32 Management of the Facial Nerve during Vestibular Schwannoma Microsurgery

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32.1 Introduction

A progressive evolution in diagnostic testing and microsurgical techniques has made it possible to reduce the perioperative mortality rate of vestibular schwannoma (VS) microsurgery to less than 1%, especially at high-volume centers.[1,2,3,4] This, in part, has led to a shift in the surgeon's attention to the preservation of cranial nerve function, in particular that of the facial nerve (FN) and the cochlear nerve.[5,6,7,8] Due to the intimate association between the FN and VS capsule, surgery for this tumor is fraught with risk of FN injury. Although the anatomy of the FN is fairly consistent in the temporal bone and the cerebellopontine angle (CPA), the tumor itself may distort or displace the nerve, which may be neither evident by way of preoperative FN deficits nor discernible on preoperative imaging. In fact, the FN is very resistant to tumor stretch and compression, and more often than not, preoperative FN function is found preserved even in most giant VS. The surgeon must be prepared to deal with difficult situations wherein the nerve is thinned and stretched, is enveloped, or is found positioned between the surgeon and the tumor. Less commonly, there are intraoperative situations that may lead to interruption of FN continuity, either intentionally or otherwise. Once a nerve is interrupted, reconstruction should be performed immediately in order to obtain the best results, either by means of a primary end-to-end coaptation or by a cable nerve graft interposition.[9] In this chapter, we will discuss various pre- and intraoperative situations with regard to the FN and how to manage them.

32.2 Clinical Onset of Facial Nerve Paralysis

As discussed previously, the FN can withstand stretching imposed by tumor growth to a great deal and hence leave the patient without clinically apparent deterioration of function. The FN, as most motor nerves, is quite resistant to tumor infiltration and nerve dysfunction typically occurs very late in the course of tumor growth. Axon and Ramsden[10] found that House–Brackmann grade I FN function can be maintained with only 10% of motor neurons functioning. Neuronal degeneration and axonal demyelination is counterbalanced with the collateral sprouting and hypertrophy of the innervated muscle fibers. Furthermore, the absence of epineurium around the CPA and internal auditory canal (IAC) segments of the FN allows effacement of the nerve fibers and spreading of the nerve fascicles over large tumors.[10,11] In slow-growing pathologies such as VS and meningiomas, FN fibers are stretched slowly over many months leading to splaying of fibers over the tumor capsule (▶ Fig. 32.1).[12] Conversely, early-onset FN paralysis in cases of smaller IAC or CPA tumors should signal clinicians to a suspect FN schwannoma, cavernous hemangioma, or, much less commonly, a malignant lesion. The incidence of FN dysfunction associated with untreated VS is generally less than 10% and correlates with tumor size. FN paralysis is often preceded by facial twitch or spasm.

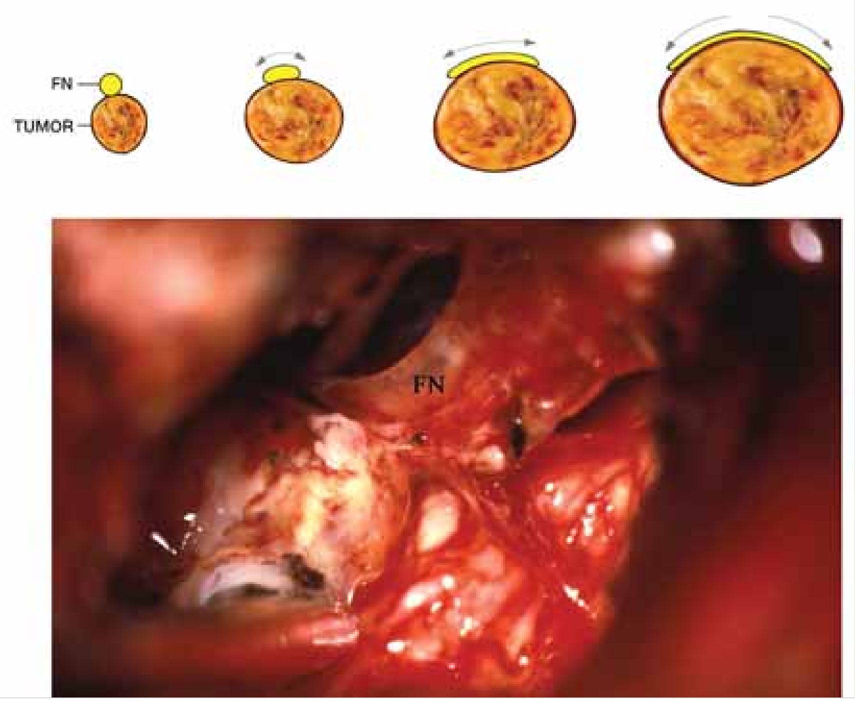

Fig. 32.1 (A) The FN is stretched and splayed over the tumor capsule in slow-growing tumors like VS. **(B)** Intraoperative picture of the FN after tumor removal wherein the nerve is seen to be markedly thinned and transparent.

32.3 Intraoperative Facial Nerve Monitoring

Intraoperative FN monitoring has established itself as an integral part of skull base surgery. Intraoperative electromyography (EMG) monitoring helps identify and map the FN accurately, thereby enhancing preservation. This is particularly important when tumors or anatomical variations place the nerve at a higher risk.[13] At the Gruppo Otologico, patients are routinely monitored using the Nerve Integrity Monitor (NIM-Neuro 3.0) manufactured by Medtronic Xomed (Jacksonville, FL). This is a two-channel electromyographic system used to detect FN function. The monitor displays the two channels simultaneously for detecting the activity of orbicularis oculi muscle and orbicularis oris muscle. To avoid interference and artifact, this machine is supplied with a "muting probe," which is connected around the output cable of equipment, such as bipolar cautery or other external devices that generate interfering signals. Electrical stimulation or surgical manipulation of the FN results in evoked EMG responses that provide immediate feedback to the surgeon via loudspeaker and an oscilloscope. Intraoperative FN monitoring assists with: (1) early localization of the FN, (2) definitive identification of the FN, (3) minimization of trauma during dissection, and (4) confirmation of the functional integrity of the nerve during and after tumor removal.

After tumor removal is complete, postoperative FN function can be appraised with electrical stimulation at the proximal and distal sites, usually at the root exit zone of the nerve at the brainstem and at the fundus of the IAC, respectively. The main parameters used in the evaluation of postoperative FN function are the threshold of proximal stimulation and the amplitude of the evoked response. Good function is expected when proximal stimulation between 0.05 and 0.1 mA elicits an FN response. It is important to examine the amplitude of this response and compare proximal and distal stimulation results. Amplitudes higher than 200 mV are usually indicative of good postoperative function. The presence of EMG potentials as bursts and trains during the last steps of tumor removal is another good prognostic factor. Elevation of the threshold to 0.3 mA or above is usually correlated with poor postoperative nerve function, especially if associated with low amplitude. High-amplitude bomber-type trains, especially when they arise suddenly, represent a poor prognostic factor. Finally, a "silent FN" during the last stage of tumor removal, associated with absence of response to the stimulation, is correlated with poor postoperative nerve function. Further discussion regarding intraoperative FN monitoring can be found in Chapter 27.

32.4 Preoperative Decision Making with Respect to the Facial Nerve

Though it is impossible to discuss the entire logic of preoperative decision making in this chapter, we will briefly outline our general approach and strategy. In the case of small tumors (grade I and II)[14] in patients of any age, we prefer to initially follow the tumor with a wait-and-scan approach,[15] except in a few circumstances. In the case of grade I and II tumors that have to be operated upon either due to vertigo, or evidence of fast growth on wait-and-scan, or patient preference, the choice of surgical approach will largely depend on hearing status. In cases where preoperative hearing is poor, the enlarged translabyrinthine approach (ETLA) is employed, which is the safest procedure for the FN preservation in our experience, even in larger tumors. In cases with good preoperative hearing, the retrosigmoid and middle cranial fossa approaches are preferred, with the middle fossa approach carrying a higher risk of FN paresis at least in the early postoperative period.[16,17] Surgery is the preferred choice in tumors greater than grade III. In patients older than 65 years with large tumors, if the patient is fit for surgery, we may perform sub- or near-total resection in an attempt to preserve good FN function. In older patients with debilitation or surgical contraindications, or in cases of regrowth after sub- or near-total resection, we prefer to refer for radiotherapy.[18,19]

Apart from the options discussed above, a variety of other factors including patient preference, occupation, experience of the operating team, tumor location, cerebral venous anatomy, and degree of brainstem compression are to be taken into consideration while deciding how best to treat the tumor and manage the FN.[20]

32.5 Intraoperative Decision Making with Respect to Facial Nerve

Intraoperatively, all attempts must be made to save the FN because of the physical, social, emotional, and psychological consequences of FN paralysis, especially in young patients. Whatever may be the surgical approach, care must be taken to dissect the tumor capsule from the nerve with utmost delicacy. However, even in the best hands, there will be circumstances when the FN will be injured or rarely even intentionally or unintentionally sacrificed. In the latter such cases, the nerve should be reconstructed by primary coaptation or an interposition cable graft whenever possible (Chapter 64).

32.5.1 Techniques to Improve Facial Nerve Outcomes during Surgery

A wide surgical approach improves the visual field, thereby enhancing safe and efficient tumor removal (▶ Fig. 32.2). In the ETLA, our experience indicates that the most common course of the FN in relation to the tumor capsule is in its anterior-medial-inferior surfaces, which is seen in about 70% of the cases. In about 15, 10, and 5%, the tumor displaces the nerve superiorly, inferiorly, and laterally, respectively (▶ Fig. 32.3). In VS microsurgery, the two major sites where the position of the FN is most consistent are at the fundus of the IAC (▶ Fig. 32.4) and the origin of the nerve at the level of the brainstem (▶ Fig. 32.5). The position of the FN varies at the level of the porus of the IAC, as shown in ▶ Fig. 32.3. At the porus, the nerve is generally found adherent to the surface of the tumor, and in large tumors, the FN is often splayed and thinned and hence one has to be very careful in dissecting the nerve from the tumor in this location (▶ Fig. 32.6).

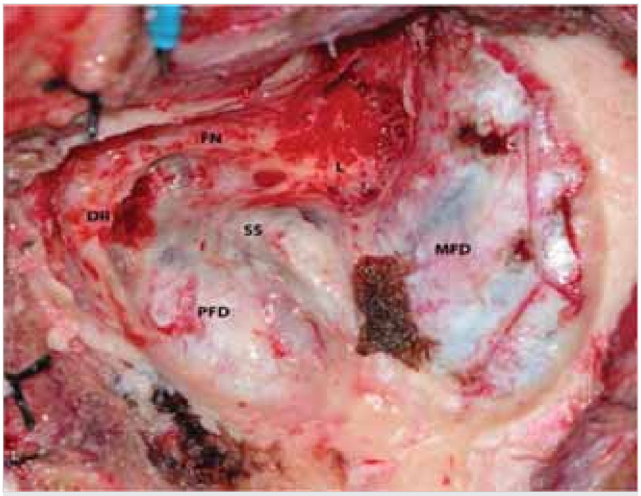

Fig. 32.2 Wide bone drilling over the middle and posterior fossa dura enlarges the visual field and allows better angles with instruments.

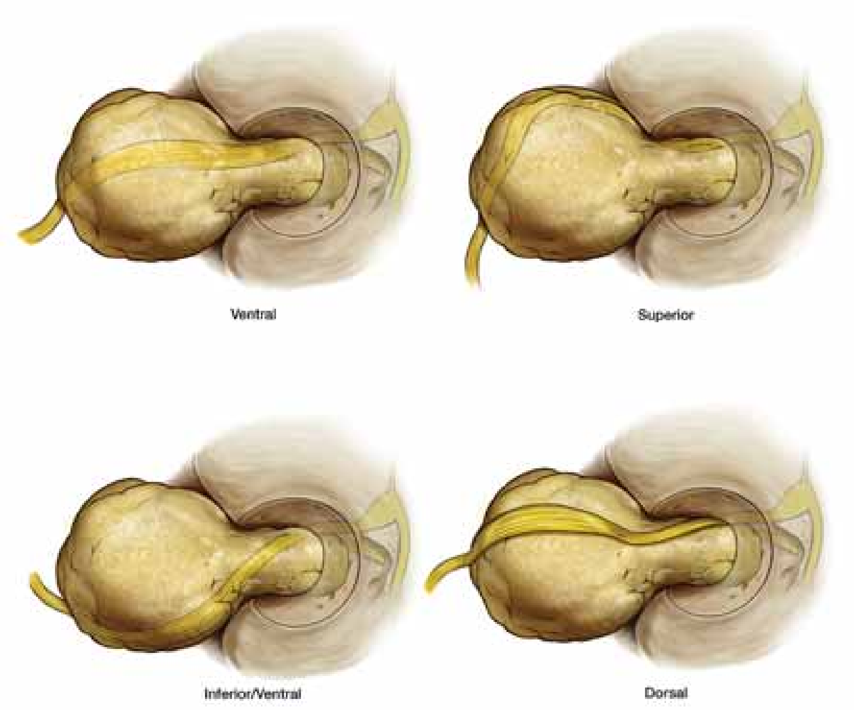

Fig. 32.3 Possible locations of the FN in relation to the tumor.

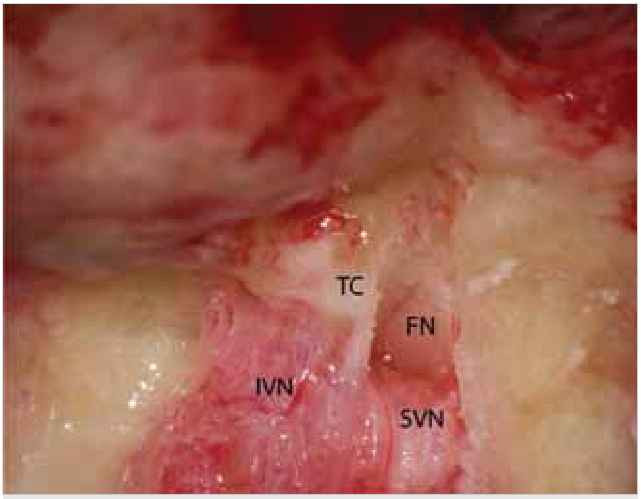

Fig. 32.4 FN in the fundus of the IAC. FN, facial nerve; IVN, inferior vestibular nerve; SVN, superior vestibular nerve; TC, transverse crest.

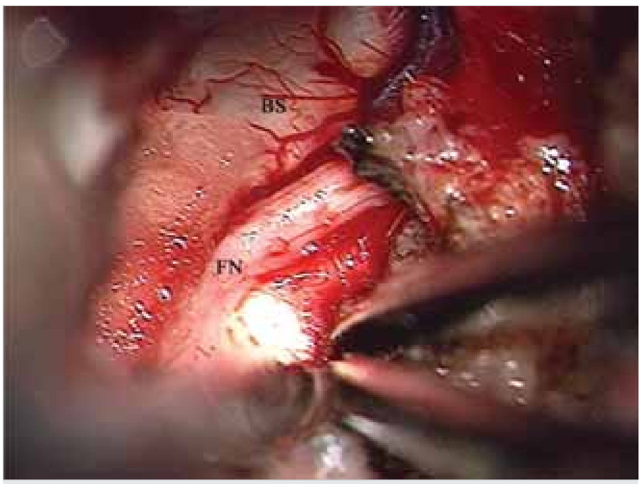

Fig. 32.5 FN at its origin from the brainstem. BS, brainstem; FN, facial nerve.

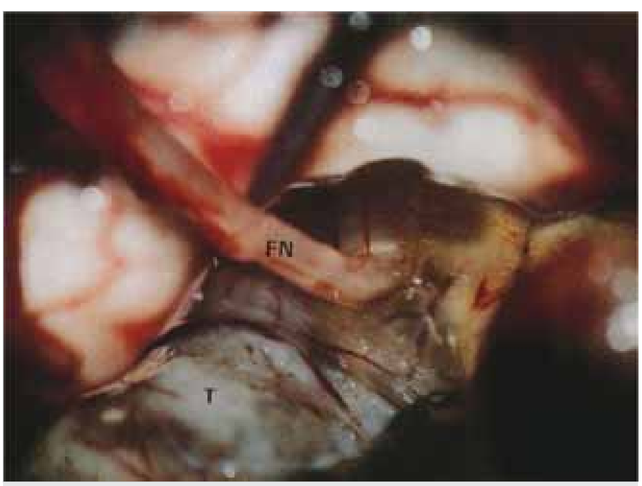

Fig. 32.6 FN at the level of the porus acusticus. FN, facial nerve; T, tumor.

The surgeon must be able to visually identify the FN and not depend solely on intraoperative FN monitoring. In small tumors, the FN is clearly identified as a grayish glistening structure. In large tumors, however, the nerve may be difficult to identify as it is usually splayed, thinned, and translucent and cannot be differentiated from the tumor or the surrounding arachnoid. In such a situation, identification of the FN depends on tracing the nerve by strict adherence to the points of reference as described above in conjunction with use of intraoperative EMG monitoring using low intensity of stimulation (0.05 mV). Understanding the amount of expected current spread with different stimulation levels is important.

Once the nerve is identified at the level of the fundus, tumor dissection proceeds from a lateral to medial direction—or if identified at the level of the brainstem, from medial to lateral. In many cases, both techniques are used. In large tumors, dissection of the tumor from the FN should be addressed only after debulking the rest of the tumor, and traction or torsion of the tumor attached to the nerve should be avoided. A train response from EMG monitoring indicates potential trauma to the FN. When this is encountered, the inciting maneuver should be stopped or changed to avoid further damage to the nerve. One must be mindful of the fact that the train response can also be triggered by cold irrigation. Blunt dissection is performed for most of the dissection; however, adherent attachments should be divided sharply using scissors to avoid excessive traction on the nerve. Bleeding from the FN itself is controlled by placing Gelfoam or Surgicel over the bleeding points. It cannot be overemphasized that an overall bloodless surgical field is one of the foremost factors that improves FN outcomes. Presence of blood obstructs the surgical field and also large clots may coalesce and envelope the nerves, which when suctioned could lead to inadvertent nerve injury. Precise use of fine-tip bipolar cautery on a low setting is required when near the FN, and indiscriminate cauterization should be avoided. Maintaining clean bipolar tips and use of irrigation when bipolaring can facilitate effective hemostasis while mitigating the risk of inadvertent FN injury.

In most studies, reported FN outcomes after tumor resection in cystic VS have been less favorable in comparison to results after removal of solid tumors of comparable size.[2,21,22,23,24,25,26] While our institutional series showed no statistically significant difference in FN results between solid and cystic tumors, we attribute this to our protocol of leaving behind tumor around the FN (near-total resection) if necessary in cystic tumors.[27]

32.5.2 Planned Facial Nerve Interruption

Although FN preservation is of paramount importance and every attempt should be made to maintain it, there may be instances wherein the surgeon may elect to sacrifice the FN when balancing certain priorities. These situations fall into three categories. Firstly, it may be acceptable to section the FN in difficult and emergent situations where the immediate safety of the patient takes priority, such as when there is arterial bleeding that cannot be controlled without either coagulating the nerve itself or sectioning it for access. We find these situations to be extremely rare. A second situation is the case where a patient presents with a large, multiply recurrent tumor that is associated with brainstem compression. In the rare care of a very aggressive recurrent tumor, particularly in a young patient, complete disease eradication to prevent future neurological complications may become a priority over FN preservation. In cases that have undergone prior microsurgical resection and radiation, the FN may take an unfavorable course and may be particularly adherent such that complete tumor removal with FN preservation is impossible. A third condition is the patient who presents with long-term FN paralysis, either from the tumor or from prior treatment. This must be distinguished from the case of acute FN paralysis that may often improve with steroid treatment or tumor removal.

During tumor dissection, the FN may become partially interrupted or thinned to the point that long-term viability is questioned. If the nerve can still be stimulated at a high threshold, then at least partial recovery can be expected. In some instances, although the FN appears to be anatomically intact, it will not stimulate even at high levels. In such situations, it is advisable to not sacrifice the nerve and place a graft since most patients will recover some function, with a subset regaining good function.

If the surgeon is convinced that the FN has been interrupted, immediate reconstruction should be performed to achieve the best possible result, either by means of a primary end-to-end coaptation or by a cable nerve graft interposition.[9] Cable graft interposition is a convenient and well-accepted procedure for immediate restitution of the FN. Our unpublished results, including a series of 213 patients, shows that the stitchless fibrin glue–aided anastomosis technique yields good results. This technique is discussed in detail in Chapter 64.

32.5.3 Subtotal or Near-Total Resection of Vestibular Schwannoma for Facial Nerve Preservation

The goal of surgical removal is to achieve complete tumor eradication with preservation of facial and cochlear nerve function. However, in certain instances it becomes unwise to attempt complete removal due to the tumor's intimate relationship with important structures, such as the FN, brainstem, blood vessels, and other nerves in the CPA, without compromising such structures. This is especially true in patients with large tumors, cases following failed radiation treatment, or in patients with associated severe comorbidities, where the aim of surgery may be to perform a planned sub- or near-total excision or to perform a primary debulking followed by a second-stage excision or radiosurgery. Less commonly, intraoperative vital sign changes or excessive bleeding may also force the procedure to be abandoned before total tumor excision has been achieved.

In case of involvement of the FN in particular, the dilemma that the surgeon faces is whether to preserve the nerve at the cost of leaving behind a small remnant of tumor or achieve gross total resection by sacrificing the nerve or at least putting it at high risk of long-term significant weakness. This is an important concept to discuss with the patient preoperatively. This is especially important in elderly patients and patients with comorbid conditions. The decision to leave behind tumor in an attempt to save the FN can be justified if the following two factors can be proved: (1) that the incidence and the rate of tumor regrowth is acceptably low, and (2) that there is a significant benefit in terms of postoperative preservation of FN function. Our recent article and a review of literature[28] have shown that this is indeed the case and hence there is undoubtedly merit in the concept of near-total and subtotal resection for FN preservation. When compared with subtotal resection, near-total resection has shown a lower rate of regrowth of residual tumor while having almost the same result in terms of FN function. In addition, advances in radiosurgery have provided a low-risk means of salvage if growth of the residual tumor remnant occurs. Patients with incomplete VS resection require prolonged and perhaps lifelong follow-up. Additional discussion regarding subtotal and near-total microsurgical resection can be found in Chapter 41.

32.5.4 Key Points and Summary

- The FN is resistant to stretch injury caused by slow tumor growth and, more often than not, preoperative function is normal even in patients with giant VS.
- Before surgery, the patient must be apprised of the risks of FN injury and its consequences. Full informed consent with a special emphasis on FN injury must be performed and the surgeon should clearly understand the patient's priorities.
- Intraoperative FN monitoring assists in: (1) localization of the FN, (2) definitive identification of the FN, (3) minimization of trauma during dissection, and (4) confirmation of the functional integrity of the nerve during and after tumor removal.
- The FN is frequently found adherent to the surface of the tumor at the porus acusticus, and in large tumors it is often splayed and thinned out. Therefore, one has to be particularly careful when dissecting the nerve from the tumor in this region.
- The surgeon must be able to visually identify the FN and not solely depend on intraoperative EMG monitoring.
- In cases where the nerve is transected, it should be reconstructed by a cable nerve interposition graft whenever possible.

32.6 Summary

In certain instances, it becomes unwise to attempt complete tumor resection due to the tumor's intimate relationship with important structures, such as the FN, brainstem, blood vessels, and other nerves in the CPA. This is especially true in patients with large tumors or in those with associated severe comorbidities, where the aim of surgery may be to perform a planned sub- or near-total excision or to perform a primary debulking followed by a second-stage operation or radiation.

32.7 References

[1] Gjurić M, Wigand ME, Wolf SR. Enlarged middle fossa vestibular schwannoma surgery: experience with 735 cases. Otol Neurotol. 2001; 22(2):223–230, discussion 230–231

[2] Samii M, Matthies C. Management of 1000 vestibular schwannomas (acoustic neuromas): surgical management and results with an emphasis on complications and how to avoid them. Neurosurgery. 1997; 40(1):11–21, discussion 21–23

[3] Sanna M, Taibah A, Russo A, Falcioni M, Agarwal M. Perioperative complications in acoustic neuroma (vestibular schwannoma) surgery. Otol Neurotol. 2004; 25(3):379–386

[4] Wiet RJ, Mamikoglu B, Odom L, Hoistad DL. Long-term results of the first 500 cases of acoustic neuroma surgery. Otolaryngol Head Neck Surg. 2001; 124 (6):645–651

[5] Brackmann DE, Cullen RD, Fisher LM. Facial nerve function after translabyrinthine vestibular schwannoma surgery. Otolaryngol Head Neck Surg. 2007; 136(5):773–777

[6] Nadol JB, Jr, Chiong CM, Ojemann RG, et al. Preservation of hearing and facial nerve function in resection of acoustic neuroma. Laryngoscope. 1992; 102 (10):1153–1158

[7] Samii M, Matthies C. Management of 1000 vestibular schwannomas (acoustic neuromas): the facial nerve–preservation and restitution of function. Neurosurgery. 1997; 40(4):684–694, discussion 694–695

[8] Sterkers JM, Morrison GA, Sterkers O, El-Dine MM. Preservation of facial, cochlear, and other nerve functions in acoustic neuroma treatment. Otolaryngol Head Neck Surg. 1994; 110(2):146–155

[9] Ozmen OA, Falcioni M, Lauda L, Sanna M. Outcomes of facial nerve grafting in 155 cases: predictive value of history and preoperative function. Otol Neurotol. 2011; 32(8):1341–1346

[10] Axon PR, Ramsden RT. Facial nerve injury caused by vestibular schwannoma compression: severity and adaptation to maintain normal clinical facial function. Am J Otol. 1999; 20(6):763–769

[11] Kartush JM, Lundy LB. Facial nerve outcome in acoustic neuroma surgery. Otolaryngol Clin North Am. 1992; 25(3):623–647

[12] Sanna M, Khrais T, Mancini F, Russo A, Taibah A. Facial nerve management in vestibular schwannoma surgery. In: The Facial Nerve in Temporal Bone and Lateral Skull Base Microsurgery. Stuttgart: Georg Thieme Verlag; 2006:149–186

[13] Sanna M, Mancini F, Russo A, Taibah A, Falcioni M, Di Trapani G. The translabyrinthine approaches. In: Atlas of Acoustic Neurinoma Microsurgery. Stuttgart: Georg Thieme Verlag; 2011:60–140

[14] Consensus meeting on systems for reporting results in acoustic neuroma. November 7–9, 2001. Tokyo, Japan. Abstracts. Keio J Med. 2001; 50 Suppl 4:13–77

[15] Patnaik U, Prasad SC, Tutar H, Giannuzzi AL, Russo A, Sanna M. The long-term outcomes of wait-and-scan and the role of radiotherapy in the management of vestibular schwannomas. Otol Neurotol. 2015; 36(4):638–646

[16] Falcioni M, Fois P, Taibah A, Sanna M. Facial nerve function after vestibular schwannoma surgery. J Neurosurg. 2011; 115(4):820–826

[17] Rinaldi V, Casale M, Bressi F, et al. Facial nerve outcome after vestibular schwannoma surgery: our experience. J Neurol Surg B Skull Base. 2012; 73 (1):21–27

[18] Friedman WA, Bradshaw P, Myers A, Bova FJ. Linear accelerator radiosurgery for vestibular schwannomas. J Neurosurg. 2006; 105(5):657–661

[19] Sawamura Y, Shirato H, Sakamoto T, et al. Management of vestibular schwannoma by fractionated stereotactic radiotherapy and associated cerebrospinal fluid malabsorption. J Neurosurg. 2003; 99(4):685–692

[20] Goddard JC, Voelker CCJ, Brackmann DE. Facial nerve and vestibular schwannoma. In: Guntinas-Lichius O, ed. Facial Nerve Disorders and Diseases: Diagnosis and Management. Stuttgart: Georg Thieme Verlag KG; 2016:238–248

[21] Sinha S, Sharma BS. Cystic acoustic neuromas: surgical outcome in a series of 58 patients. J Clin Neurosci. 2008; 15(5):511–515

[22] Fundová P, Charabi S, Tos M, Thomsen J. Cystic vestibular schwannoma: surgical outcome. J Laryngol Otol. 2000; 114(12):935–939

[23] Benech F, Perez R, Fontanella MM, Morra B, Albera R, Ducati A. Cystic versus solid vestibular schwannomas: a series of 80 grade III-IV patients. Neurosurg Rev. 2005; 28(3):209–213

[24] Charabi S, Tos M, Børgesen SE, Thomsen J. Cystic acoustic neuromas. Results of translabyrinthine surgery. Arch Otolaryngol Head Neck Surg. 1994; 120 (12):1333–1338

[25] Moon KS, Jung S, Seo SK, et al. Cystic vestibular schwannomas: a possible role of matrix metalloproteinase-2 in cyst development and unfavorable surgical outcome. J Neurosurg. 2007; 106(5):866–871

[26] Wandong S, Meng L, Xingang L, et al. Cystic acoustic neuroma. J Clin Neurosci. 2005; 12(3):253–255

[27] Piccirillo E, Wiet MR, Flanagan S, et al. Cystic vestibular schwannoma: classification, management, and facial nerve outcomes. Otol Neurotol. 2009; 30(6): 826–834

[28] Chen Z, Prasad SC, Di Lella F, et al. The behavior of residual tumors and facial nerve outcomes after incomplete excision of vestibular schwannomas. J Neurosurg. 2014; 120(6):1278–1287

Comments

1 AU: Please check all the chapter cross-references for correctness.
2 Reminder: AU: Please check whether the heading *Key Points and Summary* could be changed to *Key Points*, as the Summary section follows this section.

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Comments