a long-term risk of radiosurgical treatment. This is the first published case report of malignant transformation of meningioma to chondrosarcoma after stereotactic radiosurgery. Single case reports exist of dedifferentiation of meningioma to glioblastoma, osteosarcoma, and spindle cell sarcoma, either spontaneously or in the setting of external beam radiation.

**Conclusion:** Although stereotactic radiosurgery continues to gain favor as a treatment modality for recurrent posterior fossa meningioma, delayed complications remain unclear. In the setting of prior remote radiosurgery, sudden rapid progression of these lesions should be concerning for malignant progression, and dedifferentiation to sarcoma is a possibility.

#### **248. Radiology of Cavernous Sinus and Parasellar Region**

Michael Chan, Eric Bartlett, Walter Kucharczyk, Arjun Sahgal, Hugh Curtin, Eugene Yu (presenter), (Toronto, Canada)

The cavernous sinuses are paired dural enclosed, venous structures found on either side of the sella turcica and sphenoid sinus. Several critical structures such as cranial nerves 3, 4, 6, V<sub>1</sub> and V<sub>2</sub> as well as the internal carotid artery all pass through the cavernous sinuses. Numerous conditions can affect the region, including a wide a range of neoplastic, infectious, inflammatory, and vascular diseases. The aim of this poster is to highlight the radiographic anatomy of the region and review some of the disease processes that can arise. For each entity, the patient demographics, important clinical findings, and the key radiographic features will be reviewed.

On completion of this poster exhibit, the reader will have gained knowledge of the imaging features of the cavernous sinus and sellar region and become more familiar with the radiology of some of the diseases that can affect this area.

#### **249. A Prospective Qualitative Study on Patients' Perceptions of Endoscopic Endonasal Transsphenoidal Surgery**

Idara J. Edem, Beverly Banton, Mark Bernstein, Shelly Lwu, Allan Vescan, Fred Gentilli, Gelareh Zadeh (presenter), (Kingston, Canada)

**Background:** Endoscopic transsphenoidal surgery had been shown to be a safe and effective treatment option for patients with pituitary tumors, but there has been no study exploring patients' perceptions before and after this surgery.

**Objective:** The authors in this study aim to explore patients' perceptions on endoscopic transsphenoidal surgery.

**Methods:** Using a qualitative research methodology, two semistructured interviews were conducted with

30 participants. These participants were adults older than 18 years who underwent endoscopic endonasal transsphenoidal surgery for the resection of a pituitary tumor between December 2008 and June 2011. The open-ended interviews were audiotaped and transcribed and the resulting data was analyzed using a modified thematic analysis.

**Results:** The following seven overarching themes were identified from the data: (1) Patients had a positive surgical experience; (2) patients were satisfied with the results of the procedure; (3) patients were initially surprised that neurosurgery could be performed endonasally; (4) patients expected a cure and to feel better after the surgery; (5) many patients feared that something might go wrong during the surgery; (6) patients were psychologically prepared for the surgery; (7) most patients reported receiving adequate preoperative and postoperative information.

**Conclusions:** This is the first qualitative study reporting on patients' perceptions before and after an endoscopic endonasal transsphenoidal pituitary surgery, which is increasingly used as a standard surgical approach for patients with pituitary tumors. Patients report a positive perception and general satisfaction with the endoscopic endonasal transsphenoidal surgical experience, both preoperatively and postoperatively. However, there is still room for improvement in postsurgical care. Overall, patients' perceptions can help improve the delivery of comprehensive care to future patients undergoing pituitary tumor surgery.

### 250. Sinonasal Quality-of-Life Changes after Endoscopic Pituitary Surgery

Lee A. Zimmer (presenter), Ojas Shah, Philip V. Theodosopoulos (Cincinnati, USA)

**Objectives:** Given that the transnasal endoscopic approach to the sella involves resection of nasal cavity and sinus structures, the effect of surgery on sinonasal quality of life was tested.

**Study Design:** Case series with planned data collection was performed.

**Setting:** The study was conducted at a single tertiary care institution.

**Subjects and Methods:** Adults diagnosed with a pituitary mass and scheduled to undergo transnasal endoscopic resection underwent preoperative sinonasal quality-of-life testing using the Sinonasal Outcome Test-22 (SNOT-22). Repeat testing was performed at 1 and 3 months postoperatively. Paired Student's t-tests were used to compare pre- and postoperative scores.

**Results:** Of 39 consecutive patients who were enrolled, 37 (19 men, 18 women) completed testing at 1 month, and 34 (17 men, 17 women) completed a 3-month evaluation. The average score (out of 120) was 23.9 preoperatively, 27.5 at 1 month, and 15.3 at 3 months. A significant improvement was found between preoperative and 3-month scores ( $P = 0.03$ ), but no change in scores was seen at 1 month ( $P = 0.4$ ). Emotional well being questions such as sadness, frustration, concentration, productivity, and fatigue significantly improved 3 months after surgery ( $P < 0.05$ ). Physiological questions such as olfaction, obstruction, and postnasal drainage decreased at 1 month ( $<0.05$ ) and normalized at 3 months.

**Conclusion:** No difference was found between preoperative and 1-month SNOT-22 scores. At 3 months, clinically

significant improvement was seen in SNOT-22 scores. Analysis of individual SNOT-22 questions shows marked improvement in emotional well being after endoscopic pituitary surgery.

### 251. Factors Affecting Porous High-Density Polyethylene Implant Exposure in Patients Undergoing Endoscopic Transsphenoidal Resection of Sellar Lesions

Spencer C. Payne (presenter), Brian Hughley, Yemisi Afere, John A. Jane, Jr. (Charlottesville, USA)

**Objective:** The purpose of this study was to determine which patient characteristics are associated with exposure of porous high-density polyethylene (PHDPE) used in transsphenoidal resection (TSR) of sellar lesions.

**Design:** A retrospective chart review was performed.

**Patients:** The study included patients undergoing TSR from July 2004–December 2010 for whom complete records were available, including PHDPE exposure, demographics, tumor type, presence of otolaryngologist at surgery, comorbidities, and radiographic data.

**Setting:** We conducted the study at an academic tertiary care center.

**Outcome Measures:** Exposure of PHDPE on follow-up examination was reviewed.

**Results:** A total of 174 patients were included; 19 (10.9%) had exposure of the Porex graft. There was no statistically significant correlation of graft exposure to any of the patient data analyzed. Although not statistically significant, when the Otolaryngology service was involved in the procedure, 8/51 (15.68%) developed Porex graft exposure compared with 11/123 (8.94%) when not involved.

**Conclusions:** There is no reliable predictor of which patients will develop Porex graft exposure following TSR of sellar lesions. Patients with abnormal anatomy, previous sinus surgery, or other paranasal sinus conditions prompting the involvement of an otolaryngologist may be at higher risk for developing graft exposure. All patients should undergo routine evaluation for Porex exposure.

### 252. Imaging Features of Skull Base Tumors with Special Attention to the Central Skull Base

Arnold Saha, Peter Thurlow, Melanie B. Fukui, Michael F. Goldberg (presenter), (Pittsburgh, USA)

**Purpose:** The skull base is an anatomically complex area where a variety of pathologic processes can develop. The purpose of this exhibit is to provide the non-radiologist with an easily accessible review of the computed tomography (CT) and magnetic resonance (MR) characteristics of skull base lesions, with special attention to the central skull base.

**Approach/Discussion:** This exhibit will begin with a review of skull base anatomy as it appears on cross-sectional imaging. The bulk of the exhibit will use a case-based format to discuss the imaging appearances of various lesions involving the skull base. CT and MR are used in complementary fashion in the evaluation of skull base lesions. Specifically, CT is excellent for assessing the extent of bony involvement, whereas MR is primarily used to more definitively characterize soft tissue components of a mass.

Common central skull base masses to be reviewed include pituitary macroadenoma, aneurysm, arachnoid

cyst, epidermoid/dermoid, craniopharyngioma, hypothalamic glioma/hamartoma, metastasis, meningioma, and masses of the petrous apex. Rarer lesions to be discussed include pseudotumor, chordoma/chondrosarcoma, neuroblastoma, giant cell tumor, and fungal infection, among others. Comment will be made on key diagnostic clues and pitfalls, and imaging features of particular importance for surgical planning.

This review will also include “do not touch” lesion mimics, including trapped fluid within the petrous apex, asymmetric marrow/pneumatization of the petrous apex, and petrous apex cephalocele.

Finally, the reader will learn a systematic approach to characterizing complex lesions. Emphasis will be placed on identifying (1) lesion location and extension to critical adjacent anatomy, (2) typical imaging features, and (3) imaging technique.

**Conclusion:** The skull base is host to a wide range of pathologic processes. This imaging-based educational exhibit provides the non-radiologist with a review of CT and MR characteristics of skull base lesions as well as a systematic approach for characterizing complex lesions.

### 253. Endoscopic Transsphenoidal Resection of Giant Pituitary Adenomas: Experience in 7 Patients

Mickey L. Smith (presenter), Smruti K. Patel, Osamah J. Choudhry, Jean Anderson Eloy, James K. Liu (Newark, USA)

**Introduction:** Giant pituitary adenomas, defined as those greater than 4 cm in diameter, can be surgically formidable lesions. We evaluate our experience with resection of giant pituitary adenomas using the endoscopic transsphenoidal approach.

**Methods:** Retrospective review of a prospective database of endoscopic skull base procedures performed within a 2-year period revealed seven cases of giant pituitary adenomas. We evaluated each case for tumor size, extent of resection, and postoperative complications.

**Results:** Seven patients (4 men, 3 women) presented with giant pituitary adenomas with an average size of 4.5 cm in greatest diameter (range, 4.1 cm to 7.2 cm). Gross-total resection was achieved in three cases, where the tumors were less than 5 cm without any cavernous sinus invasion. Subtotal resection was achieved in four cases because of cavernous sinus invasion and tumor adherence to optic nerves, hypothalamus, and cerebral arteries. An extended transplanum approach was performed in two patients because of significant suprasellar extension. All patients experienced visual improvement postoperatively. Complications included postoperative apoplexy in two patients, transient diplopia in one, and permanent diabetes insipidus in one. Nasoseptal flap reconstruction was used in all cases, and there were no postoperative CSF leaks.

**Conclusion:** The endoscopic endonasal transsphenoidal approach provides excellent exposure for resection of giant pituitary adenomas with a wide-angle field of view. Tumors with considerable suprasellar extension may require a transplanum transtuberulum approach for better access. Gross total resection is limited by cavernous sinus invasion and tumor adherence to critical neurovascular structures. Postoperative residual tumor may pose a risk for postoperative pituitary apoplexy.

### 254. Combined Approaches for the Treatment of Craniopharyngioma

Chiazo S. Amene (presenter), Lissa Baird, Michael L. Levy (San Diego, USA)

**Introduction:** The authors describe the use of a combined fronto-orbitozygomatic temporopolar craniotomy to maximize the operative corridor and thereby increase the probability of maximum tumor resection while minimizing morbidity and mortality.

**Methods:** They applied this approach in 54 children with craniopharyngiomas that involved the sellar and parasellar regions, third ventricle, cavernous sinus, and interpeduncular fossa regions.

**Results:** The surgical results are summarized with a description of the operative procedure and comparison with other previously described surgical approaches, including the subfrontal, bifrontal, pterional, translamina terminalis, transsphenoidal, transcassal, and transcortical approaches.

**Conclusion:** Because each particular technique has both strengths and weaknesses, the surgeon must choose the approach that provides optimum exposure to maximize the chances for total resection. The specific operative corridor chosen will ultimately depend on the anatomy of each individual tumor as noted on preoperative magnetic resonance (MR) images and computerized tomography (CT) scans. The tenets underlying the approach include: (1) obtaining the shortest trajectory to the suprasellar region, interpeduncular fossa, and anterior third ventricle; (2) more aggressive bone removal (orbital roof, middle fossa, and sphenoid wing) to minimize retraction injury; (3) posterior mobilization of the temporal tip with preservation of the temporal tip veins; and (4) the skeletonization/decompression of cranial nerves and vascular structures to maximize their preservation during surgical manipulation.

### 255. Delayed Postoperative Pituitary Apoplexy after Endoscopic Transsphenoidal Resection of a Giant Pituitary Macroadenoma

Smruti K. Patel (presenter), Lana D. Christiano, Jean Anderson Eloy, James K. Liu (Newark, USA)

**Introduction:** Pituitary apoplexy in the postoperative period after surgical removal of a pituitary tumor is rare and has only been reported to occur after subtotal resection of giant pituitary macroadenomas (greater than 4 cm) in the immediate postoperative period (within 12 hours). All of the previously reported cases demonstrated acute neurologic worsening with eventual fatal outcomes due to massive tumor swelling, intratumoral hemorrhage, and infarction within the residual tumor. We describe a unique case of postoperative pituitary apoplexy that occurred in a delayed fashion on the third postoperative day from spontaneous hemorrhage into a small residual tumor. Early detection and immediate surgical intervention resulted in eventual gross total removal of the residual hemorrhagic tumor, decompression of the optic chiasm, and a favorable neurologic outcome.

**Methods:** A 59-year-old man underwent an endonasal endoscopic transsphenoidal removal of a giant suprasellar pituitary macroadenoma, which was causing progressive visual loss. Postoperatively, the patient's vision improved, and neuroimaging demonstrated decompression of the optic chiasm with some residual tumor in the left cavernous sinus.

**Results:** On the third postoperative day, the patient experienced acute worsening of vision with bitemporal hemianopsia from spontaneous hemorrhagic pituitary apoplexy into the residual tumor. An emergent endoscopic transsphenoidal exploration was performed to remove the remaining hemorrhagic tumor and to decompress the visual apparatus. Postoperatively, the patient regained his vision back to baseline.

**Conclusion:** This represents a unique case of postoperative pituitary apoplexy from a small volume residual tumor that occurred in the delayed postoperative period. This was successfully treated with emergent transsphenoidal decompression of the visual apparatus and complete removal of the tumor. The authors review the literature of postoperative pituitary apoplexy and emphasize the importance of rapid diagnosis and intervention to achieve significant recovery and a favorable neurologic outcome.

### 256. Primary Sellar Leiomyomas: A Report of Two Cases and Review of the Literature of a Rare Entity

Andrew Ko, David K. Su (presenter), Donald Born, Manuel Ferreira, Jr. (Seattle, USA)

Leiomyomas are benign smooth muscle tumors that are commonly found in the genitourinary or gastrointestinal tracts. Rarely, they present as primary intracranial brain tumors. A majority of these lesions have been described in immunocompromised patients. In exceedingly rare cases, these tumors have been found sporadically in the immunocompetent patient.

We present two cases of sporadic sellar leiomyomas. The first patient is a 25-year-old woman who presented with a 2-year history of amenorrhea and a heterogeneous lesion. The second is a 53-year-old man who presented with headaches and progressive panhypopituitarism, and a large cystic lesion expanding the sella. In both cases, endoscopic transnasal transsphenoidal surgery was performed for resection of the tumor. We review the intraoperative findings, neuropathology, immunohistochemistry, and the clinical follow-up.

To the best of our knowledge, with an online literature search, only two prior cases have been reported. Review of relevant literature on these rare tumors and these two cases may allow us to conclude that the natural history differs depending on the immune status of the patient and on the fact that sellar leiomyomas may cause pituitary dysfunction through infiltration of the gland, mass effect and compression, or as a byproduct of prolactin secretion intrinsic to the tumor itself.

### 257. Orbital Metastasis of Pituitary Growth Hormone Secreting Carcinoma-Causing Lateral Gaze Palsy: Case Report, Pathology Review, and Review of the Literature

Rohan R. Lall (presenter), Steven F. Shafizadeh, Omar Arnaout, Bernard R. Bendok, James P. Chandler (Chicago, USA)

**Background and Importance:** Although pituitary adenoma is one of the most common intracranial tumors, metastatic pituitary carcinoma is extremely rare. Commonalities in reported cases include subtotal resection at presentation, treatment with radiation therapy, and delayed metastatic progression. Controversy exists over pathologic descriptions in these lesions.

**Case Report:** We report the case of a 52-year-old gentleman initially diagnosed with acromegaly and pituitary tumor in 1996. He underwent three subtotal resections and five rounds of stereotactic radiosurgery over 14 years at two other hospitals. He presented to us with left eye lateral gaze palsy and was found to have an orbital metastasis with involvement of the left lateral rectus and lateral orbital wall. He underwent a left orbital craniotomy via eyebrow incision for resection of this lesion. Pathologic evaluation of this lesion showed a markedly elevated Ki67 level of 30%, higher than even most previously described cases of pituitary carcinoma.

**Discussion:** We reviewed all cases of pituitary carcinoma with clear clinical descriptions from 1990–2011. We found 45/46 (98%) reported adult cases had previous radiation exposure prior to transformation. Eight patients underwent stereotactic radiosurgery (mean: 1.13 doses) prior to transformation. 40 patients underwent external radiation therapy (mean, 1.11 doses). The mean delay from radiotherapy to metastatic transformation was 5.96 years.

Although the distinction between atypical adenoma and carcinoma had classically been based on presence of distal metastases, our review found some pathologic correlation as well. Mitoses are present in 3.9% of noninvasive adenomas, 21.4% of atypical adenomas, and 66% of carcinomas. The mean Ki-67 labeling index in noninvasive adenomas, atypical adenomas, and carcinomas was 1.37%, 4.66%, and 11.91%, respectively.

**Conclusion:** Although overall incidence of metastatic transformation of a pituitary adenoma after radiotherapy appears to be low, it appears to be a possible complication, and it could be more likely in patients receiving multiple doses of radiotherapy. Metastatic progression appears to be significantly delayed from radiation treatment, and correlated with subtotal resection of adenoma. These patients may also have more aggressive pathologic characteristics of their lesions.

### 258. Idiopathic Granulomatous Hypophysitis Presenting as Pituitary Apoplexy: A Rare Manifestation of a Rare Disorder

Osamah J. Choudhry (presenter), Alexandros Zouzas, Leroy Sharer, Jean Anderson Eloy, James K. Liu (Elizabeth, USA)

**Introduction:** Idiopathic granulomatous hypophysitis (IGH) is a chronic inflammatory lesion of the pituitary gland. It occurs rarely—only 23 cases have been reported in the literature—and it typically presents with chronic onset of headache and slow development of visual deficits. It is diagnosed only on pathologic examination. IGH has never been reported to present as pituitary tumor apoplexy. We report possibly the first case of IGH manifesting as pituitary apoplexy in a young woman, who was diagnosed preoperatively on MR imaging as harboring a pituitary macroadenoma.

**Methods:** A 36-year-old woman presented with the sudden onset of left-sided retro-orbital headaches, diplopia, and left ptosis, and she admitted to recent menstrual irregularities with intermittent galactorrhea. MR imaging of the brain demonstrated an intensely enhancing  $1.9 \times 1.1 \times 1.3$  cm enhancing sellar mass lesion with suprasellar extension, mass effect on the left cavernous sinus, and an area of low signal on T2-weighted imaging, consistent with recent hemorrhage. Pituitary tumor apoplexy was suspected, and the patient underwent an emergent transsphenoidal removal of the tumor to decompress the optic nerves and the left cavernous sinus.

**Results:** Microscopic examination demonstrated chronic granulomatous inflammation with extensive caseous necrosis. Palisading of epithelioid cells around the zones of necrosis was noted, as well as multinucleated giant cells within the necrotic zones. Postoperatively, the patient's ophthalmoplegia resolved completely; visual fields and acuity were normal. An extensive systemic workup for sarcoidosis, tertiary syphilis, and Wegener's granulomatosis was carried out; all results were negative. A diagnosis of IGH was established based on histopathologic findings and lack of systemic granulomatous pathology. Postoperative imaging 18 months out demonstrated excellent resolution of the mass lesion with decompression of the optic chiasm and cavernous sinus.

**Conclusion:** To our knowledge, idiopathic granulomatous hypophysitis has never before been reported to present as pituitary apoplexy. As it can appear identical to pituitary adenoma, both radiographically and clinically, a high index of suspicion is warranted. Treatment consists of operative intervention in the face of acute neurological deterioration and evidence of mass effect, with hormone replacement therapy commonly required for hypopituitarism either pre- or postoperatively. In the presence of caseous necrotizing granulomas, a thorough workup for tuberculosis, sarcoidosis, and other granulomatous etiologies is warranted.

### 259. Endoscopic Transnasal versus Open Transcranial Internal Carotid Artery Anatomy: A Uniform Application of Nomenclature

John J. DePowell (presenter), James L. Leach, Lee A. Zimmer, Philip V. Theodosopoulos, Jeffrey T. Keller (Cincinnati, USA)

**Introduction:** As transnasal endoscopic surgery evolves, neurosurgeons and otolaryngologists are approaching complex lesions of the skull base from a nontraditional anatomic perspective, resulting in varied anatomic descriptions including the introduction of new terminology, such as paraclival internal carotid artery (ICA). Descriptions of ICA segments identified from an endoscopic perspective have spawned nomenclature that has yet to be applied uniformly across disciplines. The goal of this study was to determine if the established terminology of ICA segments from the open transcranial perspective is applicable to the endoscopic perspective.

**Methods:** To expose the ICA, transnasal transsphenoidal endoscopic dissections and bilateral frontotemporal craniotomies were performed on five formalin-fixed cadaveric heads. Prior to dissection, the heads were injected with radiodense colored silicon and then underwent thin-cut CT imaging for CT angiographic (CTA) analysis.

**Results:** The lacerum (C3), cavernous (C4), and clinoid (C5) segments are readily identified endoscopically in the sphenoid sinus. The posterior ascending segment of C4 is not paraclival when viewed from the open transcranial or the endoscopic perspective. The opticocarotid recess identifies the transition from the anterior ascending portion of C4 to the C5 segment endoscopically in a similar manner as the optic strut intracranially.

**Discussion:** Our nomenclature is equally applicable to the segments of the ICA identified from either endoscopic or transcranial perspective and avoids the introduction of new, confusing, inaccurate terms. Correlation of the segments in a cadaveric model and subsequent application to CTA imaging validates the use of the traditional classification, thus providing a consistent nomenclature across disciplines.

### 260. Radiographic Anatomy of the Major Foramina of the Skull Base

Lee A. Zimmer (presenter), Philip V. Theodosopoulos, Jeffrey T. Keller (Cincinnati, USA)

**Objective:** Endoscopic operative intervention of anterior skull base lesions is challenging. Although various endoscopic approaches have been described, the basic anatomy of the skull base from the endoscopic viewpoint is not well understood.

**Study Design:** An anatomic study was conducted using computed tomography.

**Materials and Methods:** High-resolution, surgical guidance CT images of the sinuses from 97 patients at a tertiary care medical center between 2002 and 2007 were evaluated. Axial and sagittal images were used to evaluate the major foramina of the skull base from the nasal spine. Multiple anatomical measurements were obtained and analyzed with imaging and statistical software. Results were compared with cadaveric specimens for accuracy.

**Results:** The 97 imaging studies included 39 men and 58 women. The distance from the nasal spine to the carotid canal, first genu, and second genu was  $9.31 \pm 0.59$  cm,  $9.39 \pm 0.60$  cm, and  $8.00 \pm 0.49$  cm, respectively. The angle from the nasal spine to the carotid canal, first genu, and second genu was  $17.6 \pm 1.8$  degrees,  $18.1 \pm 1.5$  degrees, and  $9.0 \pm 1.3$  degrees, respectively. The distance from the nasal spine to foramen rotundum, ovale, and spinosum was  $6.63 \pm 0.41$  cm,  $7.58 \pm 0.44$  cm, and  $8.50 \pm 0.47$  cm, respectively. The angle from the nasal spine to foramen rotundum, ovale, and spinosum was  $16.9 \pm 2.0$  degrees,  $18.7 \pm 1.4$  degrees, and  $20.7 \pm 1.4$  degrees, respectively. Differences in length and angle are presented by side. The range of results in cadaveric specimens was similar to radiographic findings.

**Discussion:** Despite increasing popularity of the endonasal, endoscopic approaches to the cranial base, little is known about the anatomy of this complicated region. The major bony foramina of the skull base are within 10 cm and no more than 21 degrees from the nasal spine. This knowledge assists in the appropriate selection of anatomical approach and selection of instrumentation.

### 261. Importance of Trochlear Nerve Dissection for Tentorial Incision during the Subtemporal Transtentorial Approach: Technical Note

Nancy McLaughlin (presenter), Quanfeng Ma, Josh Emerson, Dennis Malkasian, Neil A. Martin (Los Angeles, USA)

**Introduction:** The subtemporal transtentorial approach provides excellent exposure of the middle incisural space. Retraction or incision of the tentorial edge improves access to the interpeduncular cistern and the basilar artery. The starting point of the tentorial incision and the tentorial flap geometry is greatly variable. We assessed the impact of freeing the trochlear nerve (TN) from its dural canal (DC) prior to dividing the tentorium.

**Methods:** We performed a subtemporal transtentorial approach on six hemispheres of cadaveric specimens. Following the exposure of the middle tentorial incisura, the TN is dissected from its DC, allowing a modified tentorial incision technique. Measurements to key anatomic structures were taken before and after tentorial incision.

**Results:** In each specimen, two sutures are placed along the tentorium edge, posterior to the TN's entrance in its DC. Initially, the TN is dissected free of its DC for a short distance. The tentorial incision is started between both sutures and oriented straight up toward the superior petrosal sinus (SPS). Dissection of the TN's DC is continued anteriorly up to its entry into the cavernous sinus. The tentorial incision is then extended anteriorly, paralleling the trajectory of the SPS. The rostrocaudal exposure of the interpeduncular cistern and basilar artery increased a mean 4.4 mm (SD, 1.7 mm) after completing this extended tentorial incision.

**Conclusion:** We present a modified technique of tentorial incision in which dissection of the TN from its DC is essential. This technique optimized reflection of the tentorium flap anteriorly and maximized the rostrocaudal exposure allowed via the subtemporal approach.

## 262. Computed Tomography Analysis of the Prevalence of Onodi Cells

Senja Tomovic (presenter), Norman Chan, Azadeh Esmaeili, James K. Liu, Jean Anderson Eloy (Hoboken, USA)

**Background:** Onodi cells are the posterior-most ethmoid air cells that lie superior to the sphenoid sinus. It is essential to recognize the presence of these cells prior to endoscopic sinus and skull base surgery as these cells are intimately related to the optic nerve and may lead to unwanted complications. In this study, CT scans from 175 patients (age range, 19–81 years) with no posterior ethmoid or sphenoid sinus fractures or associated masses were analyzed by two independent observers for the presence of Onodi cells.

**Methods:** A retrospective radiographic analysis was performed.

**Results:** The overall prevalence of Onodi cells in this cohort was 62.9–69.7%. Further subgroup analysis based on ethnicity (Asian, African American, Hispanic, and White) showed a greater prevalence in the Asian population and an equivalent prevalence among the other groups—70%, 45%, 58%, and 41%, respectively. The prevalence was equivalent among men and women, 48% and 44.5%, respectively. These figures show a greater prevalence of Onodi cells than previously reported.

**Conclusions:** Although studies of the Asian population are consistent with these data, it shows an increased prevalence in the other populations studied. It is therefore important for surgeons to anticipate and look for the presence of these cells when undertaking endoscopic sinus and skull base procedures.

## 263. Computed Tomography Analysis of Anatomic Variations of the Sphenoid Sinus

Senja Tomovic (presenter), Norman J. Chan, Azadeh Esmaeili, James K. Liu, Jean Anderson Eloy (Hoboken, USA)

**Background:** The sphenoid sinus is a distinctly complex anatomic structure with great anatomic variation in the extent of pneumatization, number and position of septae, and the relationship of the sinus to adjacent structures, including the optic nerve, maxillary nerve, vidian

nerve, and the internal carotid artery. These variations become especially important in transsphenoidal surgical approaches to the sella and parasellar regions. In this study, CT scans from 175 patients (age range, 19–81 years) with no sphenoid sinus fractures or associated masses were analyzed by two independent observers for the presence of these variations.

**Methods:** A retrospective radiographic analysis was performed.

**Results:** Four different classifications of sphenoid sinus pneumatization were defined—conchal, presellar, sellar, and postsellar—based on pneumatization relative to the anterior and posterior face of the sella. The distribution ranged from 2.8–3.4%, 6.8–7.4%, 44.6–46.9% and 41.1–43.4%, respectively. These data show a greater preponderance of sellar and postsellar variation than prior studies have demonstrated. When analyzed according to age, gender, and ethnicity, the distribution of the extent of pneumatization remained essentially the same. The prevalence of optic nerve, maxillary nerve, and internal carotid artery protrusion was found to be 24.3%, 25.4%, and 27.1%, respectively. The rate of dehiscence was found to be 3.4%, 7.4%, and 0.9%, respectively. Septa in the sphenoid were found to be present in 43.4% of cases. The lateral recesses were pneumatized in 34.3–35.7%, and the clinoid processes in 9.4–10% of patients.

**Conclusions:** This study further elucidates the prevalence of various types of anatomic variation of the sphenoid sinus in patients of different age, gender, and ethnicity, which has important implications for endoscopic endonasal sinus and endoscopic skull base surgery.

## 264. The Relationship between the Superior Petrosal Sinus and Meckel's Cave: An Anatomical Study

Martin M. Mortazavi (presenter), Christoph J. Griessenauer, Sanjay Krishnamurthy, Ketan Verma, Jason Cormier, Shane Tubbs (Birmingham, USA)

**Introduction:** Vascular relationships during intracranial approaches to the skull base are very important. One relationship that has had scant attention in the literature is that between the superior petrosal sinus and the opening of Meckel's cave.

**Materials and Methods:** Cadaver dissections were performed in 25 adult latex-injected cadaveric heads. Specifically, the relationship between the superior petrosal sinus and the opening of Meckel's cave was observed.

**Results:** Of 50 sides, 68%, 18%, and 16% of superior petrosal sinuses traveled superior to, inferior to and around the opening to Meckel's cave, respectively. In the latter case, a venous ring was formed around the proximal trigeminal nerve. No sinus entered Meckel's cave. In general, the porus trigeminus was narrowed on sides found to have a superior petrosal sinus that encircled this region. Sinuses that traveled only inferior to the porus were, in general, larger than sinuses that traveled superior or encircled this opening. No statistically significant differences were noted between the various sinus relationships and gender, age, or side.

**Conclusions:** Knowledge of the relationship between the superior petrosal sinus and the opening of Meckel's cave will be useful to the skull base surgeon. Additionally, future clinical studies may wish to discern such relationships in patients with trigeminal neuralgia.



### 265. Cavernous Sinus Access via the Translateral Orbital Wall Approach

Sebastian F. Koga (presenter), Robert M. Starke, Steven A. Newman (Charlottesville, USA)

**Introduction:** Access to the cavernous sinus remains a major technical challenge. The Dolenc approach and its variations involve transcranial drilling and some degree of dural mobilization and brain retraction. Altay et al have proposed a new approach via a lateral orbital wall. We describe our experience with this approach in vascularized cadaver models.

**Methods:** A modified version of the Aboud vascularized cadaver model was used with Thiel embalmed heads and artificial venous, arterial, and CSF circulation. A Berke canthal incision was used to expose the orbital rim, which was resected along with the lateral wall. A posterior corridor was created and the anterior clinoid process was removed, gaining ample access to the cavernous sinus and Meckel's cave. Blood pressure elevation was used to induce brisk bleeding to test the feasibility of the approach. Operative positioning, duration, ergonomics, and safety were assessed.

**Results:** The work of Altay et al was replicated without difficulty, and venous bleeding was controllable in all stages. The angle of approach was satisfactory for cavernous sinus exploration, and orbital reconstruction was achieved with good cosmetic results. Sphenoid wing drilling allowed further exposure of the petrous carotid artery and other middle fossa anatomy.

**Conclusion:** The new translateral approach to the cavernous sinus is a feasible and fast corridor to cavernous sinus lesions. This extradural pathway involves no brain retraction and yields good orbital reconstruction postoperatively.

### 266. Endoscopic Endonasal Dissection of the Infratemporal Fossa: Anatomic Relationships and Importance of Eustachian Tube in Endoscopic Skull Base Surgery

R. Terre Falcon, C. Rivera-Serrano, R. L. Carrau (presenter), J. Fernandez-Miranda, D. M. Prevedello, C. H. Snyderman, A. B. Kassam (Columbus, USA)

**Objectives:** Endoscopic endonasal approaches to the pterygopalatine and infratemporal fossae are technically challenging due to the complex anatomy of these areas. This project attempts to develop an anatomic and surgical model to enhance the understanding of these spaces from the endonasal endoscopic perspective.

**Methods:** Eight pterygopalatine and infratemporal fossae were dissected in four adult human specimens in accordance with institutional protocols. All specimens were prepared with vascular injections using colored latex. An endoscopic endonasal transpterygoid approach, which included a medial maxillectomy, controlled the pterygopalatine fossa and provided access to the infratemporal fossae. Rod lens endoscopes (with 00, 300, and 450 lenses) and microsurgical and endoscopic instruments were used to complete the dissections.

**Results:** Endoscopic endonasal approaches provided adequate access to the pterygopalatine and infratemporal fossae. Dissection of the internal maxillary artery and its terminal branches, and detachment of the medial and lateral pterygoid muscles were critical steps to access deeper structures of the infratemporal fossa. The lateral pterygoid plate was the most useful landmark to locate foramen ovale, and the mandibular branch of the trigeminal nerve. The

eustachian tube, medial and lateral pterygoid plates, and styloid process were the most useful landmarks to locate the parapharyngeal poststyloid structures (parapharyngeal segment of the internal carotid artery, internal jugular vein, and cranial nerves IX and X).

**Conclusions:** A transpterygoid endoscopic approach provides adequate access to the pterygopalatine and infratemporal fossae. The complex anatomy of the infratemporal fossa requires precise identification of surgical landmarks to assure preservation of neurovascular structures.

### 267. Practical Surgical Landmarks for the Planning of a Transpterygoid Endoscopic Endonasal Approach

R. L. Carrau (presenter), B. A. Otto, D. M. Prevedello, C. Pinheiro-Neto, L. Ditzel, D. de Lara, R. Mafaldo (Columbus, USA)

**Background:** Endoscopic endonasal approaches (EEA) to the skull base are based on the principle of using anatomical corridors to access a region of interest. We define a transpterygoid approach as one requiring the partial or complete removal of the pterygoid process. Transpterygoid (TP) approaches include those that access the lateral recess of the sphenoid sinus, the foramen lacerum or petrous ICA, Meckel's cave or cavernous sinus, lateral nasopharynx (fossa of Rosenmüller), and infratemporal fossa.

**Methods:** We investigated different variations of the TP-EEA using a previously described cadaveric model. Fresh specimens were dissected endonasally using endoscopic instruments and surgical navigation for correlation with the multiplanar images.

**Results:** The TP-EEA field may be divided by vertical and horizontal lines that cross the vidian and rotundum foramina. These lines divide the possible approaches as follows: Type A is an approach that is limited to the base of the pterygoid plates above the level of the vidian canal, and is indicated for lesions such as CSF leaks of the Sternberg canal. Type B involves the dissection of the vidian canal removing the base of the pterygoid plates to reach the petrous apex (infra- or retro-petrous), Meckel's cave, or, rarely, the cavernous sinus (zones 1, 2, 3, and 4, respectively). Type C is an extended approach to the pterygopalatine fossa involving partial removal of the medial or lateral pterygoid plates, such as that required for the transposition of a temporoparietal fascia flap. Type D provides access to the infratemporal fossa and may or may not require removal of the plates (zone 5). Type E provides exposure of the lateral nasopharynx (fossa of Rosenmüller) and requires the removal of the medial or both pterygoid plates and the medial third of the eustachian tube. Vertical and horizontal lines intersecting at the vidian and rotundum foramina help to estimate the extent of the approach. In general, lesions above the vidian foramen and medial to foramen rotundum can be exposed with a wide nasoastral window and removal of the posterior wall of the antrum. Lesions below the vidian foramen and/ lateral to the foramen rotundum require a medial maxillectomy and removal of the lateral wall of the maxillary sinus.

**Conclusions:** A safe and effective transpterygoid approach requires an experienced surgeon who is familiar with the complex endoscopic anatomy of the region. The exposed landmarks are useful for the preoperative planning as well as for intraoperative orientation.

### 268. First Stage in Predictive Measure for Transnasal Transsphenoidal Approach to Petrous Apex Cholesterol Granuloma

Nael Shoman, Angela M. Donaldson (presenter), Jeffrey J. Ksiazek, Myles L. Pensak, Lee A. Zimmer (Cincinnati, USA)

**Objectives:** This is the first in a three-stage study, looking at the feasibility of the transsphenoidal approach to the petrous apex (PA) cholesterol granuloma (CG) based on what we refer to as the petrous angle. This is the angle centered at the vomer, extending between the medial aspect of the petrous internal carotid artery (ICA) and the occipital protuberance. The aim of this study is to determine the average petrous angle in a population of normal computed tomography (CT) scans.

**Study Design:** A retrospective review was conducted.

**Setting:** The study was conducted at the University of Cincinnati Medical Center.

**Subjects and Methods:** Two readers independently reviewed 400 consecutive normal temporal bone CT scans performed between September and December of 2009. All scans had slice thickness of 1.25 mm at 0.6 mm intervals. Axial images parallel to the orbito-meatal plane were analyzed, and the petrous angle measured bilaterally. Inter-rater reliability was tested on 50 of the CT scans.

**Results:** A total of 400 CT scans were reviewed. The mean and median petrous angles were 17.7 and 16.5 degrees, respectively. Eleven (2.8%) had an angle  $\leq 10.0$ , 331 (82.8%) between 10.1 and 20.0, and 58 (14.5%)  $\geq 20.1$ . The inter-rater variability was highly correlated ( $r = 0.912$ ,  $P < 0.005$ ).

**Conclusion:** Normative data on consistent PA radiographic landmarks are important for assessing the feasibility of the transsphenoidal approach to the PA for CG drainage. Based on a large population of normal CT scans, we have found that the majority of temporal bones (82.8%) have a petrous angle ranging between 10.0 and 20.0 degrees.

### 269. Unusual Infectious Complications of Skull Base Surgery

Steven A. Newman (presenter), (Charlottesville, USA)

**Purpose:** Increasingly, complex skull base procedures contain the same risks of infectious complications of any surgical procedure. Many of these, however, may be hidden, leading to a delay in ultimate diagnosis and appropriate treatment.

**Materials and Methods:** A case series of three individuals seen following skull base procedures at the University of Virginia with unusual infectious manifestations are explored for clues that assist in making the diagnosis.

**Results:** All three patients presented with orbital apex syndrome with decreased vision, pain, varying degrees of proptosis, and ophthalmoplegia. Imaging indicated pathology in the orbital apex and superior orbital fissure but often multiple biopsies were required to make a definitive diagnosis and initiate treatment. Aggressive antibacterial treatment was effective in eliminating the infectious process in two of the three patients.

**Conclusions:** Infectious processes may occur in the orbital apex and superior orbital fissure following endoscopic and open skull base procedures. Radiation therapy may further predispose to infectious processes. Aggressive and often repeat biopsies may be necessary to make a diagnosis. Cranial nerve palsies may reverse with treatment.

### 270. External Landmarks for Identifying the Drainage Site of the Vein of Labbé: Application to Neurosurgical Procedures

Martin M. Mortazavi (presenter), Christoph J. Griessenauer, Shane Tubbs, Robert G. Louise Jr., Young-Bin Song, Marios Loukas, Mohammadali Shoja, Aaron A. Cohen-Gadol (Birmingham, USA)

**Introduction:** The vein of Labbé is an important structure of the lateral cortical surface. However, to date, studies aimed at providing external landmarks for aiding in its identification have been scant. Therefore, the present study focused on establishing reliable bony landmarks for localizing this deeper lying venous structure.

**Materials and Methods:** Fifteen adult cadavers (30 sides) underwent dissection of the lateral cortical brain surface with special attention given to the drainage site of the vein of Labbé into the transverse sinus. Measurements of the distance from this site to surrounding external bony landmarks were then made.

**Results:** We found that this drainage site into the transverse sinus was 0.8 to 1.5 cm (mean, 1.1 cm; SD, 0.567) superior to the superior border of the zygomatic arch and 2 to 5 cm (mean, 2.9 cm; SD, 0.713) posterior to the opening of the external auditory meatus. Statistically, there was no significance between left and right sides or between genders.

**Conclusions:** We found that the junction between the vein of Labbé and transverse sinus may be variable. Nonetheless, additional landmarks found in this study for identifying the junction may aid in its earlier identification during surgery, potentially decreasing operative morbidity.

### 271. Identification of a Caroticoclinoidal Foramen and Its Importance in Endonasal Skull Base Surgery

Juan C. Fernandez-Miranda (presenter), Matthew J. Tormenti, Allesandro Paluzzi, Carl H. Snyderman, Paul A. Gardner (Pittsburgh, USA)

**Introduction:** The middle clinoid is an osseous prominence that arises from the body of the sphenoid bone at the anterolateral margin of the sella turcica. The presence of a middle clinoid is not constant. In an unknown number of patients a calcified ligament may exist between the middle and anterior clinoids creating a foramen within which the carotid artery lies. This is known as the caroticoclinoidal foramen. Identifying the existence of this structure is paramount to safe removal of the middle clinoid in endonasal skull base approaches.

**Methods:** The thin slice (<2.5 mm) CT scans of 100 patients who underwent endonasal skull base procedures were reviewed. All patients with sellar pathology that enlarged or eroded the sella were excluded. All instances of a caroticoclinoidal foramen where documented.

**Results:** At least one caroticoclinoidal foramen was identified in 19% of patients. In 10% of patients bilateral foramina were identified. In patients with unilateral foramina a right foramen was present in 2% of patients and a left foramen was present in 7% of patients.

**Conclusions:** Recognition of the caroticoclinoidal foramen on preoperative radiographs is important for surgical planning and middle clinoid removal in endonasal skull base surgery. At least one caroticoclinoidal foramen was recognized in 19% of patients.

**272. Endoscopic Endonasal Approach to Meckel's Cave**  
 Alexandre A. Karkas (presenter), Jeffrey T. Keller, Philip V. Theodosopoulos, Lee A. Zimmer (Cincinnati, USA)

*Background:* External approaches to Meckel's cave and the petrous segment of the internal carotid artery (ICA) offer excellent exposure but are associated with neurological, functional, and cosmetic morbidities. Only a few articles report endoscopic endonasal exposure of Meckel's cave. Our aim is to describe an endoscopic approach to Meckel's cave. Anatomical relationships and predictable morbidities based on anatomy are discussed.

*Material and Methods:* Four cadaveric heads (eight sides) were dissected with 0° endoscopy through a transnasal, transmaxillary approach; a Caldwell-Luc approach was performed if lateral manipulation of instruments was hampered by the lacrimal bone.

*Results:* A large maxillary antrostomy was performed and the sphenopalatine artery identified; the posterior and superior walls of the maxillary sinus were removed, and the internal maxillary artery and maxillary nerve (V2) entering foramen rotundum were identified. Lateral to the pterygoid buttress, the medial attachment of the lateral pterygoid muscle was dissected and the mandibular nerve (V3) entering the foramen ovale was exposed. A large sphenoidotomy was performed and the cavernous ICA located in the carotid sulcus. The vidian nerve and V2 were followed retrogradely by removing pterygoid bone enabling identification of foramen lacerum, petrous carotid, and Gasserian ganglion in Meckel's cave. Additional bone was removed on the medial side of foramen ovale to expose the V3 retrogradely to the Gasserian ganglion, which was followed posteriorly to the retrogasserian root.

*Conclusions:* The endoscopic approach affords the same exposure as historical external approaches with significantly less morbidity based on anatomical dissections. Indications include benign lesions of the pterygopalatine fossa, infratemporal fossa, and Meckel's cave with minimal intracranial extension. Biopsy of malignant tumors in the above-mentioned regions is also indicated. Limitations of the technique and morbidity based on anatomical dissection will be discussed.

**273. Temporary Brachytherapy Seed Mesh in the Treatment of a Radiation-Induced Sinonasal Carcinosarcoma: A Case Report and Literature Review**

Benjamin A. Talei (presenter), Bhupesh Parashar, David I. Kutler (New York, USA)

Carcinosarcoma, a true malignant mixed tumor, is a rare and aggressive tumor that has been described infrequently in the literature since 1864 and has yet to be thoroughly studied or understood. Data and evidence obtained from prospective or randomized trials are lacking, and the treatment of this disease has largely been guided by personal experience and case reviews. The majority of experienced practitioners strongly recommend aggressive and immediate treatment combining surgery, different forms of radiation, and, variably, chemotherapy.

We present a complicated case of radiation-induced high-grade carcinosarcoma of the paranasal sinuses and skull base. This patient posed a unique challenge having already received partial brain radiation in this region followed by stereotactic radiotherapy and chemotherapy for recurrence of

a high-grade oligoastrocytoma. Furthering the management difficulties were the patient's poor mental and health status, precluding a host of potential interventions.

Aiming to maximize therapeutic potential and local control while minimizing potential for complications, this patient was treated with a combination of surgery and radiation. He underwent endoscopic sinus surgery with resection of all involved paranasal sinus constituents extending up to the skull base and orbit without removal of vital structures. Because the margins at the skull base could not be obtained without morbidity to the patient and the use of further external beam radiation therapy was precluded, the residual micro tumor was treated with brachytherapy seeds (Cs-131, half-life 9.7 days) attached to a mesh that was endoscopically and stereotactically placed within the nasal cavity along the tumor bed. Twenty seeds were used with an activity of 1.57 U providing a radiation dose of 60 Gy to the surrounding tissue 0.5 cm from the mesh. Brachytherapy implants are usually permanent, but the location of the tumor bed did not allow permanent interstitial implants to be placed. Therefore, we placed the seeds using customized gauze to secure the mesh in place for the duration, which allowed >95% radiation dose to be delivered using the Cs-131. The patient was monitored at regular intervals and the mesh was removed approximately 6 weeks later. At 8-month follow-up, the patient has remained without evidence of local recurrence or complications.

As suggested by this case report and supported by a comprehensive literature review, the placement of a temporary brachytherapy seed mesh following surgical resection appears to play a promising role in the local control, palliation, and treatment of aggressive sinonasal cancers where more extensive forms of radiation are prohibitive.

**274. Patterns of Recurrence in Skull Base Meningioma after Secondary Gamma Knife Radiosurgery**

Jai D. Thakur (presenter), Ashish Sonig, Imad S. Khan, Prashant Chittiboina, Shihao Zhang, Anil Nanda (Shreveport, USA)

*Introduction:* The management nuances of skull base meningiomas in the current era include optimal tumor control and maximal preservation of neurological status. Consequently, gamma knife (GK) radiosurgery has emerged as a popular alternative. Literature on maximum duration after which follow-up can be safely weaned is lacking. This study evaluates the temporal patterns of recurrence of skull base meningioma after secondary GK, either used as an adjuvant to microsurgery for residual lesions (Group A) or for treating recurrent lesions following surgical resection (Group B).

*Methods:* A total of 187 patients from 2000 to 2010 underwent microsurgical resection for skull base meningiomas by the senior author (AN). Further, 44 patients who underwent secondary GK ( $n = 25$  in Group A,  $n = 19$  in Group B) were retrospectively analyzed to determine their temporal recurrence.

*Results:* The majority of the patients were women (70%). The mean age was 55 years and the mean follow-up time after secondary GK was 51 months (range, 6–125 months). Radiological recurrence was noted in 20% of patients. Further six patients (24 %) in Group A and three patients (16 %) in Group B showed radiological recurrence. Kaplan-Meier charts were plotted to elucidate progression-free survival among Group A and Group B. The overall range

of recurrence was 6 months to 123 months following secondary GK. Out of the nine recurrences, four recurred before 5 years, four recurred between 5 and 10 years, and one recurred after 10 years.

**Conclusion:** Although GK is considered to have optimal tumor control in treatment of skull base meningiomas, long-term follow-up beyond 10 years is suggested. It is still unclear what should be the ideal duration of follow-up, and further long-term prospective studies are needed to address this issue.

### 275. Systematic Analysis of the Outcomes of Stereotactic Radiosurgery for Central Neurocytoma

Andrew Y. Yew (presenter), Marko Spasic, Winward Choy, Heather Garcia, Andy Trang, Antonio DeSalles, Isaac Yang (Los Angeles, USA)

**Introduction:** Central neurocytomas typically affect young adults, arise in the lateral ventricles, and represent 0.1–0.5% of all intracranial tumors. The current treatment of choice is gross total resection (GTR). For recurrent or residual tumors, reoperation or conventional radiotherapy has typically been used. Because central neurocytomas are surrounded by CSF and have little connection to the surrounding brain parenchyma, they serve as ideal targets for SRS. Hence, SRS may reduce the need for reoperation and minimize exposure to radiation compared with conventional radiotherapy (cRT). Here, we analyze the benefits of SRS after no resection, gross total resection (GTR), and subtotal resection (STR) to determine whether SRS is a viable alternative to current treatments.

**Methods:** A PubMed search was performed with the keywords “neurocytoma” and “neurocytoma and radiosurgery” to identify all relevant cases. Reports were excluded if patients had both cRT and SRS or if tumor size was absent.

**Results:** A total of 66 patients with neurocytoma undergoing SRS met our inclusion criteria. The average tumor reduction was 64% at an average peripheral dose of 14 Gy, and average time of radiological follow-up was 50.3 months. One patient experienced radiation-related toxicity, 6 had recurrence after SRS, 11 underwent SRS as a primary treatment, and none experienced toxicity or recurrence.

**Conclusion:** SRS for the treatment of neurocytoma has been demonstrated to be effective in case reports and case series. Similarly, the results of this study clearly show a decrease in tumor size, good control over time and few adverse radiation-related outcomes. Furthermore, our results suggest that SRS could serve as an alternative to reoperation and cRT and as a primary treatment. Additional studies and patient data will be needed to elucidate the role of SRS in the management of neurocytoma.

### 276. Post-Traumatic Mucoceles: Does Encephalomalacia Predict Advanced Disease?

William R. Schmitt (presenter), Matthew L. Carlson, Eric J. Moore (Rochester, USA)

**Introduction:** Mucoceles are a rare delayed complication of frontal sinus fractures. Although usually heralded by typical sinonasal symptoms, advanced disease can present with meningitis or facial disfigurement (forehead swelling, globe dystopia) due to posterior or anterior table erosion, respectively. The forceful anterior impact required for frontal sinus fractures is also capable of contusing the frontal lobes,

which may impair executive function. Such a cognitive deficit may permit the development of advanced disease despite asymptomatic facial disfigurement. Because encephalomalacia precedes mucocele formation, patients with frontal lobe injury may warrant closer radiographic surveillance.

**Study Design:** A retrospective chart review and analysis were performed.

**Methods:** Following IRB approval, the electronic medical record was queried for patients with a history of facial trauma and sinonasal mucocele presenting over the past 15 years. Charts were reviewed for mechanism and date of injury, presenting symptomatology, radiographic features (encephalomalacia and the number of spaces involved by mucocele), and surgical management. Patients with trauma that spared the sinonasal mucosa were excluded.

**Results:** Thirteen patients met study criteria and were included in analysis (1 woman; average presenting age 45 years). The mean duration between injury and presentation was 20.8 years (range, 9.4–37.2 years). Five patients had undergone frontal sinus surgical management (e.g., obliteration, cranialization) before presentation. Seven patients had radiographically apparent encephalomalacia. Such patients were more likely to present with facial disfigurement (85.7% vs. 16.7%,  $P = 0.009$ ); there was also a trend toward more extensive disease (4.1 vs. 2.3 involved spaces) and a longer duration of presenting symptomatology (10 vs. 1.5 months) among patients with encephalomalacia. Eight patients were managed by a primarily endonasal endoscopic approach, three of whom had adjunctive frontal trephination. A primarily open approach was employed in four patients, two of whom were endoscope-assisted. At the time of review, one patient has not undergone surgery.

**Conclusions:** The delay between injury and declaration of post-traumatic mucoceles can be decades long. Patients with associated encephalomalacia seem to observe worrisome symptoms and present with advanced disease. Although all patients at risk for mucocele should undergo prolonged radiographic follow-up, close attention should be given to those patients with frontal encephalomalacia.

### 277. Harvey Cushing's Early Operative Treatment of Skull Base Fractures

Courtney Pendleton (presenter), Shaan M Raza, Alfredo Quinones-Hinojosa (Baltimore, USA)

**Introduction:** At the turn of the 20th century, treatment of urgent and emergent neurosurgical complaints was limited by access to hospitals, and by high rates of infection and operative mortality. Fractures of the skull base were a particular challenge to neurosurgeons of the time. Harvey Cushing remained at the forefront of this clinical dilemma, using skills garnered from his surgical residency with William Halsted to increase the safety and success of neurosurgical treatment of skull base fractures.

**Methods:** Following IRB approval, and through the courtesy of the Alan Mason Chesney Archives, the surgical records of the Johns Hopkins Hospital, from 1896 to 1912, were reviewed. Patients operated on by Dr. Harvey Cushing were further analyzed. Patients who underwent operative treatment for suspected fractures of the skull base were selected and are described here.

**Results:** Twenty-four patients underwent operative treatment for suspected fractures of the skull base. Patient age was available in 22 files; the mean age was 30 years (range,

2–68 years). The majority (87.5%) of patients were men. The mean length of stay was 11.5 days (range, 1–35 days). The mechanisms of injury included work-related injuries (33%), falls (25%), vehicle injuries (25%), and other trauma (8%). Two patients had no mechanism of injury specified in their files. The outcome at the time of discharge from the hospital was “well” or “improved” in 12 patients (50%), the remaining 12 patients died during their admission.

*Discussion:* Although the mortality rate in the cases presented here remains high (50%), it is perhaps surprisingly low when the nature of the patients’ injuries, the challenges of neurotrauma cases, and the mortality rate of over 50% for neurosurgical procedures performed under the best of circumstances by Cushing’s contemporaries are considered. The cases described here demonstrate Cushing’s commitment to transforming the field of neurosurgery into a viable surgical subspecialty; moreover, they document Cushing’s extensive work in the field of neurotrauma, an arena rife with complicated anatomy and operative technique, but without the opportunities for remuneration and academic glory presented by Cushing’s beloved neuro-oncology and neuroendocrine pursuits.

#### **278. Traumatic Entrapment of the Anterior Cerebral Artery—A Case Report**

Christopher C. Gillis (presenter), Peter A. Gooderham, Charles S. Haw (Vancouver, Canada)

Traumatic entrapment of cerebral vessels has previously been described with basilar artery entrapment through longitudinal clival fractures. To our knowledge there are currently no reports in the literature of traumatic entrapment of the anterior cerebral artery.

We present a case where, as a result of a 20-foot fall, a 26-year-old man suffered multiple skull base and facial fractures including fractures through the sphenoid at the roof of the sphenoid sinus and into the clivus. This resulted in traumatic entrapment of the distal A1 and proximal A2 segments of the right anterior cerebral artery through the fracture at the roof of the sphenoid sinus.

The patient was initially treated conservatively, but developed ischemic symptoms including watershed infarcts between the anterior and middle cerebral artery territories. He also developed fluctuating motor weakness in the left lower extremity.

Subsequently, surgery was performed through a pterional craniotomy and orbital osteotomy. The frontal lobes were gently retracted and the fracture visualized medial to the optic track. The right anterior cerebral artery could be seen tracking inferiorly at the point of herniation through the fracture. The dura was opened and the roof of the sphenoid sinus and posterior ethmoid sinus was drilled using a 3-mm diamond tip to a thin bone layer that was carefully dissected off to free the anterior cerebral artery. Retraction on the frontal lobes was tenuous due to tension on the entrapped vessel; it was minimized as much as possible.

Postoperatively the patient did well and regained motor function in the affected leg. He was independently ambulatory and doing well with no gross neurologic deficit at last follow-up.

This case represents the first report of a traumatic anterior cerebral artery entrapment. Although conservative

management may be an option, the development of ischemic lesions or a neurologic deficit in the appropriate vascular territory warrants surgical management. Surgical management can be performed successfully with good neurologic outcome.

#### **279. Unilateral Frontopterional Craniotomy for Dural Arteriovenous Fistula of the Anterior Cranial Fossa: A Lateral Approach to a Midline Lesion**

Vikram V. Nayar, Dana E. Adkins (presenter), (Washington, DC, USA)

*Objective:* Dural arteriovenous fistulae of the anterior cranial fossa are supplied by the anterior ethmoidal branches of one or both ophthalmic arteries, and drain into the anteroinferior superior sagittal sinus. When present, cortical venous reflux poses a risk of intracerebral hemorrhage and warrants surgical obliteration. The commonly described surgical technique involves a bifrontal craniotomy for division of the fistulous vein at the cribriform plate. The authors propose that a unilateral frontopterional craniotomy would allow a lateral approach across the orbital roof to the fistula at the midline, and that the falx and crista galli may be divided to obliterate a fistulous vein on the contralateral side.

*Methods:* Three patients who presented with spontaneous frontal intracerebral hemorrhage underwent angiography, revealing dural arteriovenous fistulae of the anterior cranial fossa. All three patients underwent a right frontopterional craniotomy, with a lateral approach for division of the falx, obliteration of the fistula, and evacuation of the hematoma.

*Results:* Successful surgical treatment was performed in all three cases, with no postoperative morbidity. Postoperative angiography confirmed obliteration of the fistulae in all three cases.

*Conclusion:* A unilateral frontopterional approach is a safe and effective treatment for a dural arteriovenous fistula at the midline, and provides access to fistulous veins on both sides of the falx. This approach is a viable alternative to the bifrontal craniotomy, and avoids the need for frontal sinus entry or frontal lobe retraction.

#### **280. The Occipital Transtentorial Approach for Superior Vermian and Superomedial Cerebellar Arteriovenous Malformations: Advantages, Limitations, and Options**

Nancy McLaughlin (presenter), Neil A. Martin (Los Angeles, USA)

*Introduction:* Arteriovenous malformations (AVMs) of the superior vermis and superomedial cerebellum are uncommon lesions. They have been approached through various routes including the subtemporal transtentorial, suboccipital supracerebellar infratentorial, and occipital interhemispheric transtentorial (OITT). We review the advantages and limitations of the OITT route for such AVMs and discuss therapeutic options.

*Methods:* Case series was reviewed of superior vermian and superomedial cerebellar AVMs that were approached via the OITT route. The key aspects of the OITT approach specific to the treatment of these AVMs are summarized.

*Results:* The exposure from the posterior incisura to the torcular herophili provides a view of the SCAs, the nidus,

and the draining veins, which can be managed sequentially. In circumstances when the AVM extends well beyond midline to the contralateral side, deep to the ventricles, caudally to the cerebellar tonsils, and/or is vascularized by caudal branches of the SCAs, AICA, and/or PICA feeders, or has an aneurysm on any of these feeding arteries, then the OITT alone may not be appropriate. Preoperative embolization can target contralateral, deep, or caudal feeders or aneurysms, potentially rendering the OITT a favorable route. The OITT can also be combined with other approaches for AVMs that extend caudally with multiple feeders.

**Conclusion:** The OITT approach is a valuable approach for specific superior vermian and superomedial cerebellar AVMs and should be part of the surgical armamentarium of vascular surgeons. Detailed assessment of angiographic features may, however, preclude its safety as a unique treatment plan and therapeutic options should then be considered.

### 281. Management of Jugulotympanic Paragangliomas: Our Experience in India

Suresh C. Sharma (presenter), (New Delhi, India)

**Objective:** Jugulotympanic paragangliomas are vascular tumors originating from chemoreceptors situated in the roof of the jugular foramen and on the promontory along the tympanic nerve. This retrospective study shares our experience in the management of these vascular lesions.

**Study Design:** A retrospective chart review was performed.

**Setting:** The study was conducted in a tertiary care center.

**Subject and Method:** Charts of 18 patients with jugulotympanic paraganglioma operated on from 2000–2007 were reviewed. Data regarding clinical presentation, staging of tumor and surgical procedures, management of facial nerve and other cranial nerve deficits, treatment outcomes, postoperative complications, and follow-up results were recorded.

**Results:** The 18 patients with jugulotympanic paragangliomas were operated on from 2000–2007. Fourteen were glomus jugulare and 4 were glomus tympanicum. Pulsatile tinnitus (17/18) and hearing loss (16/18) were the most common presenting symptoms. Cranial nerve involvement was seen in 13 patients (72%) at the time of presentation. Multiple cranial nerve palsies were observed in 11 (61%) patients. Four patients had type B, 10 had type C, and 4 had type D stage of tumor. Complete surgical removal was possible in 14/18 patients. There was residual tumor in 4 patients (1 posterior fossa and 3 in the pericarotid region). Postoperative improvement was observed in cranial nerve and hearing function.

**Conclusion:** Complete excision of tumor with preservation of adjoining neurovascular structures is the primary therapeutic option. Facial nerve status can be improved with proper intra- and postoperative procedures, improvement of hearing is possible in selected cases. Rehabilitation of pharyngeal functional deficit is an important component of management of glomus tumors.

### 282. Orthogonal Dome First Tandem Clipping Technique for the Reconstruction of Giant Ophthalmic Artery Aneurysm: A Single-Surgeon Operative Experience

Ashish Sonig (presenter), Vijay Kumar Javalkar, Imad Khan, Jaideep Thakur, Anil Nanda (Shreveport, USA)

**Introduction:** Surgical management of giant ophthalmic artery aneurysms is a challenge due to adjacent

bony anatomy, dural rings, and proximity to the optic nerve. Commonly, right-angled fenestrated clips are applied parallel to the internal carotid artery (ICA) for large and giant aneurysms. There is a possibility of kinking of the ICA as multiple right-angled fenestrated clips are applied in tandem. This aspect has been noted by several authors. We describe an alternative orthogonal clipping technique that is useful in atherosclerotic and wide (transverse) neck aneurysms.

**Methods:** We retrospectively analyzed 22 patients with giant ophthalmic artery aneurysm from January 1994 to August 2011 operated on by the senior author (AN).

**Microsurgical Technique:** A standard pterional craniotomy along with cranial base modification, cervical ICA exposure, and clinoidectomy was used in all cases. Mobilization of the falxiform ligament, dural ring sectioning, and optic canal roof drilling were done in some cases. The following clipping techniques were used: For Group A, orthogonal clipping was done. The dome was handled first with multiple straight tandem clips (perpendicular to the long axis of the ICA). Dog-ear formation and kinking of the ICA was avoided by partial coagulation of the dome and clipping with curved clips or straight fenestrated clips. Seven patients with Barami type II/IV aneurysms were treated by this technique. These patients had atherosclerotic and wide (transverse) neck. For Group B, parallel clipping was done. Nine patients underwent parallel clipping to the ICA long axis. A combination of interlocking right-angled fenestrated and straight fenestrated clips was used. Group C patients were classified as “others.” Six patients could be managed by meticulous placement of curved and side-curved clips.

**Results:** The average age of the patients was 60.5 years, and the female:male ratio was 3:1. The most common presentation was visual loss, which was seen in 13/22 patients. Headache was the next, affecting 6/22 patients. The mean follow-up was 24.45 months. Of the 22 patients, 1 died and 2 were lost in follow-up. The clinical outcome was good (GOS score 5 or 4) in the majority (77.27%) of patients. Of the 14 patients who presented with visual problems before surgery, 78.5% showed improvement after surgical clipping. There was no significant difference between the outcomes and complications among different groups. Postoperative angiography analysis found a small residual neck in two patients, one in Group A and one in Group B. Serial angiogram in follow-up did not show any increase in size. No kinking of ICA or dog ears was seen in Group A patients.

**Conclusion:** Traditionally “parallel” clip placement is advocated, especially for giant ICA aneurysms. The technique of orthogonally placed tandem clips with fenestrated or curved clips gives an additional armament to a surgeon, especially in elderly patients with atherosclerosis or wide (transverse) neck aneurysms. The fear of kinking of the ICA and dog ear formation is uncalled for when this technique is used meticulously, and a predominantly good outcome can be expected.

### 283. Transient Adenosine-Induced Asystole during Surgical Removal of a Giant Cerebellopontine Angle Hemangioblastoma

John C. Quinn (presenter), Yuriy Gubenko, Jame K. Liu (Newark, USA)

**Objective and Importance:** Transient adenosine-induced asystole is a reliable method for producing short

periods of relative hypotension during surgical and endovascular procedures. This technique has been described in the treatment of complex anterior and posterior circulation aneurysms and as a means of controlling bleeding during an intraoperative aneurysmal rupture. We describe the use of intravenous adenosine-induced asystole as a means of rapidly gaining control of intraoperative bleeding during the resection of a large cerebellopontine angle hemangioblastoma in a patient who could not receive blood transfusions due to religious belief.

**Clinical Presentation:** A 21-year-old woman with von Hippel-Lindau disease presented with multiple intracranial and spinal hemangioblastomas. She exhibited headaches and severe gait ataxia from a large, highly vascular cerebellopontine angle hemangioblastoma compressing the brainstem. A preoperative angiogram demonstrated a hypervascular lesion supplied by branches of AICA and PICA. The patient was a Jehovah's Witness and refused transfusion of all blood products.

**Intervention:** A retrosigmoid craniectomy was performed for resection of the hemangioblastoma. Given the patient's religious beliefs and the highly vascular nature of the lesion, transient adenosine-induced asystole was performed three times during the tumor resection to facilitate hemostasis while limiting blood loss and obviating the need for transfusion of blood products. A gross total resection was achieved without any postoperative neurological deficits.

**Conclusion:** Intraoperative adenosine represents a potential means of achieving a near immediate decrease in blood pressure that allows for safe dissection of highly vascular tumors and may minimize blood loss thereby obviating the need for transfusion of blood products.

#### **284. Transient Adenosine-Induced Asystole for the Management of Complex Aneurysms at the Skull Base** Abhishek Agrawal (presenter), Gavin Britz (Durham, USA)

**Background:** Transient adenosine-induced asystole is a reliable method for producing a short period of relative hypotension during surgical and endovascular procedures. Although the technique has been described in the surgical treatment of aneurysms, little description of its use in large and giant aneurysms has been described.

**Objective:** The purposes of this study were to (1) assess the benefits of adenosine-induced transient asystole in large and giant aneurysms and (2) describe our experience in selected cases.

**Methods:** The adenosine-induced cardiac arrest protocol allows us to titrate the duration of cardiac arrest on the basis of individual patient responses. The operative setup is the same as with all aneurysm clippings, with the addition of the placement of transcatheter pacemakers as a precaution for prolonged bradycardia or asystole. Escalating doses of adenosine are given to determine the approximate dose that results in 30 seconds of asystole. When requested by the surgeon, the dose of adenosine is administered for definitive dissection and clipping. We present nine large and giant cases in which this technique was used.

**Results:** Successful treatment of cerebral aneurysms requires circumferential visualization of the aneurysm neck, the parent vessel, branches, and perforators. Skull base techniques aid in the goal. We have also found that transient adenosine-induced asystole provides excellent and safe clip application, even in large and giant aneurysms. All patients

did well neurologically and suffered no evidence of perioperative cerebral ischemia or delayed complication from the use of adenosine itself.

**Conclusion:** Transient adenosine-induced asystole is a safe and effective technique in select circumstances that may aid in safe and effective aneurysm clipping. Along with the traditional techniques of brain relaxation, skull base approaches, and temporary clipping, adenosine-induced asystole facilitates circumferential visualization of the aneurysm neck and is another technique available to cerebrovascular surgeons.

#### **285. Stent Coil Embolization of an Iatrogenic Cavernous Carotid Pseudoaneurysm**

Alexander Tuchman, Frank J. Attenello (presenter), Arun Amar, Gabriel Zada, Alexander A. Khalessi (Los Angeles, USA)

**Background:** Absorbable plates have recently become more frequently used in the repair of skull base cranial defects following endonasal operations. Traumatic intracranial pseudoaneurysms have been reported secondary to placement of these plates, often requiring endovascular intervention. Previous treatment of these pseudoaneurysms has been deconstructive with endovascular versus open carotid sacrifice.

**Objective:** The purpose of this study is to report a cavernous internal carotid artery injury from a migrating absorbable plate used to reconstruct the sellar floor, as well as successful endovascular reconstruction with stent coil embolization of the pseudoaneurysm. No short-term hemorrhagic or embolic events were observed.

**Methods:** A 57-year-old man with a large nonfunctional pituitary macroadenoma underwent a gross total endoscopic transsphenoidal resection of the adenoma. Following resection, an absorbable plate was placed extradurally to reconstruct the sellar floor.

**Results:** The patient was discharged home on postoperative day 2 in excellent condition. However 6 weeks later, he experienced repeated epistaxis, followed by delayed dysarthria as well as left-hand and facial weakness. Neuroimaging revealed subacute infarcts in right middle cerebral artery distribution. CT angiogram revealed a 6 × 4 mm pseudoaneurysm located on the medial wall of the cavernous internal carotid artery. Stent coiling with placement of eight detachable coils was used to successfully obliterate the pseudoaneurysm, and the patient regained full recovery of his strength.

**Conclusion:** Although rare, migration of a reconstructing plate of the sellar floor may account for a subacute presentation of epistaxis or embolic stroke. In addition, short segment embolization with stent coil is an excellent option for the treatment of iatrogenic carotid pseudoaneurysms following endonasal skull base operations.

#### **286. Posttraumatic Ophthalmic Artery Pseudoaneurysm Presenting Epistaxis: Case Report and Review of the Literature**

Parviz Dolati-Ardejani (presenter), William F. Morrish, John H. Wong (Calgary, Canada)

**Background:** Traumatic brain aneurysms represent approximately 1% of brain aneurysms. Most frequently, these aneurysms are associated with skull base fractures. Traumatic pseudoaneurysms (PSA) of the ophthalmic artery

(OphA) are extremely rare after severe head injury. We report an unusual example presenting as persistent posttraumatic epistaxis, with review of the literature.

**Case Report:** The patient was a 48-year-old woman presented in a comatose state to the emergency room after a 7-meter fall. Her right eye had proptosis and an unreactive 6-mm dilated pupil. Brain CT scan revealed contusions of the frontotemporal lobes and fracture of the anterior cranial base and tri-wall fracture of the orbits. She had persistent epistaxis. Cerebral digital subtraction angiography (DSA) showed a 6 × 3 mm PsA arising from the intraorbital segment of the right OphA. Attempted endovascular embolization resulted in unsuccessful access into the PsA but unexpected therapeutic occlusion of the proximal OphA and in turn the PsA. Cerebral DSA 10 days later confirmed persistent occlusion of the aneurysm. Extensive review of the medical literature including Medline, PubMed, and Google Scholar, as well as major neurosurgery and trauma journals, yielded only nine previously reported posttraumatic PsAs of the OphA.

**Conclusion:** Posttraumatic pseudoaneurysms of the ophthalmic artery are very rare; however, it should be suspected in the setting of anterior skull base or orbital wall fractures and persistent or delayed epistaxis.

### 287. Endoscopic Vascular Anatomy of the Retroclival Junction

Juan Carlos De Battista (presenter), Norberto Andaluz, Ondrej Choutka, Lee Zimmer, Jeffrey Keller (Cincinnati, USA)

**Objectives:** The purpose of this study is to examine the endoscopic vascular anatomy of the clival region (CR) in cadavers in order to determine the feasibility of vascular control during endoscopic endonasal approach to the retroclival area (RCA).

**Methods:** Modified endonasal endoscopic approaches were performed using rigid endoscopes (4 mm diameter, 18 cm length, 0° lenses) in five formalin-fixed cadaveric heads injected with colored silicone to study the RCA and adjacent structure. Retroclival regions were divided in three segments—upper, middle and lower. We studied the length of posterior vascular exposure of each segment and the adjacent anatomy. Vascular exposure was marked with hemoclips, and segments between clips were measured in situ and in radiographs.

**Results:** The upper segment, bounded posteriorly by the dorsum sellae in the midline and the posterior clinoids in the paramedian region, was exposed after pituitary transposition. Average width was 10.8 mm (range, 10–12 mm). Basilar artery length averaged 7.4 mm (range, 6–8 mm). Endoscopic control of P1 and proximal superior cerebellar artery (SCA) was obtained.

The middle segment, extending from the sellar floor superiorly and a projected line between both paraclival carotids at the vidian intersection inferiorly, had an average length of 15 mm (range, 15–16 mm) and a trapezoidal shape. Upper width averaged 14.6 mm (range, 12–20 mm); lower width averaged 12.2 mm (range, 10–14 mm). The anterior inferior cerebellar arteries (AICAs) were followed laterally to expose an average of 4.6 mm (range, 3–7 mm) on the right and 3.2 mm (range, 1–5 mm) on the left.

The lower segment was exposed by removing the lower third of the clivus, extending from cranial nerve VI at the pontomedullary sulcus to the inferior border of the basiocciput. The

vertebrobasilar junction was exposed, and the anterior spinal artery was visualized in 60% of specimens. Upper width of this segment averaged 12.2 mm (range, 10–14 mm), and the lower width averaged 9.4 mm (range, 11–8). Length of exposure of the right vertebral artery (VA) was 8.2 mm (range, 4–13 mm); the left VA was 7.2 mm (range, 2–13 mm).

**Conclusion:** Exposure of the RCA using the modified endoscopic endonasal approach allowed for exposure of the vertebrobasilar complex vessels, and the proximal branches are also feasible, potentially affording vascular control. Further anatomic studies are required to establish the potential clinical applications of these results.

### 288. Post-Transplant Lymphoproliferative Disorder of the Temporal Bone: Report of a Unique Case and Discussion

Eric E. Berg (presenter), Ken Kazahaya, Luv Javia (Philadelphia, USA)

Post-transplant lymphoproliferative disorder (PTLD) is a well-recognized but relatively rare complication of solid organ and allogeneic bone marrow transplantation. Tumors, whether localized or disseminated, are aggressive, rapidly progressive, and often fatal. The vast majority of these cases are associated with Epstein-Barr virus (EBV) infection of B-cells. Most cases occur within the first year after transplantation, and incidence is directly related to the intensity of the immunosuppressive regimen. Accordingly, the mainstay of treatment is reduction or withdrawal of immunosuppression in spite of the risk of allograft dysfunction or loss. A variety of additional treatment approaches, including surgical excision, radiation therapy, combination chemotherapy, monoclonal antibodies, interferon therapy, and the use of immunoglobulin and cytotoxic T lymphocytes, have also been described.

The majority of cases present with lymphadenopathy, and in the head and neck cervical lymphadenopathy and adenotonsillar hypertrophy are the most common presenting signs. Here we report a unique case of facial nerve paralysis of unknown etiology ultimately found to be secondary to post-transplant lymphoproliferative disorder of the temporal bone. To our knowledge, this is the first reported case of PTLT presenting with facial palsy, and just the second reported case of PTLT of the temporal bone. We then discuss management of this complicated lesion and review the literature regarding treatment outcomes.

### 289. Cystic versus Non-Cystic Large Vestibular Schwannomas: Presentation and Outcome, a Matched Controlled Series

Michael Canty (presenter), Sarah Eljamel, Musheer Hussain, Sam Eljamel (Dundee, Scotland, United Kingdom)

**Objective:** Cystic vestibular schwannomas (CVSs) present different clinical, radiological, and treatment-outcomes from their solid counterparts. We reviewed our database to identify CVSs and compare them to matched controls.

**Methods:** The skull base database of 431 vestibular schwannomas at our institution was reviewed to identify all patients presenting with CVS. Each CVS was matched with non-cystic VS (NSVS). Data were collected on both groups



from imaging and from review of the health records. The two groups were compared in terms of demographic features; presenting symptoms and signs; tumor characteristics; and treatment outcomes in terms of hearing preservation, facial function preservation, and complications. Tumor and cyst volumes were calculated on imaging using Kodak Carestream software and the Broderick method,  $(A \times B \times C)/2$ . The means were compared using Student's paired t-test.

**Results:** Twenty-six patients were included in this study, 13 of which were CVS and 13 NCVS. The cystic tumor group were slightly older than the control group (66.5 vs. 57.2 years;  $P = 0.053$ ). Overall tumor volumes were similar between the two groups (4.4 vs. 5.5 c cm;  $P = 0.13$ ). At presentation, there was no significant difference hearing loss, tinnitus and headaches. However, CVS had had longer duration of hearing loss (48 vs. 18 months;  $P < 0.01$ ) and facial pain (23.1% vs. 0%;  $P < 0.05$ ) compared with their counterparts. The mean volume of VS in each group was comparable (6.1 vs. 5.5 c cm). There was no difference in follow-up (4.8 vs. 5.3 years). Following retrosigmoid surgical excision, 22.2% of CVS had normal facial function compared with 36.4% in NCVS. HB 2 and 3 was 66.6% in CVS compared with 27.3% in NCVS, 44.4% of CVS had serviceable hearing postoperatively (46.2% preoperatively) compared with 18.2% of NCVS (38.5% preoperatively), and 22.2% of CVS had presented with hydrocephalus compared with 11.1% of NCVS. There was one VPS in the NCVS and one CSF and infection in each group.

**Conclusions:** Patients presenting with cystic vestibular schwannoma had presented with significantly longer duration of hearing loss and were more likely to present with facial pain. Though more patients with CVS had better facial and hearing preservation, this was not statistically significant.

### 290. Anatomical Delineation of a Safety Zone for Drilling the Internal Acoustic Meatus

Rajesh Chhabra (presenter), Sunil Gupta, Tulika Gupta (Chandigarh, India)

**Introduction:** Drilling the internal acoustic meatus (IAM) is an important step during surgical removal of vestibular schwannomas. In the present study, measurements were made between the IAM and the nearest points on the top of the jugular bulb, the saccus endolymphaticus and the petrous ridge. The incidence of an HJB was also calculated.

**Material and Methods:** Twenty-five disarticulated temporal bones and 58 articulated dry skulls, of adults of unspecified sex were used for the study.

**Discussion:** The minimum distance between the IAM and the top of the jugular bulb was found to be approximately 4.09 mm. In most of the cases (98%), there was at least 5.5 mm of bone between the IAM and the jugular bulb that could be drilled. Thus, regardless of the height of the jugular bulb, there was approximately 5 mm of bone available for safe drilling. This is an important observation highlighting the fact that the presence of HJB does not preclude safe drilling. However, in many patients with vestibular tumors, it may be necessary to drill more than 5 mm of bone to adequately expose the seventh cranial nerve. In these cases, the position of the jugular bulb assumes importance. The incidence of HJB was found to be 38.6% with 18.1% having a very high bulb. The shortest distance from the posterior lip of the IAM to the slit on which saccus opens was found to be 9.9 mm, with minimum distance being 5.7 mm.

**Conclusions:** It was found that about 5 mm of bone could be safely drilled away from the posterior lip of the IAM

without damaging either the jugular bulb or the saccus endolymphaticus in most of the cases. This could be thus called the "safety zone" available for drilling. Any more drilling, if required, has to be tailored individually. Because there are significant individual variations, a preoperative radiological study for delineation of important bony landmarks is necessary in all patients undergoing surgery for vestibular schwannomas.

### 291. Labyrinthine Artery Aneurysm as an IAC Mass

Rodney C. Diaz (presenter), Thomas Konia (Sacramento, USA)

We present a case report of a labyrinthine artery aneurysm masquerading as an internal auditory canal tumor. A 72-year-old woman presented to the clinic with a 1-week history of sudden onset right facial paralysis, right facial pain, hearing loss, and vertigo. On examination, she was found to have a dense right-sided facial paralysis involving all branches of the facial nerve, left-beating horizontal nystagmus, and anacusis of the right ear. MR imaging of the brain with gadolinium contrast enhancement demonstrated a 6 × 7 mm peripherally enhancing lesion with lack of central uptake filling the right internal auditory canal. After exhaustive consideration of treatment options, the patient elected to proceed with resection of the internal auditory canal mass via a translabyrinthine approach to decompress the neural structures of the internal auditory canal in an attempt to recover neural function, particularly of the facial nerve. Intraoperatively, the internal auditory canal mass was resected with minimal difficulty, with intraoperative dissection notable for brisk bleeding at the medial base of the tumor just as the tumor was dissected off of its medial fibrous attachments. Final pathology of the resected mass revealed a blood vessel with mucinous degeneration of the medial layer of the vessel wall. Immunohistochemical staining demonstrated positive staining to human muscle actin throughout the vessel wall, confirming presence of smooth muscle cells within the tumor wall, and negative staining to S-100, militating against neural or nerve sheath origin as the composition of the tumor specimen.

This case represents the first reported case of a labyrinthine artery aneurysm within the internal auditory canal masquerading as a schwannoma of the intracanalicular vestibulocochlear or facial nerve. Recognition of the existence of this entity will allow surgeons and radiologists to include labyrinthine artery aneurysm within the differential diagnosis of similar clinical case presentations and allow surgeons to counsel such patients and approach treatment decisions in a more comprehensive fashion.

### 292. Symptoms of Petrous Apex Lesions

Neerav Goyal, Jenny Liu, Sangam G. Kanekar, Soha Ghossaini (presenter), (Hershey, PA, USA)

**Background:** The petrous apex is a portion of temporal bone lying between the sphenoid bone anteriorly and occipital bone posteriorly. It has a close anatomic relationship with the internal carotid artery, midbrain, pons, and cranial nerves. Pathology in the petrous apex can present either as an incidental finding or as a manifestation of various neurological and cranial nerve deficits.

**Methods:** This is a retrospective review of our experience of patients with petrous apex lesions who presented to the Hershey Medical Center between 2003 and

2011. Patients who had undergone CT or MRI of the temporal bone region with noted petrous apex abnormalities were included. Symptoms at presentation (if any), audiogram data, and treatment modalities were recorded. Imaging appearances of the various processes will be illustrated and clinical significance will be discussed.

**Results:** One hundred and fifteen patients that met inclusion criteria were identified in this retrospective study. Patients were found to have anatomic variations (petrous apex pneumatization, asymmetric fatty marrow, trapped fluid), infection (petrous apicitis, Gradenigo's syndrome), cholesteatoma and cholesterol granuloma, neoplastic lesions (primary involving the bone and secondary metastasis to apex), and vascular pathology (internal carotid artery aneurysm). Of the temporal bone imaging reviewed, 18.3% of the pathology were asymptomatic incidental findings ( $n = 21$ ), 12.2% were cholesterol granulomas ( $n = 14$ ), 25.2% were meningiomas ( $n = 29$ ), 8.7% were internal carotid artery aneurysms ( $n = 10$ ), and 2.6% represented petrous apicitis ( $n = 3$ ). The most common presenting symptoms were headache (28.9%,  $n = 33$ ), visual symptoms (27.8%,  $n = 32$ ), and hearing loss (24.3%,  $n = 28$ ).

**Conclusion:** Petrous apex lesions are rare and may remain silent for a long period of time, or may present with nonspecific signs and symptoms. Imaging plays a vital role in diagnosing the normal anatomical variation and classifying the various pathologies.

### 293. Malignant Transformation of a Vestibular Schwannoma Following Gamma Knife Radiosurgery: Case Report and Review of the Literature

David J. Fusco (presenter), Richard Williamson, Vijay Yanamadala, Jennifer Eschbacher, Randall Porter, Peter Weisskopf (Phoenix, USA)

**Introduction:** Whether used in a primary or adjuvant fashion for treatment of brain neoplasms, external beam radiation therapy is associated with the development of secondary malignancy and malignant transformation of benign tumors. Radiosurgery is designed to minimize these risks by delivering a highly targeted, cytotoxic dose of radiation to the tumor. Nonetheless, there is a growing body of literature describing patients with malignant transformation of primary benign tumors after radiosurgery, including vestibular schwannoma (VS).

**Case Report:** We report the case of a 46-year-old woman who presented with right facial paresthesias and imaging consistent with a right-sided vestibular schwannoma (volume  $\sim 18.5$  cm<sup>3</sup>). She underwent subtotal resection followed by gamma knife radiosurgery (GKRS) at 6 months postoperatively. Initial histology demonstrated benign vestibular schwannoma with a MIB-1 labeling index of 5.7%. At 59 months following GKRS, repeat resection demonstrated frank malignant transformation on histology (MIB-1 index, 33.8%).

**Discussion:** Malignant vestibular nerve tumors are an extremely rare entity, with only 18 reports in the literature. Our report describes the sixth pathologically confirmed case of malignant transformation following radiosurgery, supporting the contention that radiosurgery itself plays a causative role in transformation. The presence of an elevated MIB-1 labeling index in a histologically benign lesion may predispose toward malignant transformation in the setting of adjuvant radiosurgery.

### 294. Autologous Fascia Sling Technique for Dural Reconstruction Following Transtemporal Petrosectomy Approaches

Amanda J. Podolski, Robert W. Jyung, James K. Liu (presenter), (Newark, USA)

**Background:** Reconstruction of presigmoid dural defects after transtemporal petrosectomy skull base approaches (translabyrinthine, retrolabyrinthine, partial labyrinthectomy, transpetrosal, and infratemporal fossa) is paramount to prevent CSF leakage.

**Objective:** This report describes our technique of dural reconstruction of presigmoid dural defects by creating a dural "sling" using an autologous fascia graft. The closure technique and postoperative cerebrospinal (CSF) leak rates are reported.

**Methods:** We reviewed 11 patients who underwent dural sling reconstruction using autologous fascia to prevent CSF leakage after a transmastoid transtemporal petrosectomy skull base approach. Presigmoid dural exposure was used as the surgical corridor to access the pathologies. In all of the surgeries, primary dural approximation was not possible. A dural sling was created by suturing an autologous fascia graft to the edges of the presigmoid dural defect using interrupted 4-0 Nurolon sutures. A monolayer of Surgicel was then placed over the suture line. The mastoid antrum and air cells were occluded with bone wax or bone cement. A fat graft was placed on top of the sling to occlude the mastoid defect, and care was taken not to compress the facial nerve. Fibrin glue was placed above the fat graft followed by another layer of Surgicel. The rest of the superficial mastoid cavity was filled with an additional layer of autologous fat graft. The fat graft was then bolstered by a titanium mesh plate imbedded in porous polyethylene to cover the mastoidectomy defect. Meticulous multilayered wound closure was then performed. Patients were evaluated for the presence of postoperative CSF leakage (including symptomatic pseudomeningocele requiring reoperation or shunting, incisional leak, rhinorrhea, otorrhea). Comparisons were made to an earlier cohort of 12 patients who underwent dural sling reconstruction using dural allograft material.

**Results:** There were no postoperative CSF leaks (0%) when an autologous fascia graft was used as the sling. However, 4 out of 12 (33%) CSF leaks were observed in patients whom a dural allograft sling was used.

**Conclusion:** An autologous fascial sling is a useful adjunct to standard dural repair techniques following transtemporal petrosectomy surgeries as a means of preventing postoperative CSF leaks.

### 295. Atypical Schwannoma: A 10-Year Experience

Selena E. Heman-Ackah (presenter), Maura K. Cosetti, John G. Golfinos, John T. Roland (New York, USA)

**Introduction:** Atypical schwannoma represents a distinctive disease process whereby histopathologic analysis reveals findings not entirely typical of benign vestibular schwannomas, suggesting an atypical lesion or low-grade malignancy. An initial review of 14 patients with findings consistent with atypical schwannoma or low-grade malignancy was published by representatives from New York University in 2001. It described the clinical presentation and characteristic findings of patients with this distinct entity.

**Objective:** The goals of this study were to (1) describe the clinical presentation in association with atypical schwannoma of the cerebellopontine angle, (2) describe characteristic findings on pathology in association with atypical schwannoma, (3) describe the long-term outcome of patients with atypical schwannoma, and (4) propose a potential course for clinical surveillance in these patients.

**Study Design:** A retrospective chart review was performed.

**Setting:** The study was conducted in a tertiary referral center.

**Patients:** Individuals with the histopathologic diagnosis of atypical schwannoma of the cerebellopontine angle were diagnosed at the study institution between January of 2000 and December of 2010.

**Main Outcomes Measure:** Demographic data were recorded. Clinical presentation, including cranial nerve deficits at the time of presentation, was recorded. Findings on pathology were evaluated. Initial treatment and postoperative course were recorded.

**Results:** At presentation, a somewhat accelerated course of cranial nerve deficit was noted. In the immediate postoperative period, there were no differences noted in the complication rate. Recurrence rates and long-term follow-up will be presented.

**Conclusions:** Atypical schwannoma is an intermediate disease process with a slightly accelerated clinical course compared with vestibular schwannoma. Traditional operative approaches may be employed without increased concern for postoperative complications. Annual MRI scans to evaluate for recurrence and clinical evaluation are proposed for long-term follow-up in these patients.

### **296. Complications in Acoustic Neuroma Microsurgery: Progress Since the Turn of the Century**

Selena E. Heman-Ackah (presenter), Maura K. Cosetti, John G. Golfinos, John T. Roland (New York, USA)

**Introduction:** Many advances have been made in the microsurgical resection and perioperative care of patients with acoustic neuromas.

**Objective:** The goal of this study was to identify and describe the current complications associated with acoustic neuroma microsurgery compared with previous reports in the literature.

**Study Design:** A retrospective chart review and review of the literature were performed.

**Setting:** The study took place in a tertiary referral center.

**Patients:** The patients underwent primary acoustic neuroma resection microsurgery at the study institution from 2000 to 2010.

**Intervention:** Acoustic neuroma resections via trans-labyrinthine, retrosigmoid, or middle fossa approach were reviewed.

**Main Outcomes Measure:** Demographic data were recorded. Complications including cerebrospinal fluid leaks, meningitis, cerebrovascular accident, dural sinus thrombosis, cranial neuropathy, seizure, recurrence, and mortality were reviewed.

**Results:** The most common complication encountered was cerebrospinal fluid (CSF) leak. The rate of meningitis was approximately 1%. All patients had a history of CSF

leak. The rate of facial nerve preservation was 91% for House-Brackmann grade I or II function. The recurrence rate following total resection was 1%. These findings correlated with recent reports within the literature and were compared with studies performed prior to 2000. There were no associated mortalities following acoustic neuroma microsurgery within this series.

**Conclusions:** With the advances in surgical technology and perioperative care, acoustic neuroma microsurgery is now associated with few complications, the most common of which is CSF leak. With early detection and appropriate management, the morbidity and mortality of complications can be minimized.

### **297. Use of a Reciprocating Suction Microdebrider for Resection via the Middle Fossa Approach of Acoustic Neuromas with Significant Cerebellopontine Angle Extension**

Marc S. Schwartz (presenter), Gregory P. Lekovic (Los Angeles, USA)

**Introduction:** Resection of acoustic neuromas via the middle fossa route is technically challenging, especially as tumor size increases with extension into the cerebellopontine angle. The Myriad reciprocating suction microdebrider enables rapid and safe tumor debulking through a very limited corridor of access. When used as an adjunct to traditional techniques, this device allows larger tumors to be resected via this route with excellent facial nerve and hearing outcomes.

**Methods:** All operations were carried out by an operative team consisting of a neuro-otologist and a neurosurgeon. The middle fossa approach was used for small, mostly intracanalicular acoustic neuromas in patients with good preoperative hearing. Thirteen consecutive operations using the Myriad reciprocating suction microdebrider via the middle fossa route between April and October 2010 are reported. This device was used exclusively for resection of tumors with significant cerebellopontine angle extension. The diameter of the cerebellopontine angle portion of these tumors ranged from 0.7 to 1.1 cm (mean, 0.9 cm). Total tumor size (including the intracanalicular portion) ranged from 1.0 to 1.8 cm (mean, 1.4 cm).

**Results:** There were no major complications. One patient developed postoperative cerebrospinal fluid rhinorrhea, which was successfully treated with lumbar drainage, and 12 patients had gross total tumor resection. All of these patients had normal facial nerve function postoperatively. Two of these patients (17%) developed significant delayed facial weakness (House-Brackmann grade 4-5), but, at last follow-up, all patients had maintained or returned to normal facial nerve function. Serviceable hearing (>70% speech discrimination) was preserved in 9/12 patients (75%), and hearing was preserved at the preoperative level (Gardner-Robertson class) in 8/12 (67%). One patient was found to have a tumor originating from the facial nerve. No resection was carried out in this case, and this patient's speech discrimination score improved from 72% to 100%.

**Conclusions:** Resection of acoustic neuromas via the middle fossa route is often technically challenging. Nevertheless, in appropriately selected cases and using appropriate tools, excellent outcomes can be obtained. The Myriad reciprocating suction microdebrider facilitates debulking in tumors approaching the size limit for this approach. In

fact, this device may allow the size limit to be increased. The Myriad proved very useful in all cases in which resection was undertaken (12/13; 92%).

### 298. Removal of Hairy Polyp of the Eustachian Tube Using a Novel Skull Base Approach: Extended Transmastoid Excision

Anita Konka (presenter), Matthew B. Hanson (Brooklyn, NY, USA)

Hairy polyps are rare dermoid tumors associated with the temporal bone. The majority of reported cases have been left-sided, in women, and with significant middle ear or nasopharyngeal components, allowing removal by a simple transmastoid or endoscopic approach. We present the case of a 3-year-old girl with a hairy polyp of the left eustachian tube. Diagnosis was made at surgery 14 months after initial presentation. Preoperative CT and MRI aided surgical planning but were nondiagnostic. The location of this lesion high in the eustachian tube and its intimate association with the carotid artery precluded a traditional transcanal, endoscopic, or simple transmastoid approach and required more aggressive surgical dissection. A novel extended transmastoid skull base approach with removal and replacement of the anterior external canal wall and glenoid fossa provided complete visualization of the intrapetrous portion of the carotid artery, which was immediately adjacent and adherent to the tumor, and granted access to the apex of the cartilaginous eustachian tube from which the tumor arose. This exposure allowed for complete excision of the tumor and reconstruction of the ear with the usual features of a canal wall down mastoidectomy. This case represents the 15th such lesion reported in the English literature and the first described extended transmastoid skull base approach for complete visualization of the intrapetrous portion of the carotid artery and access to the cartilaginous eustachian tube.

### 299. NFAT and T-Cell Response Play Major Roles in the Formation of Sporadic Vestibular Schwannomas

Boris Krischek (presenter), Isabel Gugel, Antje Bornemann, Georgios Pantazis, Guenther C. Feigl, Constantin Roder, Florian Roser, Martin Schuhmann, Gelareh Zadeh, Marcos Tatagiba (Toronto, Canada)

*Introduction:* Even though clinical and morphological differences of vestibular schwannomas are well documented, the knowledge on molecular mechanisms of development is limited. In this study, we examined differences in gene expression between tumor and control tissue in search of underlying disease-causing deregulated pathways.

*Material and Methods:* We performed whole genome microarray expression profiling (HG-U219 Array Plate, Affymetrix) and pathway analysis of tissue samples from 36 patients with sporadic vestibular schwannomas versus 7 postmortem samples of the vestibulocochlear nerve.

*Results:* We identified 2,694 genes that were deregulated over twofold: 1,471 were upregulated and 1,223 were downregulated. The most significantly deregulated pathways in vestibular schwannomas include the role of nuclear factor of activated T-cells (NFAT) in immune response, phospholipase C signaling and antigen presentation.

*Conclusion:* An important role in vestibular schwannoma formation is attributed to nuclear factors of activated

T-cells and their transcriptional partners, whose combined interactions result in a deranged T-cell response and may thereby lead to an imbalance between tumorigenesis and immune response.

### 300. Outcomes Following Lateral Temporal Bone Resection for Squamous Cell Carcinoma

Aaron D. Tward (presenter), Alicia Quesnel, Michael G. Moore, Daniel D. Deschler, Michael J. McKenna, Derrick T. Lin (Boston, USA)

*Objective:* This study aims to determine clinical outcomes following lateral temporal bone resection (LTBR) for squamous cell carcinoma.

*Subjects and Methods:* A retrospective review of medical records was performed on patients receiving LTBR for squamous cell carcinoma between 1990 and 2011 at a single tertiary referral center.

*Results:* The records of 36 patients were analyzed with the mean age at the time of surgery being 64.1 years. Overall survival was 93%, 83%, 77%, 77%, and 58% at 1, 2, 5, 10, and 15 years after surgery, respectively. Disease free survival was 63%, 50%, 43%, 43%, and 43% at 1, 2, 5, 10, and 15 years after surgery, respectively. Achieving negative margins improved overall survival, disease-free survival, and local control. Additional subgroup analyses are also presented.

*Conclusions:* In patients with squamous cell carcinoma of the ear and temporal bone, surgical excision, including lateral temporal bone resection, is an effective management strategy. Complete removal of disease may improve outcomes. When present, recurrences occur within a few years of surgery, and are likely to be local.

### 301. Spontaneous Otogenic CSF Leaks: A Presentation of Cases and Review of Literature and Management Options

Meghan N. Wilson (presenter), James Lin, Daniel W. Nuss, Moises A. Arriaga, Jason Durel (Baton Rouge, USA)

*Objective:* Spontaneous otogenic CSF leak is a life-threatening problem. The types of spontaneous CSF fistulae have been previously classified into defects through, adjacent to, or distal to the otic capsule. This paper presents case reviews representative of these three different spontaneous CSF fistulae and reviews pertinent literature. The clinical evaluation and surgical management of each type of CSF fistula are reviewed, highlighting the importance of variables such as the functional status of the ear, age-related limitations, and potential for concomitant anatomic anomalies.

*Study Design:* The study consists of a case series and literature review.

*Setting:* The study was conducted at an academic tertiary referral practice.

*Patients:* Two patients with leaks through malformed inner ears are presented—one with persistent tympanomeningeal fissure and one with middle fossa encephalocele with leak.

*Intervention(s):* Skull base closure techniques, selective middle ear packing, middle fossa craniotomy and CSF diversion were interventions chosen based on hearing status and site of leak.

*Main Outcome Measure(s):* Resolution of CSF leakage and absence of meningitis were indicators of successful outcomes.

**Results:** None of the cases described in this series had return of CSF otorrhea in the postoperative period, and none of them had subsequent episodes of meningitis. Each type of CSF fistula required individualized diagnostic and therapeutic strategy with regard to preoperative workup, type of surgical procedure, adjunctive lumbar drainage and postoperative functional expectations.

**Conclusions:** Otogenic CSF fistulae can occur through, adjacent to, and distant to the otic capsule. Identification of leak type and concomitant potential pitfalls impact treatment options and outcomes.

### 302. Pigmented Villonodular Synovitis of the Infratemporal Fossa

Nimish A. Patel (presenter), Matthew Cox, Michael Medina (Pittsburgh, USA)

A 35-year-old woman is referred to the otolaryngology clinic for evaluation of a palpable mass in the left preauricular region present for approximately 1 year prior to presentation. The mass is associated with intermittent swelling and tenderness, as well as headaches radiating along the left temporal region. Physical examination revealed a 1-cm, palpable, subcutaneous mass in the left preauricular region. MRI revealed a well-defined, enhancing mass measuring 19 mm in diameter. The mass is located anterosuperior to the left external auditory canal with evidence of erosion of the outer cortex of the petrous temporal bone.

Excision was performed under general anesthesia with facial nerve (cranial nerve VII) monitoring. Intraoperatively, a firm, soft tissue mass adherent to the temporomandibular joint (TMJ) capsule was identified. Erosion of the outer cortex of the temporal bone immediately superior to the infratemporal fossa was noted; therefore, this region was drilled down to the dura to ensure complete removal of the mass. Pathologic evaluation confirmed pigmented villonodular synovitis (PVS). The patient's case was reviewed at the multidisciplinary head and neck tumor board, where recommendations were for postoperative proton therapy due to close margins of excision and adjacent soft tissue invasion.

PVS is a benign, yet locally destructive lesion arising from the synovial tissue of joints, tendon sheaths, and bursae. More than 80% of the lesions arise from the knee joint. Disease progression can range from slow growth with compression of adjacent structures to rapidly expansile lesions with destruction of adjacent bone including the skull base. PVS of the TMJ is exceedingly rare, with less than 35 reported cases since the disease entity was initially described in 1941. Extra-articular lesions, as in this case, are less frequently reported as most lesions involving the TMJ have evidence of mandibular destruction. This case report will discuss the incidence of PVS, with review of the literature pertaining to radiologic characteristics, surgical management, and differential diagnosis of infratemporal masses. Further awareness of this disease entity among the head and neck surgery community is crucial because failure to accurately diagnose the condition leads to inappropriate treatments and progression of disease.

### 303. Management of Inverted Papilloma of the Temporal Bone

Nicholas R. Rowan, Evelyne Kalyoussef (presenter), James K. Liu, Robert W. Jyung (Newark, USA)

**Objective:** The purposes of this study are to (1) understand the clinical presentation, etiology, and histopathology

of inverting papilloma of the temporal bone; and (2) discuss current treatment and management of inverting papilloma of the temporal bone as well as considerations for future management.

**Methods:** Inverted papilloma (IP), a benign neoplasm typically arising within the sinonasal tract, has rarely been reported to occur outside the sinonasal tract. Only 17 cases of temporal bone IP have been reported. We review our two cases of temporal bone IP and discuss their management.

**Results:** Our first case was a patient with a history of sinonasal IP who had undergone three previous endoscopic resections when she presented with a subepithelial mass extending from the posterior wall of the ear canal. She was found to have extensive bony destruction and underwent a retrolabyrinthine approach with tympanomastoid obliteration. Recurrence was monitored with baseline and follow-up PET-CT scans. The second case was a primary lesion with an atypical otoscopic appearance of a granular mass extending from the middle ear through a tympanic membrane perforation. This was managed with a tympanomastoidectomy and clinically followed for recurrence.

**Conclusion:** Temporal bone IP is a rare neoplasm with no definitive treatment algorithm. We recommend aggressive surgical resection with close postoperative follow-up. PET-CT may be useful for identifying multicentric disease at presentation or for early identification of recurrent disease. HPV detection may identify IPs at risk for multicentric or recurrent disease.

### 304. Recurrent Facial Palsy: The Role of Surgery

Mihaela Cristiana Tatu (presenter), Lucian Constantin Esanu (Bucharest, Romania)

Repeated episodes of acute idiopathic facial paralysis present both a diagnostic and management dilemma. The authors discuss these issues in relation to a series of three adult cases managed between 2006 and 2010. Patients presented with between 3 and 12 episodes of ipsilateral paresis or paralysis. In all cases, there was evidence of progressive facial weakness with synkinesis in one. Underlying facial nerve pathology was excluded by a combination of high resolution CT and MRI scans.

All cases are managed surgically to decompress the geniculate, second, and third segments of the nerve.

Following surgery, all cases had no further episodes of facial weakness; one case that was diagnosed with Melkersson-Rosenthal syndrome had rare episodes but was substantially improved.

The authors consider that in cases of recurrent acute facial weakness with three or more documented episodes, especially in the presence of a progressive deterioration in function, that there is a role for surgical decompression.

### 305. Facial Nerve Schwannomas Presenting as Occluding External Auditory Canal Masses

Richard K. Gurgel (presenter), Robert K. Jackler (Menlo Park, USA)

**Introduction:** Facial nerve schwannomas are rare tumors of the lateral skull base. Treatment options for these tumors include observation, stereotactic radiation, and microsurgical removal. Erosion of the bony posterior canal from the descending segment of an entirely intratemporal tumor

is an unusual growth pattern. With tumor in the external canal, a unique set of clinical challenges arises. We discuss the management strategies for facial schwannomas with this unusual growth pattern in patients of two disparate ages.

**Setting:** The study was conducted at a tertiary care academic medical center.

**Methods:** Records were reviewed for two patients with facial nerve schwannomas eroding into the external auditory canal (EAC).

**Results:** Two patients are presented, a 69-year-old woman and an 11-year-old boy, with facial nerve schwannomas showing atypical growth patterns of erosion through and occlusion of the EAC. Both patients had normal facial function (HB I/VI) and had tumors that medially entrap squamous debris, thus forming canal cholesteatomas. They would remain free of infection, however, if the keratin accumulation was regularly débrided. Stereotactic radiation, while possibly controlling future tumor growth, would not relieve the

anatomic obstruction in the EAC. The 69-year-old patient has been managed successfully for 3 years with regular débridement, no tumor growth, normal facial function, and no other symptoms. The 11-year-old had a 30-dB conductive hearing loss. Due to his young age and anticipated future complications, surgery with either dissection of the tumor from the main facial nerve trunk or complete resection with nerve grafting was recommended.

**Conclusion:** Erosion into the external auditory canal from facial nerve schwannomas presents a unique management dilemma. In addition to facial nerve function, issues such as conductive hearing loss, canal cholesteatoma, otitis externa, and chronic otitis media must all be considered. Treatment must be tailored to the individual patient. In young patients who face near-certain tumor growth and future complications, early microsurgical resection with nerve grafting is recommended. In older patients who remain minimally symptomatic, observation is reasonable.