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Middle Cranial Fossa Surgery for Hearing Preservation in Vestibular Shwannomas: A Comparative review of Contemporary Findings

Stephanie Shephard

stephanieshephard@plvan.com Pacific Link College, Vancouver, BC

ABSTRACT :

Vestibular Schwannomas (Vs) are slow growing, benign tumors that derive from the eighth cranial nerve and the neural crest of the inner ear. Historically, they have been considered benign because of their slow growth rate and asymptomatic nature. However, case studies show that when left untreated, they can grow into large tumors that may cause sensorimotor disturbances, hydrocephalus, and untimely death. Common symptoms of Vestibular Schwannomas are hearing loss, tinnitus, headaches, imbalance, dizziness, vertigo and paresthesia.

Several procedures are presently in use for the treatment of Vestibular Schwannomas: Middle Cranial Fossa, Retrosigmoid, and Translabyrinth Approach, Conventional External Beam Radiation Therapy and Stereotactic Radiosurgery(SRS). Although there have been significant advances in current technologies and surgical procedures, all treatments are associated with risk of hearing loss and other complications. The outcomes and complications of treatments are discussed in this paper, with the middle cranial fossa as the preferred method of treatment for hearing preservation.

Keyword: Vestibular Schwannomas, Active Surveillance, Wait and Scan, Surgical Resection, Middle Cranial Fossa, Retrosigmoid, Translabyrinth Approach, Conventional External Beam Radiation Therapy, and Stereotactic Radiosurgery(SRS).

OBJECTIVE

The objective of this review is to draw a comparison between the hearing outcomes of traditional surgical procedures and radiation treatments for vestibular schwannomas, with the middle cranial fossa approach as the preferred method of treatment to preserve integrity of hearing.

METHOD

Cross reference findings gathered from publications about three surgical procedures and two radiation therapies have been presented and examined in this paper, along with a detailed interpretation of the findings associated with detection, diagnosis, treatment, and post-operative hearing results of small to large Vestibular Schwannomas. The procedures discussed are the middle fossa, retrosigmoid, translabyrinthine approach; radiotherapy, and fractionated stereotactic radiotherapy.

Hearing loss has been defined as 61-80 decibels(db). Tumor size has been defined as 2 cm for small to medium size tumors; 4 cm for large tumors (Fujita et al., 2023).

The information gathered for this review was obtained from online sources, journal publications, original research papers, clinical studies, and review articles, gathered from the National Library of Medicine and the National Center for Biotechnology Information. Outside sources have been referenced, accordingly. Terms searched were: Vestibular Schwannomas, Active Surveillance, Wait and Scan, Surgical Resection, Middle Cranial Fossa, Retrosigmoid, Translabyrinth Approach, Conventional External Beam Radiation Therapy, and Stereotactic Radiosurgery(SRS). Inclusion was limited to publications pertaining to hearing loss from Vestibular Schwannomas and their respective treatments.

INTRODUCTION

Vestibular Schwannomas (Vs) are a benign tumor, stemming from Schwann cells anywhere along the path of the eighth cranial nerve, the neural crest, and the internal acoustic meatus (Torchalla et al., 2024). Vs account for most brain tumors, with 80% to 90% located in the cerebellopontine angle (Torchalla et al., 2024).

Historically, Vs have been considered benign because of their slow growth rate and asymptomatic nature (Torchalla et al., 2024). However, case studies show that when left
untreated, they can grow into middle-sized to large tumors that can cause sensorimotor disturbances to patients (Torchalla et al., 2024). Large schwannomas proximity to the brain stem
and cerebellopontine angle can also make them especially dangerous to patients: causing hydrocephalus, a condition that leads to compression or invasion of cerebrospinal fluid to neurovascular structures (Joudar, 2023), resulting in death (Fujita et al., 2023).

The most common symptoms of Vestibular Schwannomas are unilateral sensorineural hearing loss (94% of patients) and tinnitus (83% of patients) (Torchalla et al., 2024). Other common
symptoms are headaches, imbalance, dizziness, vertigo and paresthesia (Torchalla et al., 2024).

Presently, there is no genetic profile for patients with Vs (Fujita et al., 2023). The only consistency is a genetic alteration in the inactivation of the neurofibromatosis type 2 (NF2), merlin: a cytoskeletal protein encoded by the NF2 gene on chromosome 22q (Fujita, 2023).
Vs cases are categorized as either sporadic and unilateral: occurring randomly rather than by a genetic condition; and, bilateral: neurofibromatosis type 2 (NF2) (Fujita et al., 2023).
Incidence rate of Vs is 1 in 100,000 per year (Nelis et al., 2018). Prevalence rate is 1 in 2000, and 1 in 500 in patients 70 and older (Fujita et al., 2023).

Several treatments are presently in use for Schwannomas: Active Surveillance (Wait and Scan), Surgical Resection (Middle Cranial Fossa, Retrosigmoid, and Translabyrinth Approach), Conventional External Beam Radiation Therapy and Stereotactic Radiosurgery(SRS).

PRE-OPERATIVE CONSIDERATIONS

A specific protocol for test batteries has not yet been established to measure indicators such as tumor size and tumor growth; though identifying tumors appears to be central to management options and affects treatment of choice (Radparvar, 2025). This might be due to individual differences in the inner ear and individual differences in tumors: while some tumors remain stable over time, others progress to cause life-threatening symptoms in a very short time (Joudar et al., 2023). Magnetic Resonance Imaging(MRI) is currently the method of choice for detection, diagnosis, tumor characterization, operative planning, and post-operative treatment evaluation (Chen et al., 2021).

In recent years, sporadic diagnosis for Vestibular Schwannomas has increased and the use of traditional microsurgeries to treat Vs has decreased, due to the adoption of serial imaging as the
most common initial evaluation and treatment strategy, especially for small sized Schwannomas (Fujita et al., 2023).

NEUROPATHOLOGY: AND VESTIBULAR TESTING

Modern refinements to traditional surgical procedures began in the 1960s with advancements in the operating microscope, audiometric testing, radiological imaging, electromyography, and stereotactic radiosurgery (Radparvar, 2025).

Radiological Imaging
The microscope was introduced to neurosurgery by Theodore Kurze, who used the device for Vestibular Schwannoma resection in 1957 (Radparvar, 2025). 1963, Harvey Gass, described the opaque cisternography procedure of early lesions in the CPA (Radparvar, 2025). In 1964, Robert Scanlon, improved the procedure and advocated for early diagnosis of small intracranial tumors (Radparvar, 2025).

CT Scans
In 1971, Computerized Tomography (CT) scans replaced all tests for evaluation of tumors. Metrizamide cisternography using nonionic water soluble subarachnoid contrast, reported by the Arne Grepe in 1974, and gas CT cisternography using intrathecal air or filtered carbon dioxide as a subarachnoid contrast material by Ove Sortland in 1979, became the predominant method of evaluation (Radparvar, 2025).

Magnetic Resonance Imaging
Diagnosis for Vestibular Schwannomas was revolutionized in the 1980s with the development of the Magnetic Resonance Imaging machine (Radparvar, 2025). Magnetic Resonance Imaging(MRI) is currently the method of choice for detection, diagnosis, tumor characterization, operative planning, and post-operative treatment evaluation (Chen et al., 2021).

SURGICAL PROCEDURES

The procedures presently in use for the treatment of Vestibular Schwannomas are the Middle Cranial Fossa, Retrosigmoid, and Translabyrinth Approach, Conventional External Beam Radiation Therapy and Stereotactic Radiosurgery(SRS). Of the three surgical procedures, the Middle Fossa and Retrosigmoid approaches, are the preferred method of recision for small to medium sized schwannomas and are associated with integrity of hearing; while the translabyrinth approach is utilized for larger tumors and associated with complete hearing loss. In the following excerpt we discuss the leading surgical procedures and radiation therapies for the treatment of Vs.

Middle Fossa

The middle fossa is a type of surgical procedure for the removal of small to medium schwannomas that allows for hearing integrity (Maina et al. 2007). The extradural approach that was first utilized more than 130 years ago (Scheich et al., 2024). It was originally described by Parry in 1904 (Maina et al. 2007) and utilized in the 1960's by House (Maina et al. 2007).

The procedure has become an effective treatment for pathological conditions in the temporal region while minimizing trauma and hearing loss. The approach gives access to challenging regions like the cerebellopontine angle (CPA), petroclivial area, basilar artery, and cavernous sinus (Marina, 2007).

The middle fossa approach is typically utilized for tumors 2 cm and smaller in size. MCF surgery usually involves elevating the temporal lobe with a retractor to access the petrous bone (Scheich et al., 2024). Required elevation of the brain is often associated with irreversible damage to the temporal lobe, cerebrospinal fluid leak, and gliosis (Scheich et al., 2024).

Surgery of the middle cranial fossa requires specialized understanding of extreme variability in temporal lobe anatomy, and different surgical landmarks (Maina et al. 2007). Consequently, the middle cranial fossa and its variations, is considered one of the most difficult surgical procedures to perform (Maina et al. 2007).

With further advances, the fossa approach has become one of the primary surgical procedures for recision of schwannomas and accessing challenging regions of the brain (Maina et al. 2007).

Reported success of hearing preservation is 55% to 70% (Wilkinson et al., 2016).

Retrosigmoid

In 1925, Dandy, advocated for Intracapsular Denuncleation: a procedure that removes tumors by separating them from their capsule without affecting the nerve sheath, followed by a capsular

dissection from the brainstem with the unilateral suboccipital surgical approach. After further refinement, this procedure became known as the Retrosigmoid Approach (Radparvar, 2025).

The retrosigmoid approach is the most popular approach for surgical recision of vestibular schwannomas, being one of two recision procedures utilized for hearing preservation (Radparvar, 2025). This procedure is suitable for patients with serviceable hearing and is often used for small to medium sized shwannomas (Gajic et al., 2022).

Retrosigmoid surgery involves dissecting the transverse sinus and sigmoid sinus. After an incision to the dura, the cerebellum is retracted, the cerebellomedullary cistern is opened, cerebrospinal fluid released, and the tumor separated from the cochlear nerve (Chen et al., 2021).

Translabrynth

The translabrynth approach, utilized for medium to large schwannoma recision, is considered the best approach for patients with unserviceable hearing. The procedure requires minimal brain retraction to access the internal auditory canal (IAC), minimizing the risk involved in parenchymal injury (Ansari et al., 2012).

Translabrynth surgery involves creating a surgical incision behind the ear lobe, creating a cavity to expose the dura and inner ear, removing bone for access to the internal auditory canal and removing the tumor. Because the translabrynth approach involves chiseling out the mastoid and removing the translabrynth entirely, complete hearing loss is unavoidable (Gajic et al., 2022).

RADIOSURGERY

Conventional Beam Therapy

Beam therapy is an effective treatment for Vestibular Schwannomas, that involves a radiation beam delivered precisely to the tumor. The types of beam therapy are Stereotactic radiosurgery, hypofractionated, fractionated, photon and proton beam therapy. Radiation therapy does not remove the tumor but inactivates Schwann cells, reducing the size of the tumor. The effect of radiation on hearing is largely dependant on dose to the cochlea: independent of radiation treatment modality. Hearing preservation is associated with smaller tumor size.

Stereotactic Radiosurgery (SRS)

In 1993, the first tumors were treated with SRS (Radparvar, 2025). SRS is considered the dominant treatment for small to large Vestibular Schwannomas due to its safety and control rates (Ehret et al., 2025). SRS can be delivered with the gamma knife (elektra ab), cyberknife (accuray, inc), zap-x (zap surgical systems, inc), other linear accelerator- based techniques, and protons frameless/ frame based (Ehret et al., 2025).

In SRS, high-energy gamma rays, align the beam of radiation toward the isocenter of the tumor. This practice offers a noninvasive alternative to surgery (Gajic et al., 2022). SRS has been shown to be effective in tumors 3 cm and smaller (Gajic et al., 2022). This form of treatment is not efficacious for tumors larger than 3 cm, as large tumors often require decompression (Gajic et al., 2022). Failed gamma-knife radiosurgery is associated with

complications and more difficulty in correcting surgical injury than other forms of treatments because it may result in severe fibrosis (Chen et al., 2021).

FINDINGS

A multivariate comparison of surgical and radiation procedures and their outcomes indicated that there is a correlation between early onset detection, treatment, and prevention of hearing loss in Vestibular Schwannomas.

Although there have been significant advances in current technologies and surgical procedures, all treatments are associated with risk of hearing loss and other complications. Tumor size does not correlate with degree of hearing loss, as small tumors are associated with hearing loss (Fujita et al., 2023). Phenotypical considerations should be taken into account when choosing a treatment procedure.

Traditional surgical procedures, middle cranial fossa and retrosigmoid microsurgery, have been viewed more favourably for small to medium sized tumors, though each comes with its complications. The middle cranial fossa approach has been associated with irreversible damage to the temporal lobe and 70% temporal gliosis; while the retrosigmoid approach has been associated with facial nerve damage, hearing loss, and numbness or tingling of the face, along with cerebrovascular issues like blood clots and stroke, and potential wound-related problems including infections and cerebrospinal fluid (CSF) leaks (Scheich et al., 2024).

Retrospective studies show that patients who underwent primary microsurgery for Vs from 2002 to 2012, where preoperative hearing did not differ between approaches, concluded that a decline in hearing was greater in the retrosigmoid approach (55.5 dB and 45.6 discrimination) than in the middle fossa (38.9 dB and 31.7) ($p<0.011$ and 0.033, respectively) (Wilinson et at., 2016). The observed effects remained after controlling for tumor size (Wilinson et at., 2016).

Small to large vs, delivered platforms, including the gamma knife (elektra ab), cyberknife (accuray, inc), zap-x (zap surgical systems, inc), other linear accelerator- based techniques, and protons frameless and frame based are gaining more popularity; however, these approaches are known to be associated with hearing loss (Ehret et al., 2025).

There is a higher incidence of recurrence of vestibular shwannomas in patients treated with radiation therapy: hearing loss observed in post operative followups in comparison to other treatments is significantly higher in patients treated with radiation therapy. Radiation therapy damage to the inner cochlea can be attributed to varied doses in radiation therapy.

Oncological findings report poorer than expected results for hearing preservation in Stereotactic patients than less invasive microsurgical and endoscopic techniques, debate surgical resection vs treatment. To date, no randomized control trials are available for patients of Stereotactic Surgery (Radparvar, 2025).

The outcomes and complications of treatment are comparable between procedures and mostly dependent on the expertise of the surgeon. Currently, neuroendoscopic procedures are utilized to complement conventional surgeries (Scheich et al., 2024).

DISCUSSION

Post operative Test Battery

A specific protocol and test battery has not established correlation between clinical outcome and tests before and after surgery. To this day, there are no reliable predictors for tumor growth. This might be due to differences in tumor growth rate: while some tumors remain stable over time, others progress to cause life-threatening symptoms in a very short time (Radparvar, 2025).

Magnetic Resonance Imaging(MRI) is currently the method of choice for detection and diagnosis of Vestibular Schwannomas (Joudar et al., 2023). Sporadic diagnosis for Vestibular Schwannomas has increased due to the adoption of neuroimaging techniques(MRI) (Fujita et al., 2023).

Currently, the surgical procedures, middle cranial fossa and retrosigmoid microsurgery, have been viewed more favourably for hearing preservation, though each comes with its complications.

The middle cranial fossa approach has been associated with irreversible damage to the temporal lobe; while the retrosigmoid approach has been associated with facial nerve damage, hearing loss, and numbness or tingling of the face, along with cerebrovascular issues like blood clots and stroke.

CONCLUSION

After a thorough assessment of the diagnostic tools, treatments presently available, the author concluded that the implementation of surgical techniques in the early onset of Vestibular Schwannoma Tumors may help to prevent hearing loss.

A specific protocol and test battery has not established correlation between clinical outcome and tests before and after surgery, though identifying tumors appears to be central to management options and affects operating view, proper testing is not yet in place. Magnetic Resonance Imaging(MRI) is currently the method of choice for detection and diagnosis of Vestibular Schwannomas (Joudar et al., 2023).

The approaches utilized for hearing preservation are the retrosigmoid cranioctomy and the middle cranial fossa, of which the cranial fossa is more apt for hearing preservation. Findings of hearing preservation are consistent in small to medium sized tumors (Chen et al., 2021).

Tumor size is an important parameter that affects nerve localization, extent of resection, postoperative outcomes and complications (Chen et al., 2021).

Small to large vs, delivered platforms, including the gamma knife(elektra ab), cyberknife(accuray, inc), zap-x(zap surgical systems, inc), other linear accelerator- based techniques, and protons frameless and frame based (Ehret et al., 2025). The radiosurgery approach has excellent safety and control rates (Ehret et al., 2025); however, gamma-knife radiosurgery is associated with severe fibrosis and surgical injuries (Chen et al., 2021).

Recurrence of vestibular shwannomas after radiation therapy is normal, with greater hearing loss observed more often than in other treatments. Radiation therapy damage to the inner cochlea, this observation can be attributed to varied doses in radiation therapy.
Optimal operation depends on the tumor characteristics, patients hearing status, surgeon comfort, objective of operation (Chen et al., 2021). Intraoperative electrophysiological techniques combined with neuronavigation may be helpful to improve resection (Chen et. al, 2021).

VS microsurgery has been successful at achieving tumor removal with minimal morbidity and mortality. Although a general consensus for the treatment of vestibular schwannomas has not yet been established, the middle cranial fossa remains a viable alternative treatment for hearing preservation.
Ethics

The present paper utilizes qualitative and retrospective methods to describe its findings. Patients' personal data were omitted from this paper. As this was a review of published research, no requirement of ethical approval needed to be fulfilled.

Availability of data and material None.

Competing interests

The author declares that there were no conflicts of interest with regard to the content in this review.

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Authors' contributions

The author contributed in the research and writing of this paper.

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