

A Cross-sectional Survey of the North American Skull Base Society: Current Practice Patterns of Vestibular Schwannoma Evaluation and Management in North America

Matthew L. Carlson^{1,2} Jamie J. Van Gompel^{1,2} R. Mark Wiet³ Nicole M. Tombers¹ Anand K. Devaiah⁴
Devyani Lal⁵ Jacques J. Morcos⁶ Michael J. Link^{1,2}

¹ Department of Otolaryngology-Head and Neck Surgery, Mayo Clinic School of Medicine, Rochester, Minnesota, United States

² Department of Neurologic Surgery, Mayo Clinic School of Medicine, Rochester, Minnesota, United States

³ Department of Otolaryngology-Head and Neck Surgery, Rush University Medical Center, Chicago, Illinois, United States

⁴ Department of Otolaryngology-Head and Neck Surgery, Boston University School of Medicine, Boston Medical Center, Boston, Massachusetts, United States

⁵ Department of Otolaryngology-Head and Neck Surgery, Mayo Clinic College of Medicine, Phoenix, Arizona, United States

⁶ Department of Neurological Surgery, University of Miami, Miller School of Medicine, Miami, Florida, United States

Address for correspondence Matthew L. Carlson, MD, Department of Otolaryngology-Head and Neck Surgery, Mayo Clinic, 200 1st Street SW, Rochester, MN 55905, United States
(e-mail: carlson.matthew@mayo.edu).

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Abstract

Background Very few studies have examined vestibular schwannoma (VS) management trends across centers and between providers. The objective of this study is to examine current practice trends, variance in treatment philosophies, and nuanced or controversial aspects of VS care across North America.

Methods This is a cross-sectional survey of North American Skull Base Society (NASBS) members who report regular involvement in VS care.

Results A total of 57 completed surveys were returned. Most respondents claimed to have over 20 years of experience and the majority reported working in an academic practice with an affiliated otolaryngology and/or neurosurgery residency program. Sixty-three percent of respondents claimed to evaluate VS patients in clinic with both an otolaryngologist and neurosurgeon involved. Eighty-six percent of respondents claimed to operate on VS with both an otolaryngologist and neurosurgeon involved, while only 18% of neurosurgeons and 9% of otolaryngologists performed surgery alone. There was a wide range in the number of cases evaluated at each center annually. Similarly, there was wide variation in the number of patients treated with microsurgery and radiation at each center. Additional details regarding management preferences for microsurgery, stereotactic radiosurgery, stereotactic radiotherapy, and conservative observation are presented.

Keywords

- ▶ vestibular schwannoma
- ▶ acoustic neuroma
- ▶ skull base surgery
- ▶ cranial fossa
- ▶ microsurgery
- ▶ radiosurgery

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Conclusion VS management practices vary between providers and centers. Overall, most centers employ a multidisciplinary approach to management with collaboration between otolaryngology and neurosurgery. Overall, survey responses concur with previous studies suggesting a shift toward conservatism in management.

Introduction

Despite being histologically benign and relatively rare, otolaryngologists and neurosurgeons have maintained an enduring and deep-rooted fascination with the management of vestibular schwannoma (VS). The treatment of VS has a storied past of controversy rising from the frequent collision of dogmatic views and innovative advances. Many of the early debates between pioneering surgeons have come full circle as the pendulum swings between conservatism and definitive cure.

In 1777, Eduard Sandifort provided the earliest postmortem description of “a hard body” involving the auditory nerve of a patient with a history of deafness, declaring this malady incurable.¹ In the *pre-Cushing* era, patients with VS were generally observed until life-threatening tumor growth mandated a heroic, and often dreadfully morbid or fatal, attempt at tumor resection.² Early advances pioneered by Harvey Cushing, and his apprentice and later rival Walter Dandy, resulted in an unprecedented reduction in mortality from over 80% to less than 20%.²⁻⁵ Cushing advocated for subtotal intracapsular piecemeal tumor removal, approached through a mastoid-to-mastoid suboccipital craniectomy. Dandy openly opposed this strategy, favoring a unilateral suboccipital approach with complete tumor resection, citing the high rate of recurrence with subtotal removal.

Subsequent advancements in technology and surgical techniques during the 1950s and 1960s culminated in the application of the surgical microscope and electric dental drill to VS surgery by William House, ushering in the era of skull base microsurgery.⁶⁻⁹ William House teamed with the neurosurgeon William Hitselberger and first adopted a collaborative approach to VS care. It was also during this time that the middle cranial fossa and translabyrinthine approaches were revitalized after being abandoned nearly 60 years earlier secondary to technical limitations.^{6,8,10,11} Thus, it can be said that VS defined the subspecialty of neurotology and forged the establishment of the interdisciplinary model of care between otolaryngology and neurosurgery. While commonly accepted today, these original developments incited intense disputes regarding specialty jurisdiction and over the merits of the suboccipital versus translabyrinthine approach. In more recent years, debates within the surgical community have evolved to include the use of middle cranial fossa versus suboccipital craniotomy for hearing preservation.

Paralleling developments in lateral skull base microsurgery, Lars Leksell, a student of the preeminent neurosurgeon Herbert Olivecrona of Sweden, pioneered the development of his arc-centered stereotactic frame as a

means of noninvasive, precise ablation of intracranial lesions utilizing convergent beam radiation.^{12,13} In reaction to witnessing the morbidity of surgical resection, in 1971 Leksell published the inaugural account of VS treatment using stereotactic radiosurgery (SRS).¹⁴ With advances in radiation delivery techniques, there has been an exponential increase in the use of single-fraction SRS and fractionated stereotactic radiotherapy (SRT) for treatment of VS between 1990 and present. This rise in use has largely shifted the attention of the VS community from disputes over best surgical approach to optimal treatment modality comparing microsurgery and SRS/SRT. Within the radiation community are additional controversies regarding fractionation schedules (i.e., single fraction, hypofractionation, highly fractionated), delivery platforms (i.e., GammaKnife, Cyberknife, Novalis), and type of radiation employed (i.e., photons or protons).

The most recent period in VS management has been driven by developments in noninvasive neuroimaging, including contrast-enhanced computed tomography and magnetic resonance imaging (MRI). In this setting, tumor observation with serial imaging became a viable strategy. Initially, only patients with minimal symptoms, small tumors, advanced age, or severe comorbidities were considered for a conservative “wait-and-scan” strategy; however, over time, this approach has been adopted with increasing frequency.^{15,16}

The evolution in VS treatment over the past century has ultimately led to an environment where functional outcome and quality of life has taken precedence over disease eradication.¹¹ In the absence of high-level evidence, debates over optimal management are frequently muddled by anecdotal interjection and dogmatism from proponents on all sides. While most large skull base centers of today offer microsurgery, SRS/SRT, or observation for treatment of small to medium sized VS, one treatment often predominates reflecting strong institutional biases. To date, very few studies have examined evolving management trends across centers and between providers. To this end, the objective of the current study was to examine current practice trends, variance in treatment philosophies, and nuanced or controversial aspects of VS care.

Materials and Methods

A 64-item Web-based survey assessing VS practice trends was devised by members of the North American Skull Base Society (NASBS) Research Task Force and distributed to the NASBS membership via SurveyMonkey (→ **Appendix A**, online only). Voluntary participation was solicited via email with an attached electronic survey link available from

November 29 through December 14, 2016. Following initial contact, survey reminders were sent 1 week and 24 hours before survey closure.

Responses were requested from those who are engaged in VS treatment. As a secondary screening measure, the first question of the survey inquired, "Are you actively involved in vestibular schwannoma treatment at your center?," and the survey episode was subsequently closed for respondents who selected "no." All survey questions were multiple choice and in most cases, survey items required selection of the single best answer. Respondent data were collected and compiled anonymously. Data from this large survey were apportioned into two separate reports according to topic: (1) overall management trends in VS across North America; (2) practice patterns of perioperative VS care in North America. This article presents data for the first of these two publications. Associations between features of interest were analyzed using Spearman's rank correlation, and comparisons between variables were assessed using Kruskal-Wallis, Wilcoxon rank-sum, and Fisher's exact tests as appropriate. Statistical analyses were performed using version 9.4 of the SAS software package (SAS Institute, Cary, North Carolina, United States). All tests were two sided and *p*-values <0.05 were considered statistically significant. The Mayo Clinic Institutional Review Board deemed this study exempt from review.

Results

Population Demographic

A total of 719 members were initially emailed a survey link, comprising the entire membership of the NASBS as of October 2016. Of these, 87 opened the survey questionnaire. Eight reported they were not actively involved in VS treatment and an additional 22 did not finish the complete question set. Therefore, 57 completed surveys were analyzed from NASBS members who reported to have regular involvement in VS care. Most respondents were between 50 and 59 years of age, all were men, and the most common self-reported race/ethnicity was White/Caucasian, followed by Asian/Pacific Islander, and Hispanic. Eighty-four percent of survey participants practice in the United States. Additional details regarding respondent demographics are outlined in ►Table 1.

Training, Experience, and Setting

With regard to training background, 58% reported "neurosurgery with specialization in skull base and cerebrovascular surgery," 32% reported "neurotology with accredited fellowship," 9% reported "otology without accredited fellowship in neurotology," and 2% claimed "general neurosurgery"; none reported "general otolaryngology" or "no formal training in neurosurgery or otolaryngology." Most claimed to have over 20 years of experience and the majority reported working in an academic practice with an affiliated otolaryngology and/or neurosurgery residency program. Additional details regarding respondent training and practice setting are outlined in ►Table 2.

Table 1 Responder demographics

Variable	%	N
Age		
< 30 y	0.0	0
30–39 y	17.5	10
40–49 y	26.3	15
50–59 y	40.4	23
60–69 y	14.0	8
70–79 y	1.8	1
≥80 y	0.0	0
Sex		
Female	0.0	0
Male	100.0	57
Race/Ethnicity		
American Indian or Alaskan Native	0.0	0
Asian/Pacific Islander	22.8	13
Black or African American	0.0	0
Hispanic	12.3	7
White/Caucasian	61.4	35
Multiple ethnicity/ other (please specify)	3.5	2
Country		
Canada	3.5	2
Mexico	3.5	2
United States of America	84.2	48
Outside of North America	8.8	5
States in United States		
Arizona	8.3	4
Arkansas	2.1	1
California	12.5	6
Florida	8.3	4
Illinois	6.3	3
Indiana	2.1	1
Kansas	2.1	1
Kentucky	2.1	1
Louisiana	2.1	1
Maryland	2.1	1
Massachusetts	6.3	3
Michigan	6.3	3
Minnesota	6.3	3
Missouri	2.1	1
New Mexico	2.1	1
New York	8.3	4
Ohio	6.3	3
Pennsylvania	4.2	2

(Continued)

Table 1 (Continued)

States in United States		
Tennessee	4.2	2
Texas	4.2	2
Washington	2.1	1
Province in Canada		
Alberta	50.0	1
British Columbia	50.0	1

Overall Practice Patterns

Sixty-three percent of respondents claimed to evaluate VS patients in clinic with both an otolaryngologist and neurosurgeon involved, while 26% of neurosurgeons and 52% of otolaryngologists evaluated and counseled patients alone without cross-specialty involvement. Eighty-six percent of respondents claimed to operate on VS with both an otolaryngologist and neurosurgeon involved, while only 18% of neurosurgeons and 9% of otolaryngologists performed surgery alone.

There was a wide range in the number of cases evaluated at each center annually. Similarly, there was wide variation in the number of patients treated with microsurgery and radiation at each center (► **Table 3**). With regard to initial management preference for small (<1.5 cm) VS, 91% recommended initial observation until growth was demonstrated, while 7 and 2% advocated for upfront microsurgery or SRS/SRT, respectively. Overall, most respondents (50.9%) felt that observation offered the best chance of retaining serviceable hearing at 10 years in patients presenting with excellent hearing, while 42% felt microsurgery (31.6% middle cranial fossa; 10.5% retrosigmoid craniotomy) and 7% felt radiation offered advantages toward long-term hearing preservation.

Microsurgery

With regard to microsurgical resection, the following topics were evaluated in the survey with individual responses outlined in the respective appendix item number(s): preferred surgical approach for hearing preservation surgery with intracanalicular tumors (AQ20); estimated probability of serviceable hearing preservation in a patient with a small, primarily intracanalicular tumor, with a limited (1–2 mm) cerebrospinal fluid (CSF) fundal cap and 100% word recognition (AQ27); tumor size cutoff where hearing preservation becomes unlikely (AQ30); level of hearing that is worth attempting to preserve when tumor characteristics are reasonably favorable (AQ32); patient- and tumor-related factors that predict hearing preservation outcome (AQ31); preferred surgical approach for removal of VS with CPA extension when hearing preservation is not a goal (AQ29); headache associated with retrosigmoid craniotomy (AQ41); effect of surgery on tinnitus (AQ45); effect of surgery on dizziness in patients reporting severe/frequent preoperative dizziness (AQ46); strategy for treatment of

Table 2 Responder practice characteristics

Variable	%	N
Training background		
General neurosurgery	1.8	1
Neurosurgery with specialization in skull base and cerebrovascular surgery	57.9	33
General otolaryngology	0.0	0
Otology without accredited fellowship in neurotology	8.8	5
Neurotology with accredited fellowship	31.6	18
No formal training in neurosurgery or otolaryngology	0.0	0
Length of time in clinical practice		
Still in training (residency or fellowship)	1.8	1
1–5 y	15.8	9
5–10 y	8.8	5
11–15 y	17.5	10
16–20 y	14.0	8
> 20 y	42.1	24
Clinical practice setting		
Solo private practice	1.8	1
Group private practice	5.3	3
Private practice with academic affiliation	19.3	11
Primarily academic practice	73.7	42
Affiliation with residency or fellowship program		
Residency	82.5	47
Fellowship	43.9	25
None	5.3	3

concomitant trigeminal neuralgia (AQ47); extent of resection and use of subtotal resection (AQ48–50); treatment of residual disease following subtotal resection (AQ57); preferred surgical approach for large (>3 cm) tumors (AQ51); and surgical approach with highest risk of postoperative CSF leak (AQ52).

Radiation

With regard to SRS/SRT, the following topics were evaluated in the survey with individual responses outlined in the respective appendix item number(s): access to a SRS/SRT program and type of radiation employed (AQ18); number of VS treated with radiation at center each year (AQ14); involvement of surgeon in radiation treatment planning (AQ15); maximum size cutoff for use of SRS/SRT (AQ16); counseling regarding risk of malignant degeneration with radiation (AQ17); estimated probability of serviceable hearing preservation in a patient with an

Table 3 Responder-reported case volume

Variable	%	N
Annual number of new VS evaluated at center		
< 25 cases per year	17.5	10
25–50 cases per year	28.1	16
51–75 cases per year	15.8	9
76–100 cases per year	8.8	5
101–150 cases per year	12.3	7
151–200 cases per year	7.0	4
> 200 cases per year	10.5	6
Annual number of VS treated with surgery at center		
None	0.0	0
1–5 cases per year	14.0	8
6–10 cases per year	10.5	6
11–30 cases per year	29.8	17
31–50 cases per year	21.1	12
51–100 cases per year	15.8	9
> 100 cases per year	8.8	5
Annual number of VS treated with radiation at center		
None	3.5	2
1–5 cases per year	8.8	5
6–10 cases per year	28.1	16
11–30 cases per year	38.6	22
31–50 cases per year	12.3	7
51–100 cases per year	7.0	4
> 100 cases per year	1.8	1

small, primarily intracanalicular tumor; and 100% word recognition (AQ27).

Observation

With regard to observation with serial MRI, the following topics were evaluated in the survey with individual responses outlined in the respective appendix item number(s): based on experience, percentage of intracanalicular tumors that grow over the first 5 years of observation (AQ21), and based on experience, percentage of tumors with <1.5 CPA extension that grow over the first 5 years of observation (AQ22).

Associations between Responses

Overall there was no statistically significant association between the number of tumors evaluated each year and the respondents' length of clinical practice ($p = 0.72$), type of practice setting ($p = 0.15$), and use of a multidisciplinary team approach ($p = 0.12$). Additionally, there was no statistically significant association between use of a multidisciplinary team approach and initial management of small tumors ($p = 0.23$), selection of surgical approach for hearing preservation surgery ($p = 0.30$), and selection of surgical

approach for large tumors ($p = 0.062$). However, surgical teams incorporating both a neurosurgeon and neurotologist were more likely to utilize a translabyrinthine approach, instead of a retrosigmoid approach, in cases where hearing preservation was not a goal ($p < 0.001$).

Discussion

In this cross-sectional survey study analyzing practice patterns in VS management in North America, 57 physician members of the NASBS who reported regular involvement in VS treatment returned a completed survey. Sixty percent of respondents were neurosurgeons and 40% were otolaryngologists. Approximately three-fourths of respondents claimed an academic practice setting, with over 80% evaluating at least 25 new cases at their center per year, and over 50% evaluating more than 50 cases per year. To date there have been few published studies evaluating practice patterns in VS management. Below, we compare the results of this study to the existent literature with regard to the multidisciplinary model of care, modality selection, as well as preferences pertaining to microsurgery and SRS/SRT.

Multidisciplinary Approach

In 2014, Fusco et al distributed a 17-item survey to 3,858 eligible residency-trained members of the American Association of Neurological Surgeons practicing in the United States and Canada.¹⁷ Of 706 (18%) neurosurgeon respondents, 86% reported utilizing an interdisciplinary team approach to microsurgical resection. Though not statistically significant, the authors noted that those surgeons who had cumulatively treated more than 50 tumors tended to utilize a multidisciplinary team more frequently than surgeons with less experience. Notably, 76% of respondents felt that an interdisciplinary team approach should be considered the “standard of care.”

In 2002, the British Association of Otorhinolaryngologists—Head and Neck Surgeons Clinical Practice Advisory Group devised the *Clinical Effectiveness Guidelines for Acoustic Neuroma*—a consensus document with representation from key specialty associations.^{18,19} Following this, in 2006 two separate surveys were sent to the British Association of Otorhinolaryngologists—Head and Neck Surgeons and the Society of British Neurological Surgeons to evaluate adherence to consensus guidelines.^{18,20} Saeed et al reported that 22 of 28 (79%) neurotologists regularly worked with neurosurgeons when treating VS and Goodden et al reported that 41 of 56 (73%) neurosurgeons worked with an ENT surgeon.^{18,20}

This study differed from the publications reviewed earlier in several areas. Most notably, we surveyed the NASBS membership, a large multidisciplinary skull base society, providing responses from a pool of otolaryngologists and neurosurgeons specializing in management of skull base disorders such as VS. This distinction is apparent when comparing case volume per respondent between studies. However, all studies reported remarkably similar rates of utilizing a multidisciplinary surgical team, between 73 and

86%, clearly demonstrating the departure from the “lone surgeon” model of care that was prevalent in years past to a multidisciplinary approach to both evaluation and treatment. Prior publications have reported several notable benefits of specialized care through a high-volume multidisciplinary team.^{21–25} These studies have shown reduced mortality and lower perioperative complications as well as fewer discharges to inpatient rehab facilities for patients having VS surgery. In addition, higher volume centers frequently require a shorter length of stay and an associated reduction of inpatient costs.

Modality Selection

Another evolving and highly nuanced aspect of VS care is modality selection, particularly for small to medium sized tumors.^{11,26,27} Historically, surgical resection with the goal of complete tumor removal was standard practice, and radiation or observation was considered only in the extreme elderly patients or those deemed unfit for surgery.^{4,11} Within the VS community as a whole, there has been a gradual but certain paradigm shift toward conservatism.¹⁶ Specifically, surgeons are more willing to perform subtotal tumor removal to mitigate risk of facial paralysis, and a greater number of patients are undergoing SRS/SRT or observation. Between the late 1990s and 2012, several publications documented an upsurge in radiation use and most recently, the use of serial observation has become the fastest growing management strategy.^{16,28–31} This recent transition toward observation is strongly evidenced in this study, where an astonishing 91% of respondents reported that at their respective centers most small (<1.5 cm) VSs are managed with initial observation until growth is demonstrated. Furthermore, 51% of respondents felt that conservative observation confers the best chance of retaining serviceable hearing at 10 years in patients with intracanalicular tumors and good hearing, compared with 42% for microsurgery (32% middle cranial fossa, 11% retrosigmoid) and 7% for single-fraction radiosurgery. It is also fascinating to note that anecdotally, almost half of the respondents felt that at least 50% of purely intracanalicular tumors grew during the first 5 years of observation, and nearly three quarters of the respondents believed that at least 50% of small cisternal tumors grew. These estimates are notably higher than the Danish natural history data report, although the threshold within the Denmark data for assigning growth of an intracanalicular tumor, being extension into the CPA, may underestimate the true incidence of growth.³² Despite this clear trend toward initial observation, there appeared to be considerable variability between centers with regard to the ratio of cases treated with microsurgery and observation. This variance in management between centers parallels findings from another recent study, implying that provider and institutional biases still significantly impact treatment trajectory.³³

Microsurgery

Although less contentious today, the “best” surgical approach for hearing preservation and non-hearing preservation surgery remains a debated topic in the VS community. In the

cross-sectional surveys by Saeed et al and Goodden et al, the majority of British neurosurgeon and neurotologist respondents worked in a multidisciplinary team and were not married to one particular approach, but modified the surgical approach depending upon circumstances.^{18,20} Both groups utilized the retrosigmoid/suboccipital and translabyrinthine approaches frequently, while the middle cranial fossa approach was used only in very selected cases. In 2014, Fusco et al found that among 706 neurosurgeons, 54% preferred the retrosigmoid approach alone and 41% tailored their approach based on specific tumor characteristics.¹⁷ In these studies, explicit details regarding preferred surgical approaches for hearing preservation surgery, non-hearing preservation surgery, and resection of large tumors were not pursued. In this study, we found that most respondents favored the middle cranial fossa approach for intracanalicular tumors when attempting hearing preservation surgery (see **Appendix A** [Q20] for additional details); most favored the translabyrinthine approach for resecting cisternal tumors when hearing preservation is not a goal (see **Appendix A** [Q29] for additional details); and for very large tumors, most respondents preferred a single-stage retrosigmoid approach (see **Appendix A** [Q51] for additional details). Overall, the largest category of respondents reported using subtotal resection “sometimes (20–50%)” for tumors larger than 3 cm in CPA dimension, which is in line with a recent publication that abstracted data from a large national tumor registry sample.¹⁶ Overall, 79% of respondents favored initially observing the tumor remnant following subtotal resection and only treating with radiation if unequivocal growth is seen.

Radiation

Over the past 30 years, there have been several publications documenting increasing use of radiation for benign and malignant tumors, including sporadic VS. Several recent studies from the SEER database reveal that between 22 and 27% of VSs are treated with SRS/SRT in the United States.^{16,28,30} This number approximates an estimate by Hamilton and Lunsford, that in 2014 up to 17% of all benign tumors appropriate for Gamma Knife Radiosurgery (GKRS) were treated with radiation in North America.³⁴ This study concurs with a prior publication documenting substantial variance in radiation use between centers.³³

To the best of our knowledge, there is only one other published survey study in the English literature detailing SRS/SRT treatment practices for VS. In 2011, German et al received responses from 132 of 302 members of the American Neurotology Society.³⁵ In this report, 56% of respondents used GammaKnife, and 44% used Cyberknife. This compares to 63% GammaKnife, 25% Cyberknife, 25% Novalis LiNAC, and 16% proton beam in this study, with some centers using more than one platform as evidenced in the sum of the percentages equaling more than 100%. It is interesting to note the percentage of proton beam used (16%) despite little data regarding its effectiveness compared with SRS/SRT at this time. In the study by German et al, the average maximum tumor size respondents would consider for radiation was

2.5 cm; notably six respondents reported they would irradiate tumors larger than 3 cm. These findings closely parallel data in the present study. Regarding pretreatment counseling, over 85% of respondents felt that $\leq 40\%$ of subjects with intracanalicular tumors and good pretreatment hearing would retain serviceable hearing 10 years following SRS/SRT. Finally, regarding the risk of malignant degeneration of VS following radiation, 90% reported that this event is extremely rare and should only be a very minor consideration when deciding treatment, 10% did not even discuss this issue with patients unless raised by the patient, and none felt that this should be a major consideration when deciding treatment.

In conclusion, there are several strengths and limitations of the present study that merit review. This cross-sectional survey study incorporated a large detailed question set that was completed by members of the NASBS who reported regular involvement in VS treatment and relatively large annual case numbers. These data enhance our understanding of current treatment practices in North America. The overall distribution of age, duration of clinical experience, and specialty background of respondents was broad, which strengthens external validity. However, the generalizability of this data is hindered by exclusive involvement of NASBS membership, which potentially introduces certain biases concerning multidisciplinary care and modality selection.

Conclusion

Significant variation in VS care exists across North America. Results from the current survey allow providers an opportunity to evaluate their current practice in the context of the greater VS community. Most centers employ a multidisciplinary model of care including a neurotologist and neurosurgeon. With a high percentage of providers adopting initial observation for small- to medium-sized tumors, currently the proportion of cases allocated to microsurgery is diminishing. Evolving practice patterns in VS treatment may carry significant implications with regard to surgical volume and training and the growing need for centralization of care.

Financial Material and Support

Internal departmental funding was utilized without commercial sponsorship or support.

Conflict of Interest

None.

Institutional Review Board Approval

Institutional review board exempts this study from review.

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