Operative Techniques in Otolaryngology 30 (2019) 207–211

Operative Techniques in Otolaryngology

Vestibular nerve section via retrosigmoid craniotomy ☆

Lorenz Epprecht, MD[a,b], **Alexander M. Huber, MD**[a,b]

From the [a] *Department of Otorhinolaryngology, Head & Neck Surgery, University Hospital Zürich, Zürich, Switzerland*
[b] *University of Zürich, Zürich, Switzerland*

KEYWORDS
Menière's disease;
Vestibular nerve;
Retrosigmoid approach;
Vestibular neurectomy

Vestibular neurectomy for Meniere's disease is considered as a treatment option when conservative methods fail to control debilitating vestibular symptoms. Most common surgical approaches today consist of transtemporal supralabyrinthine (middle fossa), retrolabyrinthine and retrosigmoid craniotomies. The aim of this article is to describe the procedure of vestibular neurectomy via a retrosigmoid approach. This approach can be performed alone or in combination with a retrolabyrinthine approach and allows good exposure of the cranial nerves VII and VIII in the cerebellopontine angle.

Introduction

Vestibular neurectomy for Meniere's disease is performed when conservative methods fail to control debilitating vestibular symptoms. First-line therapy usually comprises medication, such as betahistine and/or intratympanic injection of steroids.[1,2] More invasive techniques include intratympanic gentamycin injections and endolymphatic sac surgery. Injections with gentamycin are thought to affect more the vestibular than the cochlear system.[3] There is still the risk, however, that the hearing is affected as well. If the less-invasive approaches fail or there are contraindications, there are several ablative techniques that allow for relatively good control of vertigo. The concept behind vestibular nerve section is that the fluctuating vestibular input from the affected side is cut off and centrally compensated by the contralateral vestibular system. Most common surgical approaches today consist of transtemporal supralabyrinthine (middle fossa), retrolabyrinthine, and retrosigmoid craniotomies.

History

The different approaches to the cranial nerve (CN) VIII were developed over the course of the last century. Parry and Frazier reported the first series of vestibular neurectomies via a transtemporal supralabyrinthine approach at the turn of the last century.[4,5] House and Fisch later adopted the technique to section the superior branch of the vestibular nerve.[6,7] The challenge with the transtemporal supralabyrinthine approach is that the dura of the internal auditory canal (IAC) is skeletonized in proximity to the nerves in the canal, especially the facial nerve. Silverstein popularized the retrolabyrinthine approach.[8] This posterior fossa approach allows direct access to CN VIII and the IAC, if needed. The approach significantly reduces the risk to the facial nerve. Compared to the transtemporal supralabyrinthine approach, however, one problem is

☆ Funding: None.
Address reprint requests and correspondence: Lorenz Epprecht, MD, Department of Otorhinolaryngology, Head & Neck Surgery, UniversitätsSpital Zürich, Klinik für Ohren-, Nasen-, Hals- und Gesichtschirurgie, Frauenklinikstrasse 24, Zürich CH-8091, Switzerland.
E-mail address: lorenz_epprecht@hotmail.com

http://doi.org/10.1016/j.otot.2019.07.006
1043-1810/

the elevated risk of a cerebrospinal fluid (CSF) leak, since the dura of the posterior fossa is opened during the procedure and a watertight closure is necessary in this approach.[9] For the reduction of the rate of CSF leaks in this approach, subcutaneous abdominal fat is usually packed into the mastoidectomy over the dural defect. Another posterior fossa approach, namely the retrosigmoid approach, has a reduced risk for CSF leakage compared to the retrolabyrinthine approach.[10] The retrosigmoid approach was put to use for sectioning of the vestibular nerve as the most recent technique in 1985.[8] It is thought to provide the same access to the CN VIII and the IAC as the retrolabyrinthine approach. The 2 approaches, retrolabyrinthine and retrosigmoid, can also be combined if needed. In the United States, the majority of vestibular nerve sections are now performed by a posterior fossa approach.[1] In this article, we outline the procedure of a retrosigmoid craniotomy for vestibular nerve sectioning.

Indications

Sectioning of the vestibular nerve is considered indicated in cases with debilitating symptoms of vertigo resistant to conservative treatment options. The procedure makes most sense in patients with relatively useful hearing. If hearing is no longer serviceable, other surgical options are available, such as a labyrinthectomy. There is no ultimate definition of useful hearing in the prospect of vestibular nerve sectioning. Silverstein proposed a threshold in terms of pure tone average of 80 dB and a word recognition score of 20%.[11] As outlined at the beginning, sectioning of the vestibular nerve relies on central compensation derived from the contralateral vestibular system. The contralateral vestibular system (peripheral and central) is therefore of utmost importance. Corresponding detailed preoperative testing of the vestibular system by apparative means is recommended. However, patients have to be advised that a normal contralateral vestibular function at the time of surgery can deteriorate any time in the future. The prognosis of the development of bilateral Meniere's disease vs uniquely unilateral disease is difficult to make as there is only emerging evidence for the distinction of these different entities.[12]

Contraindications

Bilateral disease is considered a contraindication for the reasons explained above. Because there is a risk of hearing impairment on the side of surgery, the procedure is usually not performed in case of contralateral significant hearing loss. Caution is warranted in older patients since they are thought to compensate less the loss of 1 peripheral vestibular input. It is unclear to what extent the presence of additional polyneuropathy in these patients influences the central compensation mechanism.

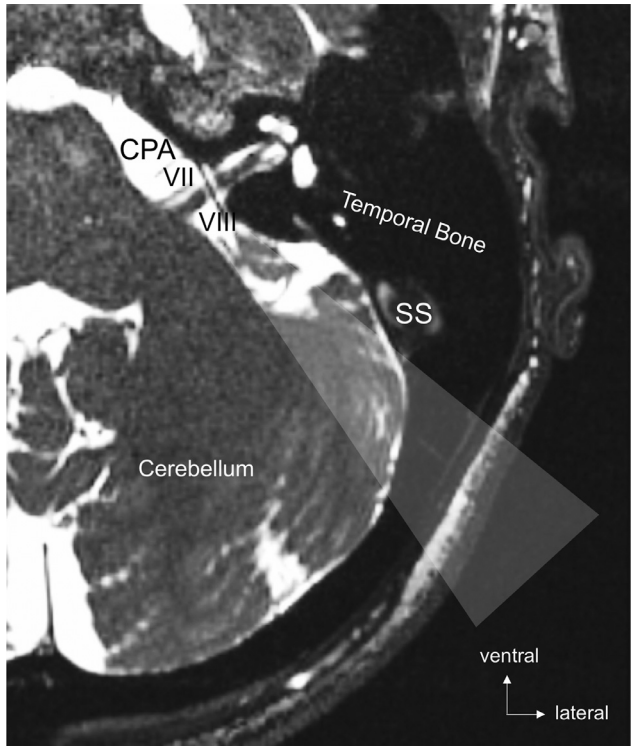

Figure 1 Magnetic resonance image axial section. The highlighted cone represents the line of sight of the surgeon in the retrosigmoid approach that allows access to the cranial nerves VII and VIII in the cerebellopontine angle (CPA). In some cases, the cerebellum has to be cautiously retracted. SS, sigmoid sinus.

Technique

The retrosigmoid approach is widely used to access the CPA (Figure 1), most commonly for the resection of schwannomas or meningiomas. Most neurologic and otologic surgeons are familiar with the procedure and have worked out their own particularities. The procedure outlined here is 1 possibility out of many.

Preoperative considerations and procedures

Magnetic resonance imaging is usually obtained prior to surgery to assess vascular and neural anatomy of the patient in the surgical corridor and on the site of nerve section in the CPA. Computed tomography can additionally aid the planning and opening of the craniotomy if used in combination with navigational techniques. It can also help to document the extent of mastoid air cells as a risk factor for CSF leakage in the case the IAC has to be drilled open. A lumbar drainage can be applied and might reduce the potential for a postoperative CSF leak, but is not widely performed. The facial nerve is monitored by the application of electrodes at the innervation points in the face (frontal, orbital, and perioral). Additionally, a camera can be placed aimed at the face in order to detect facial spasm once it is draped over. In order to monitor cochlear function during

surgery, auditory brainstem response equipment can be installed while prepping the patient in the operating room.

Positioning

Several positions are possible. The most common position is the supine one. The patient lies flat on his back and the head is turned away from the surgeon. The head can be stabilized either with a donut cushion or with in a pin head holder according to the surgeon's preference. The supine position requires significant mobility in the cervical spine in order to rotate away the head enough to obtain a straight line of sight from the craniotomy to the CPA and may not be available for all patients. In that case, the patient can be further rotated away by using a shoulder roll. In smaller patients, this may be a useful adjunct to the classical supine position. In case this does not suffice or is impractical due to the patient's habitus, patients can also be positioned in a lateral position. Pin head holders provide the necessary stability of the head in this position. In both positions, the shoulder on the side of the approach may be in the way of the surgeon. The shoulder can be lowered, but arm traction should not be excessive to avoid brachial plexus lesions. One other possibility to position the patient is the park bench position that has the advantage that the irrigation fluid, blood, and CSF drain away from the surgical site. Transesophageal echocardiography is performed preoperatively to exclude a patent ovale foramen that could cause air embolism.

Craniotomy

The vascular anatomy of the transverse sinus (TS) and sigmoid sinus (SS) is crucial for the retrosigmoid approach. The TS and SS form the cranial and anterior boundaries of the retrosigmoid craniotomy, respectively. The TS lies posterior to the ear in the line that can be extended from the zygomatic bone to the inion. The TS curves around the asterion that usually can be palpated through the skin as a slight depression in the skull bone at the junction of the lambdoid, parietomastoid, and occipitomastoid sutures. From there, the SS drains the venous blood toward the tip of the mastoid. The asterion serves as reference point for the retrosigmoid craniotomy. A "C-shaped" incision with its base toward the root of the auricle or a linear cranial-caudal incision is performed allowing the exposure of the bony landmarks. Alternatively, imaging-based navigational techniques can be used to determine the optimal extent of the incision. Hemostasis of the skin incision can be achieved by scalp clips. In the case of a "C-shaped" incision, the cutaneous flap is retracted anteriorly and fixed with sutures. Muscle tissue is detached from the bone in a cranial-caudal fashion with a rasp or electrocautery. Damage to the occipital artery and nerve should be avoided during this procedure. Initial opening of the cranial bone can be performed with a cutting burr inferior to the asterion to expose the SS. The dura at the bottom of the burr hole is detached from the bone circumferentially with a dissector in order to allow the safe insertion of the craniotome. Starting the craniotomy over the SS helps to avoid rushing into it. The craniotomy is performed with a craniotome in an oval fashion. Part of the TS and SS should now be exposed and form the cranial and anterior borders of the opening. The craniotomy can be extended anteriorly over the SS to allow better mobilization of it if needed. This gives more maneuverability of instruments later during surgery. In order to avoid injury to the dura during the extension of the craniotomy over the sinus, a groove can be milled with some distance to and along the bony edge. When the bone is sufficiently thinned, it can be removed with a classical bone punch. Air cells are waxed. To open the dura, it is elevated with a small pointy hook and incised with the scalpel. This avoids accidental cutting of cerebellar vessels. From there, a crescent dural flap with its base toward the SS is performed with scissors. The dural flap can be stitched to the subcutaneous tissue of the skin flap in order to avoid shrinking and drying out of the dura over the course of the following procedure. This facilitates later closure.

Exposure of the CNs

After the dura has been opened, CSF is released from the cistern in order to allow the cerebellum to fall away from the surgical site with gravity. If exposure is not sufficient, gentle retraction of the cerebellum with a self-holding retractor can be employed. Retractors, however, should be avoided. The arachnoid is bluntly dissected to expose the CNs in the CPA. From caudal to cranial, the lower CNs (CN IX, X, XI), the choroid plexus, the CNs VII and VIII, and CN V are identified. CN VII can be confirmed by electric stimulation (Figure 2).

Nerve sectioning

The CNs VII and VIII can be best separated close to the IAC. If clear separation is not possible, 2 options are available. Classically, the IAC is drilled open to inspect the nerves in the canal where they are clearly separated. From there the nerves can be followed centripetally toward the brainstem. Some authors argue the use of 30° or 70° angled endoscopes to inspect the nerves at the meatus that may render the opening of the IAC obsolete. The cleavage plane between the cochlear and vestibular divisions of the CN VIII rotates as the nerves travel from the brainstem into the IAC. In the CPA, the plane between the cochlear and vestibular nerves runs ventral-dorsally, that is, in the line of sight of the surgeon. Upon entrance into the IAC it runs rostrocaudally, or perpendicular to the line of sight of the surgeon. The vestibular nerve lies closer to the surgeon in the IAC. These anatomical details have to be considered when the branches are identified. The intermediate nerve and small blood vessels frequently run along the cleavage plane and can help its identification. Some consider the cochlear nerve to appear whiter than the vestibular nerve.

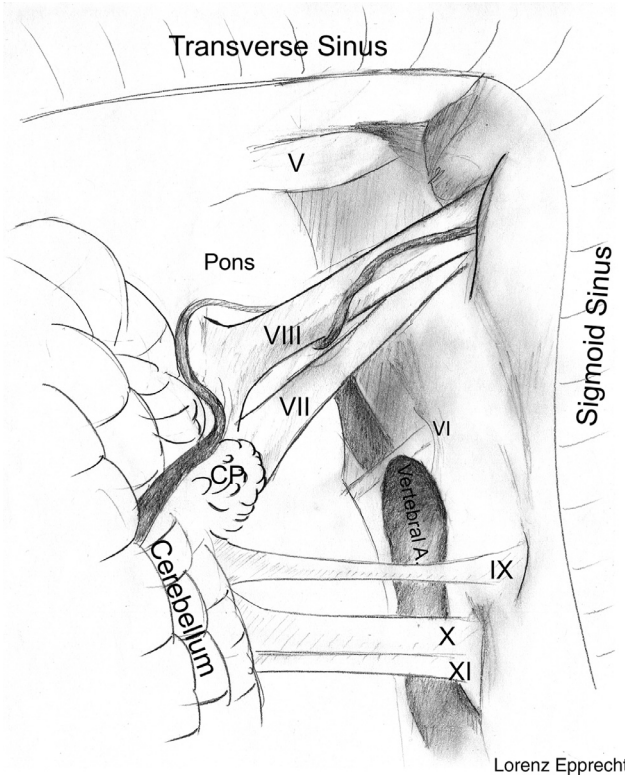

Figure 2 Surgical view of the retrosigmoid approach, which cranially lies the transverse sinus and anteriorly the sigmoid sinus. Important are landmarks, such as the lower cranial nerves (IX, X, and XI), the choroid plexus (CP), the facial nerve (VII), and trigeminal nerve (V). The facial nerve can be electrically stimulated for verification. The approach allows good access to the cranial nerve VIII.

If the cochlear and vestibular nerves can be clearly separated close to the internal acoustic meatus, both the superior and inferior vestibular nerve can be sectioned. If clear identification within the CPA is not possible, the IAC can be drilled open. This is necessary in around one-third of the cases.[8,13] To open the IAC, the dura over the temporal bone is removed between the endolymphatic sac and the meatus/porus. Then, the posterior wall of the IAC is milled with a diamond burr exposing approximately 5-6mm of the IAC dura. The dura is opened and the nerves exposed. Within the IAC, only the superior vestibular nerve and the singular (posterior ampullary) nerve should be sectioned because of the proximity of the the inferior vestibular nerve to the cochlear nerve and the blood supply for the inner ear.

Closure

Any mastoid air cells that are opened during the procedure are waxed. This reduces the risk of postoperative CSF leak. The dura is continuously sutured in a watertight fashion. The bone piece is put back in place and fixed with small titan plates and screws. Alternatively, a polyetheretherketone or polymethylmethacrylate (Palacos) cranioplasty can be used.

Discussion

Success rate

Two main outcome measures determine success: one is control of vertigo and the other is preservation of hearing. Complete control of vertigo can be achieved in around 90% of cases by vestibular nerve section.[14,15] Long-term failure is usually due to the development of contralateral disease. A detailed study of the vestibular and cochlear fibers in the CN VIII showed that the respective fibers not always are divided exactly by the cleavage plane between the vestibular and cochlear nerves.[16,17] In some cases, vestibular fibers run with the cochlear nerve and may contribute to part of the cases where nerve sectioning fails to control vertigo in the short term. The success rate of nerve sectioning has to be compared with other methods. A comparison of endolymphatic sac shunt surgery and gentamycin injections reported complete control of vertigo in 86% and 71% of cases, respectively.[18] Labyrinthectomy also has a short-term vertigo control rate of around 90%, while the effect seems to taper to 70% after 3 years.[19] Control of vertigo after vestibular nerve sectioning remains at around 90% also in the long-term with the advantage hearing preservation in most cases.[20] The risk for profound hearing loss in vestibular neurectomy is 4%. Hearing preservation at preoperative levels is achieved in around 75%.[9]

Complications

Facial nerve palsy is one of the most feared complications in any otologic surgery. In the posterior fossa approaches, facial nerve palsy occurs in <1% of cases.[21] In contrast, the middle fossa approach carries a risk of facial nerve paralysis of around 7%.[22] The reason for this is that the facial nerve is directly exposed during drilling in this approach. Posterior fossa approaches on the other hand carry the risk of postoperative CSF leak. CSF leaks in up to 10% after a retrosigmoid craniotomy.[8] The cerebellum and vasculature are potentially at risk as well, but rarely injured.

Exposure

The different approaches for vestibular nerve sectioning have different advantages regarding nerve exposure. The crucial part in the retrosigmoid approach consists of the correct assessment of the cleavage plane. In case the plane is difficult to determine in the CPA, the IAC can be drilled open. An innovative approach in this regard is the use of angled endoscopes in order to better look at the nerves as they enter the internal acoustic meatus and splay.

Conclusion

The retrosigmoid approach provides good exposure of CN VIII in the CPA and proximal IAC for safe vestibular nerve sectioning.

Disclosure

The authors reported no proprietary or commercial interest in any product mentioned or concept discussed in this article.

References

1. Michaelides E, Schutt CA: Vestibular neurectomy for Meniere's disease. Oper Tech Otolaryngol Head Neck Surg 27:216–220, 2016. doi:10.1016/j.otot.2016.10.007.
2. Beyea JA, Instrum RS, Agrawal SK, et al: Intratympanic dexamethasone in the treatment of Ménière's disease: A comparison of two techniques. Otol Neurotol 38:e173–e178, 2017. doi:10.1097/MAO.0000000000001437.
3. Harner SG, Driscoll CL, Facer GW, et al: Long-term follow-up of transtympanic gentamicin for Ménière's syndrome. Otol Neurotol 22:210–214, 2001. http://www.ncbi.nlm.nih.gov/pubmed/11300271.
4. Parry RH: A case of tinnitus and vertigo treated by division of the auditory nerve. 1904. J Laryngol Otol 105:1099–1100, 1991. http://www.ncbi.nlm.nih.gov/pubmed/1787370.
5. Frazier CH: Intracranial division of the auditory nerve for persistent aural vertigo. Surg Gynecol Obs 15:402–407, 1912.
6. House W: Surgical exposure of the internal auditory canal and its contents through the middle, cranial fossa. Laryngoscope 71:1363–1385, 1961. doi:10.1288/00005537-196111000-00004.
7. Fisch U: Vestibular nerve section for Meniere's disease. Am J Otol 5:543–545, 1984. http://www.ncbi.nlm.nih.gov/pubmed/6517145.
8. Silverstein H, Norrell H, Smouha E, et al : Vestibular neurectomy through combined retrolab-retrosigmoid approach. In: Fisch U, Valavanis A, Yasargil M, editors. Neurological Surgery of the Ear and Skull Base. ed 6 Zurich, Switzerland: Kugler & Ghedini Publications. 1988, p. 481–486.
9. Haberkamp TJ: Complications of surgery for vertigo. Oper Tech Otolaryngol Head Neck Surg 12:167–171, 2001. doi:10.1053/otot.2001.25847.
10. Silverstein H, Norrell H, Smouha EE: Retrosigmoid-internal auditory canal approach vs. retrolabyrinthine approach for vestibular neurectomy. Otolaryngol Neck Surg 97:300–307, 1987. doi:10.1177/019459988709700309.
11. Levine S.C.: Vestibular nerve section. 12:137-140, 2001
12. Bächinger D, Luu N, Kempfle J, et al: Vestibular aqueduct morphology correlates with endolymphatic sac pathologies in Meniere's disease—A correlative histology and computed tomography study. Otol Neurotol, 2019 (in press).
13. Master AN, Flores JM, Gardner LG, et al: Anatomical factors influencing selective vestibular neurectomy: A comparison of posterior fossa approaches. J Neurol Surg B Skull Base 77:19–23, 2015. doi:10.1055/s-0035-1556876.
14. Colletti V, Carner M, Colletti L: Auditory results after vestibular nerve section and intratympanic gentamicin for Ménière's disease. Otol Neurotol 28:145–151, 2007. doi:10.1097/MAO.0b013e31802c7989.
15. Schlegel M, Vibert D, Ott SR, et al: Functional results and quality of life after retrosigmoid vestibular neurectomy in patients with Ménière's disease. Otol Neurotol 33:1380–1385, 2012. doi:10.1097/MAO.0b013e318268d1cd.
16. Brackmann D, Monsell E. Histologic findings after retrolabyrinthine vestibular nerve section. In: Fisch U, Valavanis A, Yasargil M, editors. Neurological Surgery of the Ear and Skull Base. Zurich, Switzerland: Kugler & Ghedini Publications. 1988, p. 487–493.
17. Rasmussen A: Studies of the VIIIth cranial nerve of man. Laryngoscope 50:667, 1940.
18. Derebery MJ, Fisher LM, Berliner K, et al: Outcomes of endolymphatic shunt surgery for Ménière's disease: Comparison with intratympanic gentamicin on vertigo control and hearing loss. Otol Neurotol 31:649–655, 2010. doi:10.1097/MAO.0b013e3181dd13ac.
19. Levine SC, Glasscock M, McKennan KX: Long-term results of labyrinthectomy. Laryngoscope 100:125–127, 1990. doi:10.1288/00005537-199002000-00003.
20. Silverstein H, Smouha E, Jones R: Natural history vs. surgery for Menière's disease. Otolaryngol Head Neck Surg 100:6–16, 1989. doi:10.1177/019459988910000102.
21. Silverstein H, Norrell H, Rosenberg S: The resurrection of vestibular neurectomy: A 10-year experience with 115 cases. J Neurosurg 72:533–539, 1990. doi:10.3171/jns.1990.72.4.0533.
22. Silverstein H, Wanamaker H, Flanzer J, Rosenberg S: Vestibular neurectomy in the United States—1990. Am J Otol 13:23–30, 1992. http://www.ncbi.nlm.nih.gov/pubmed/1598980.