Is Preoperative Facial Palsy a Deterrent to Facial Nerve Preservation after Gross-Total Removal of Giant Vestibular Schwannomas?

Debabrata Sahana[1] Sanjeev Kumar[1] Lavlesh Rathore[1] Jatinder Mittal[1] Rajiv K. Sahu[1] Amit K. Jain[1] Manish Tawari[1]

[1] Department of Neurosurgery, DKS Post Graduate Institute and Research Center, Raipur, Chhattisgarh, India

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Address for correspondence Debabrata Sahana, MCh, Department of Neurosurgery, DKS Post Graduate Institute and Research Center, Raipur, Chhattisgarh, 492001, India (e-mail: desahana@gmail.com).

Abstract

Background Although rare in small vestibular schwannomas, preoperative facial nerve paresis is often present in giant schwannomas. Preserving facial nerve function in these cases remains a herculean task. This study evaluates the facial functions after complete tumor removal and whether preoperative facial nerve involvement affects postoperative functional status.

Methods This retrospective study from January 2014 to August 2021 excluded nongiant tumors (< 4 cm), neurofibromatosis type 2 cases, incomplete removals, redo surgeries, deaths, and cases done without nerve monitoring. These were grouped into preoperative facial palsy present (PFP) and no preoperative facial palsy (NFP). Facial nerve functions were assessed on first postoperative day, at the time of discharge, and at last follow-up and dichotomized into two groups: nondisfiguring (House–Brackmann [HB] grades I–III) and disfiguring (HB grades IV–VI). The cohort outcomes of patients with nondisfiguring PFP (HB grades I–III) were also analyzed.

Results There were 88 cases (PFP, $n = 57$; NFP, $n = 31$). Facial nerve was preserved anatomically in 62 (70.45%) patients (PFP, $n = 38$; NFP, $n = 24$) without any statistical difference ($p = 0.29$). Statistically significant disfiguring facial outcomes (HB IV, V, VI) were seen in patients with preoperative facial palsy ($p = 0.01$); however, a comparison of facial functions in patients with only nondisfiguring PFP with those in NFP group did not show the statistical difference ($p = 0.12$).

Conclusion Facial nerve palsy present before surgery does not seem to be a deterrent to intraoperative preservation of facial nerve during complete removal of giant vestibular schwannomas. Patients with nondisfiguring facial palsies have postoperative facial functions comparable to those without facial palsy.

Keywords
- giant vestibular schwannomas
- facial palsy
- facial nerve preservation

Introduction

Vestibular schwannomas (VS) are the commonest (80%) cerebellopontine angle tumors arising from the inferior vestibular division of the eighth nerve.[1–6] Earlier, microsurgical decompression was the only treatment modality. With changing goals of surgery, namely, facial

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and hearing preservation, newer modalities of treatment like radiosurgery or subtotal removal followed by radiosurgery have come up. The Gamma knife is suitable for smaller tumors, but surgery remains the mainstay for larger ones. Many of these large tumors often present with facial palsy. Such a presentation is rare for smaller tumors (2–6%) but is often seen in large and giant VS.[7–13] Besides the large size of the tumor, another factor contributing to facial palsy is the cisternal or more medial tumor location. Both these factors also preclude facial preservation during surgical decompression of tumors.[14] Although facial nerve preservation along with preservation of salvageable hearing has now become the norm in VS surgery, this becomes exponentially difficult in giant tumors.

Ours is a state government-run tertiary care center attended mainly by people from poor socioeconomic backgrounds. They reach the hospital at a stage when tumors have attained giant sizes, hearing is not salvageable, and many have preoperative facial palsy (PFP). Due to financial constraints and long distances from our center, they are also less likely to come for follow-up. So, the goal with which we operate upon such patients is gross-total decompression whenever possible. Our study is a retrospective analysis of such cases. It analyzes the postoperative facial nerve functions in those having facial palsy before surgery and those not having them; it may help prognosticate patients regarding their already compromised facial functions.

Materials and Methods

This retrospective study includes giant VS, operated from January 2014 to August 2021. The three primary operating surgeons have surgical experience in performing such surgeries for 8 to 14 years. The total number of VS operated in this period was 180. We included non-NF2 patients with only giant VS (>4 cm maximum extra-meatal diameter) with complete tumor removal confirmed on postoperative magnetic resonance imaging (MRI; performed either on the first postoperative day or 2 months after surgery), with or without preoperative facial nerve palsy (►**Fig. 1**). Intraoperative neuromonitoring was used in all cases. Ninety-two patients were excluded (35 with tumors less than 4 cm, 17 with incomplete removal, 2 patients with NF2, 2 redo surgery cases, 5 postoperative mortalities, and 31 without nerve-monitoring). For the final analysis, 88 cases were eligible. This cohort was divided into PFP and those without facial paralysis (NFP). The criteria chosen for anatomical facial nerve preservation were the visualization of intact facial nerve intraoperatively following tumor removal using standard anatomical landmarks and confirmation by

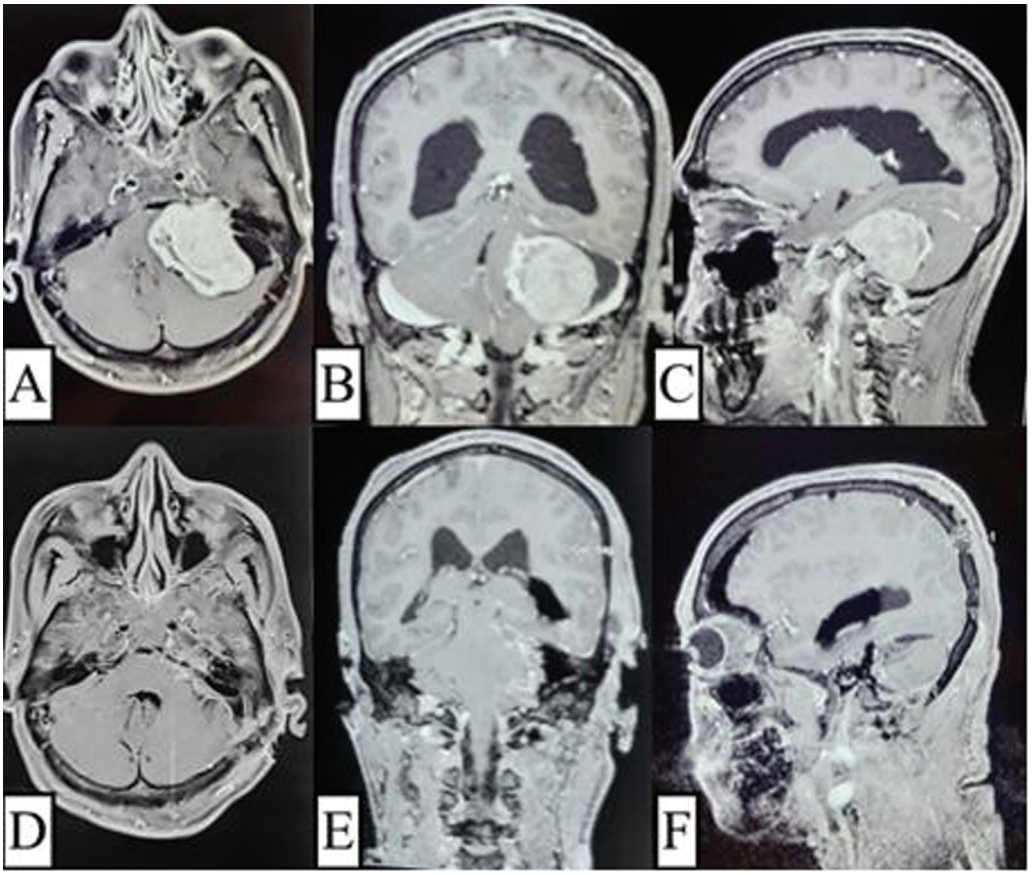

Fig. 1 Magnetic resonance imaging preoperative axial, coronal, and sagittal (**A–C**) showing giant vestibular schwannoma, and postoperative image (**D–F**) showing complete tumor removal.

direct nerve stimulation using neuromonitoring. House–Brackmann (HB) classification was used to grade facial function preoperatively, on the first postoperative day, at discharge, and at the last follow-up. Facial functions were considered good (HB grades I–II), fair (HB grade III), poor (HB grade IV), and no function (HB grades V–VI). The rate of facial nerve preservations was compared and analyzed. For further analysis, functional outcomes were dichotomized into HB I to III (nondisfiguring) and HB grades IV–VI (disfiguring). The cohort outcomes of patients with nondisfiguring PFP (HB grades I–III) were also analyzed separately.

In patients with preoperative significant hydrocephalus and symptoms of raised intracranial pressure (ICP) ($n = 14$), a ventriculoperitoneal shunt was done on the side opposite the tumor. In other cases ($n = 24$), external ventricular drain (EVD) was placed through Frazier's point to drain cerebrospinal fluid (CSF) and release pressure for 3 to 5 days.

Operative Details

Surgery was performed under general anesthesia. Total intravenous anesthesia was used in all cases for nerve monitoring. NIM Eclipse E4, SD module by Medtronics, was used for nerve monitoring. Dual needle electrodes were inserted into the mentalis muscle, orbicularis oris muscle, orbicularis oculi muscle, and the frontalis muscle. Two corkscrew electrodes were placed transcranially on standard C3/C4 for motor-evoked potential (MEP). Ground electrodes were placed on the sternum. Depth of anesthesia was assessed using the bispectral index, and a train of four was used to check neuromuscular blockade. Baseline MEP was recorded to determine the minimum voltage threshold required for obtaining electrical activity on needle electrodes. The direct nerve stimulation with a monopolar electrode was applied on the posterior surface of the tumor before proceeding with tumor decompression. This was repeated at regular intervals during tumor dissection close to the internal auditory meatus, brainstem–nerve junction, and along the possible facial nerve tract to confirm its anatomical location. MEP after tumor removal was compared with its baseline values.

All the patients were placed in a park-bench position on three-pins head clamp. A standard lazy S-shaped incision was placed. Retromastoid craniotomy was fashioned flush with the transverse and sigmoid sinus, extending to the foramen magnum rim. CSF was drained till the cerebellum was lax. In five cases, cerebellectomy was performed when the cerebellum did not sink even after CSF drainage or bulged during surgery. After cerebellar retraction, the tumor was defined superiorly and inferiorly. A nerve stimulator was used, as described earlier. The tumor was initially decompressed. When the walls started falling onto themselves, arachnoid dissection was attempted. After meatal drilling, the facial nerve was identified as a fascicle. Following this, the tumor was gently dissected off the facial nerve and removed (►**Fig. 2**). Hemostasis was achieved using bipolar cautery, except close to the meatus, brainstem, and facial nerve, where Surgicel, Gelfoam, and gentle pressure were utilized for as long as needed.

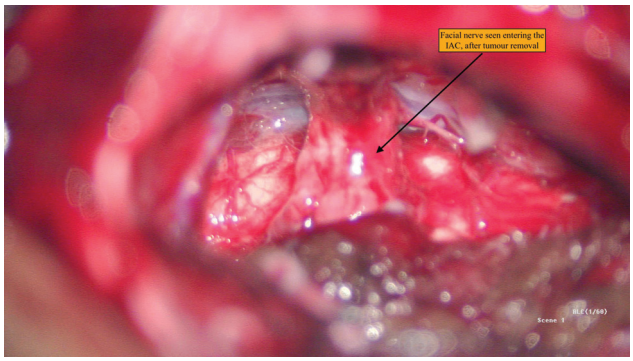

Fig. 2 Intraoperative image showing preserved facial nerve after completely excised vestibular schwannoma. IAC, internal auditory canal.

Lax dural closure was done using the posteroinferior part of the temporalis fascia graft, obtained from the uppermost parts of the skin incision. Bone was replaced; muscle and skin were sutured in layers. Postoperatively, the patient was extubated either on the same day or the day after surgery. Postoperative computed tomography scan/MRI was done in all patients on day 0 or day 1.

SPSS software (version 25) was used for statistical analysis. Analysis was done using the chi-squared test. Statistically, significance was considered for a p-value less than 0.05.

Results

PFP group was seen in 57 (64.77%) and was absent in 31 (NFP group) (35.22%) of the 88 patients included. The PFP group had a mean age of 46.44 years, while the NFP group had a mean age of 45.80 years. There were 46 males and 42 females (M: F—PFP 30:27, NFP 16:15). The two groups were comparable without any statistical significance (age, $p = 0.79$; sex, $p = 0.92$). The mean tumor size was 4.53 cm in the PFP group, while it was 4.47 cm in the NFP group ($p = 0.40$; ►**Table 1**).

The PFP group had 26 patients in HB grade II, 19 with HB grade III, 10 in HB grade IV, and 2 in HB grade V. Postoperatively, the facial nerve was intact anatomically in 62/88 (70.45%) patients. Thirty-eight of these 62 patients had PFP, and 24 did not (►**Tables 2** and **3**).

Overall, 21 patients had good facial nerve functions in the days up to discharge, which improved to 28 at the last follow-up. In the PFP group, on the first day after surgery, good facial nerve function persisted in 14, Fair in 12, and poor in 6 patients, which decreased to fair function in 11 and poor function in 7 patients at discharge. On the last follow-up (mean: 6.93 ± 3.01 months, range: 3–18 months), facial function improved to good in 14 patients, fair in 7, and poor in 12 patients (►**Table 3**).

In the NFP group, out of 31 patients, facial nerve was preserved anatomically in 24 patients. On the first day of surgery, facial functions were good in 12, Fair in 6, and poor

Table 1 Patients characteristics

	Preop facial palsy (PFP group) ($n = 57$)	Preop no facial palsy (NFP group) ($n = 31$)	*p*-Value
Age (years) (mean ± SD)	46.44 ± 8.86	45.80 ± 11.27	0.79
Sex (M: F)	30:27	16:15	0.92
Tumor size (cm)	4.53 ± 0.33	4.47 ± 0.17	0.40

Abbreviations: NFP, no preoperative facial palsy; PFP, preoperative facial palsy present; SD, standard deviation.

in 3 patients. At discharge, a good function was seen in 10, a fair function in 7, and a poor in 4 patients. Facial functions improved to good in 14, fair in 6, and poor in 3 patients at the last outpatient department (OPD) visit. No statistical difference was found in the two groups' anatomical facial nerve preservation rates (PFP vs. NFP; $p = 0.29$; ►**Tables 2** and **3).**

Comparison of overall facial nerve function between the two groups, at last, follow-up (mean 6.93 + 3.01 months, range: 3–18 months) revealed statistically significant difference towards disfiguring facial outcomes (HB grades IV–VI) in those having PFP ($p = 0.01$; ►**Table 4)** However, a statistical difference was not found in comparing only those patients with nondisfiguring PFP (HB grades I–III) with those in the NFP group ($p = 0.12$; ►**Table 5).**

The complications were mainly CSF leaks from the wound (11 patients), requiring additional sutures. Two of such cases developed meningitis but responded to higher antibiotics. We also had five cases of tumor bed hematoma that did not require evacuation. Three of the 24 patients in whom EVD was placed intraoperatively, and removed later, developed hydrocephalus and required a ventriculoperitoneal shunt later.

Table 2 Comparison of anatomical facial nerve preservation in the two groups

	Facial nerve preserved	Facial nerve not preserved	
PFP group	38	19	**Chi-squared test: 0.29 NS**
NFP group	24	07	
Total	62	26	

Abbreviations: NFP, no preoperative facial palsy; NS, nonsignificant; PFP, preoperative facial palsy present.

Discussion

VS affect 0.6 per 100,000 person-years people every year.[15] Treatment modalities other than surgery, like gamma-knife, are available for small tumors, but surgery is the only option for giant tumors. Most Indian neurosurgeons encounter these tumors when they attain sufficient size to bring about a significant mass effect and signs of raised ICP with or without hydrocephalus. Hearing in such patients is often not within salvageable range. Preserving the facial nerve in such large tumors is a formidable task. Using newer imaging modalities like diffusion tensor imaging fiber tracking may help locate the facial nerve's position in large tumors

Table 3 Postoperative facial nerve outcomes

HB grade	PFP group				NFP group			
	n	Postoperative outcome			*n*	Postoperative outcome		
		Day 1	At discharge	At last, follow-up		Day 1	At discharge	At the last follow-up
I	–	–	–	2	31	–	–	3
II	26	14	11	12	–	12	10	11
III	19	12	11	7	–	6	7	6
IV	10	6	7	12	–	3	4	3
V	2	6	7	5	–	3	3	1
VI	–	23	21	19	–	7	7	7
Total	57/88				31/88			

Abbreviations: HB, House–Brackmann; NFP, no preoperative facial palsy; PFP, preoperative facial palsy present.

Table 4 Overall comparison of the functional status of the facial nerve at the last follow-up

	HB grades I–III preservation	HB grades IV–VI preservation	Total	
Preoperative facial palsy present	21	36	57	**Chi-squared test: 0.01 S**
No preoperative facial palsy	20	11	31	
Total	41	47	88	

Table 5 Comparison of facial functions at the last follow-up between patients with preoperative HB grades I–III facial palsy and those without facial palsy

	HB grades I–III preservation	No HB grades I–III preservation	Total	
Preoperative facial palsy present (HB grades I–III)	21	24	45	**Chi-squared test: 0.12 NS**
No preoperative facial palsy	20	11	31	
Total	41	35	76	

Abbreviations: HB, House–Brackmann; NS, nonsignificant.

preoperatively, which helps in surgical planning.[16,17] Intraoperative nerve monitoring increases the chances of facial nerve preservation, although some studies have found its predictions inconsistent. A positive response after tumor removal should be considered a good predictor of function, and its absence does not always predict poor facial outcomes.[18]

VS affect people in the age group of 45 to 64 years without any gender difference. In Turel et al series, the mean age of patients was 41.8 years for tumors between 4 and 5 cm; and 34.8 years for tumors larger than 5 cm.[19] In our series, the mean age in the PFP group was 46.44 years, while it was 45.80 years in the NFP group.

The cisternal (from the brainstem to internal auditory canal [IAC]) length of the facial nerve roughly measures 15.8 mm. CSF and pia mater envelop this part. It runs anterosuperior to the vestibulocochlear nerve, making it susceptible to compression by VS. Dissection during surgery may damage this part as only a thin glial layer is present over it; however, it shows tolerance to compression/stretching produced by slow-growing tumors. Several physiological studies have reported neuropraxia of the facial nerve from regional ischemia, altered axonal transport, and conduction through the nerve because of compression. Slow-growing small VS produce gentle pressure producing only minor changes in anatomy and conduction. Studies have also shown that the portion of the nerve proximal to the geniculate ganglion is more prone to compression damage as it lacks epineurium and perineurium.[20] VS may be located anywhere along the eighth nerve from the junction of glial and Schwann cells to its terminal end. Most are located at or medial to the porus acusticus, distal to the Redlich–Obersteiner zone.[21] As the tumor grows more medially and acquires giant dimensions, the areas of the seventh nerve more amenable to compression injury get involved, producing motor symptoms. About 1% of VS are associated with facial weakness before surgery; however, much higher percentages have been reported in giant tumors (14–93.85%)[19,22–25] (►**Table 6**). In the Turel et al series of giant VS, facial paresis was seen in 92.74 to 96.3% of patients, varying with tumor size.[19] Facial palsy in the range of 92.5% (370 of 400 patients) has been reported by Xiang et al.[26] Jain et al have reported facial paresis in 65.2% of his patients, where normal-to-mild facial dysfunction was seen in 92 patients, and moderate dysfunction was seen in 11 out of 140 patients with giant tumors making it 73% in such cases.[22] Huang et al reported PFP in 31.3% of his patients.[24] In our study, facial dysfunction was present preoperatively in 64.77% ($n = 57$) of cases, of which 45.61% ($n = 26$) cases had grade II facial palsy, 33.33% ($n = 19$) had grade III facial palsy, 17.54% ($n = 10$) grade IV, and 3.5% ($n = 2$) had grade V facial palsy.

Facial nerve preservation is the norm in current practice. Many surgeons advocate subtotal removal in large tumors followed by Gamma knife therapy. The facial preservation rates tend to improve with such an approach[10,19,22,24,25,27,28] (►**Table 6**). An extra arachnoid dissection and minimal tailored drilling of IAC also tend to produce better facial preservation rates.[29] The goal with which we operate at our center is complete tumor removal, wherever possible, as most of our patients are from remote areas with rugged terrain, making long-term repeated follow-up and redo surgery less feasible. Also, Gamma-knife facilities are unavailable at our center or our state.

Kohno et al described VS as subarachnoid in origin, without a proper plane between tumor and facial nerve, making safe separation of the nerve less probable in giant schwannomas. Histological examination of certain portions of the tumor has also shown no definite plane between the facial nerve and schwannoma.[30] Tumors in contact with the nerve in these areas may invade it.[31] It has been suggested that surgical damage to such fibers does not produce facial dysfunction every time. However, unperceivable damage to these fibers during surgical dissection may bring about immediate facial dysfunction.[32] It has also been suggested that common blood supply may be shared by the tumor and facial nerve such that tumor removal may bring about disturbances in local microcirculation, causing ischemic dysfunction.[33] Vasoactive treatment may delay facial dysfunction in the postoperative period. Our facial preservation rates after the complete removal of giant VS are comparable to those described in the literature. Turel et al could preserve the facial nerve anatomically in 66.9 % of cases where tumor size was between 4 and 4.9 cm and 65.4% in cases where the tumor was more than 5 cm.[19] Jain et al could do so in 76.5% of cases where tumor size was more than 4 cm[22] (►**Table 6**).

Turel et al have reported normal function (HB I) at last follow-up in 5.1 and 2.7% of patients; good function(grade II, III) in 30.6 and 61.1% patients, with 4 to 5 cm tumors and more than 5 cm tumors size, respectively.[19] Samii et al, in their study on giant VS with complete tumor removal, reported

Table 6 Review of literature for facial nerve preservation in giant vestibular schwannoma (tumor size >4 cm)

Author	Country	*n*	Preoperative facial palsy incidence	Extent of resection	Anatomical facial nerve preservation rate	Facial nerve functional preservation rates					
						HB grade I	HB grade II	HB grade III	HB grade IV	HB grade V	HB grade VI
Jain et al 2005[22]	India	142	65.2%	Total + subtotal	76.5%	30.43%		52.17%		17.39%	
Zhang et al 2005[25]	China	105	54.3%	Total + subtotal	79.1%	40.2%	16.5%	8%	13.8%	11.5%	10.4%
Samii et al 2006[10]	Germany	20	–	Total + subtotal	85%	18%	12%	18%	22%	12%	18%
Samii et al 2010[23]	Germany	50	14%	Total	92%	25%	19%	31%	19%	6%	–
Silva et al 2012[27]	Portugal	29	–	Total	86%	45%		17%	10%	28%	
Turel et al 2016[19]	India	179	93.85%	Total + subtotal	66.48%	4.42%	53.09%	25.6%		16.8%	
Huang et al 2017[24]	China	657	31.3%	Total + subtotal	89.7%	32.9%		46.9%	20.2%		–
Hong et al 2017[28]	China	53	–	Total + subtotal	–	26.41%	35.84%	24.52%	13.2%	–	–
Gupta et al 2022[29]	India	210	53.3% (112)	Total + subtotal + near total	–	68.5% (146)		19.2% (41)			12.2% (26)
Present series	India	88	64.77% (57)	Total	70.45% (62)	5.68% (5)	26.13% (23)	14.77% (13)	17.04% (15)	6.81% (6)	29.54% (26)

Abbreviation: HB, House–Brackmann.

facial functions at last follow-up in the order of HB grade I in 25%, HB grade II in 19%, and HB grade III in 31%, respectively.[23] In our study, on the first postoperative day, at discharge, and at the last OPD visit, a good function was seen in 26, 21, and 28 (31.8%) patients, respectively; Fair function was seen in 18 and 13 (14.7%) patients, respectively. Our study helps to address concerns regarding postoperative outcomes in already compromised facial functions in giant tumors. It is logical to believe that, in giant tumors with complete tumor excision, the facial function is destined to be poor compared to those with their smaller counterparts. Our study has reflected the same, which suggests that PFP in a patient leads to statistically poorer functional outcomes (p-value = 0.01) even though anatomical preservation rates do not differ ($p = 0.29$; ►**Tables 2** and **4**) Also, the postoperative functional status of the facial nerve does not differ statistically among those with preoperative nondisfiguring (HB grades I–III) facial palsy and those without PFP ($p = 0.12$) (►**Table 5**). Therefore, postoperatively, patients with low-grade facial palsies have facial outcomes comparable to those without facial palsy. One may interpret from these conclusions that disfiguring facial palsies (HB grades IV–VI) occur due to causes other than just neuropraxia or axonal stasis. The growth rate of VS is very slow, and for tumors to attain such giant sizes, a considerable amount of time is needed. This longer duration of facial nerve compression/stretching in giant tumors may disrupt neuromyogenic feedback producing degeneration of the neurons in the face area of the motor homunculus.[34]

The role of facial reanimation procedures cannot be undermined in patients where facial nerve function remains poor even after surgery. Surgical options include primary nerve repair and interposition nerve grafts/transfers. Primary nerve repairs with tension-free coaptation are the best in terms of outcomes. Interpositional nerve grafts with great auricular/ sural nerves are helpful in cases where primary suturing is impossible. Free flaps, muscle transfers, and tissue rearrangements may help patients smile again. In long-standing cases with motor end plate degeneration where nerve repair is impossible, static cosmetic procedures like placing a gold weight under the eyelid, facial lift procedures, and tarsal lift procedures may help restore facial symmetry and prevent dry eyes or corneal abrasions.[35]

Hearing preservation rates for giant schwannomas with a salvageable hearing range from 9.1 to 56.3%. In the follow-up period, deterioration occurs in up to 56%, even after hearing preservation. Therefore, patients of VS may benefit from hearing rehabilitation. The options include cochlear implants, auditory brainstem implants, contralateral routing of signal, and bone anchoring hearing aid.[36]

Conclusion

PFP does not obscure the chances of intraoperative facial nerve preservation, and every attempt at preserving this structure should be made, even in giant tumors. Patients with nondisfiguring facial palsies have postoperative facial functions comparable to those without facial paralysis.

Conflict of Interest
None declared.

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