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Small Vestibular Schwannomas: Does Surgery Remain a Viable Treatment Option?

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Abstract

Background Surgery for small vestibular schwannomas (Koos grade I and II) has been increasingly rejected as the optimal primary treatment, instead favoring radiosurgery and observation that offer lower morbidity and potentially equal efficacy. Our study assesses the outcomes of contemporary surgical strategies including tumor control, functional preservation, and implications of pathologic findings.

Design Retrospective review.

Setting/Participants Eighty consecutive patients (45 women, 35 men; mean: 47 years of age).

Main Outcomes Measures Approaches included retrosigmoid approach (52%), translabyrinthine (40%), and middle fossa (8%). Operated on by the same surgical team, we analyzed presentation, radiographic imaging, surgical data, and outcomes.

Results At last follow-up (mean: 34 months), 95% had good facial nerve function (House-Brackmann grade I or II); 36% who presented with serviceable hearing retained it; and 93% who presented with vestibular dysfunction reported resolution. Pathology identified two grade I meningiomas.

Conclusions As one of the largest contemporary surgical series of small vestibular schwannomas, we discuss some nuances to help refine treatment algorithms. Although observation and radiosurgery have established roles, our results reinforce microsurgery as a viable, safe option for a subgroup of patients.

Keywords
- acoustic neuroma
- disequilibrium
- hearing preservation
- vestibular dysfunction
- outcomes
- facial nerve function
- dizziness
- quality of life

Introduction

The optimal treatment paradigm for vestibular schwannomas remains elusive. Although traditional surgical treatment remains the preferred option for most large lesions, it has become less favored for small vestibular schwannomas. Improved access to health care and imaging technology has also led to the frequent diagnosis of smaller lesions, for which radiosurgery and more recently observation have become the preferred treatment options.

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Radiosurgery used extensively in the treatment of small vestibular schwannomas has achieved good results. However, as longer term data accumulates, a clear minority of these tumors do require retreatment after radiosurgery.[1–5] The recent focus on observation as primary treatment has argued for a delay in any decision making.[6–10] Yet the same studies would indicate a significant percentage of patients who exhibit growth were identified with prolonged follow-up.

Following this broad paradigm shift, the past 3 decades have seen a limited number of series that address surgical treatment of small acoustic neuromas.[11–22] At the same time, however, the goals of surgical treatment have evolved significantly from tumor control and survival to functional preservation, particularly facial nerve preservation. Technological advances as well as improvements in neuroanesthesia have also redefined the safety and outcomes of surgical resection. However, only one other study exceeding 25 patients has assessed surgical results for small vestibular schwannomas during the past 5 years.[12]

In pondering the optimal treatment for small vestibular schwannomas and undecided about whether surgical treatment should be reinforced as the primary treatment, we reviewed our surgical results for 80 patients with Koos grades 1 and 2 tumors. Contemporary outcomes included tumor control, functional preservation, complications, and implications of pathology. Based our findings, we hope to refine expected surgical results and compare them with other treatment modalities, thus generating a more nuanced treatment algorithm for small vestibular schwannomas.

Methods

We retrospectively identified 80 consecutive patients who underwent surgical treatment for Koos grade 1 or 2 vestibular schwannomas performed by a single-surgeon team (P.T. and M.P.) from 2003 to 2012 (University of Cincinnati institutional review board approved). Preoperatively all patients had at least one contrast-enhanced magnetic resonance imaging (MRI) to confirm consistency with a vestibular schwannoma, a thorough neurologic examination, and at least one audiogram. During consultation, patients were offered observation, radiation, or surgical resection. Reasons for surgical treatment included patient preference, tumor growth, and disabling vertigo or tinnitus. Patients who initially opted for observation and later chose surgery because of radiographic evidence of tumor growth or worsening symptoms were included in this series; patients with preoperative radiation treatment were excluded.

Outcomes Measured

Patient demographics, presenting symptoms, facial nerve function, and hearing status at presentation, time from presentation to treatment, age at treatment, operative approach, and tumor size and grade were recorded; length of stay was not collected (►**Table 1**). All patients with serviceable hearing, defined as American Academy of Otolaryngology-Head and Neck Surgery class A or B, underwent a retrosigmoid or middle fossa approach (►**Table 2**). For middle fossa approaches, a lumbar drain was placed preoperatively in the operating room. In cases of significant adhesions to the facial nerve, a near-total resection was performed, leaving a thin piece of tumor capsule on the nerve that would preserve function.

Outcome parameters included extent of resection, anatomical and functional preservation of the facial nerve, hearing preservation, resolution of vertigo, and complication rates (►**Tables 3–5**). Specifically, extent of resection was based on comparison of pre- and postoperative contrast-enhanced MRIs reviewed by the primary surgeons as well as a radiologist. In cases of discrepancy in the interpretation, the most conservative reading with respect to tumor residual was used. Facial nerve function as per the House-Brackmann (HB) scale was based on postoperative neurologic examination by the primary surgeons at last follow-up. Hearing was assessed with pre- and postoperative audiograms. Disequilibrium and its resolution were based on patient reporting.

Our literature review compiled the results of large surgical studies (i.e., $>$ 25 patients) of small vestibular schwannomas reported in the ears, nose, throat and neurosurgical literature (Medline search) and a larger study in which subgroups of small tumors were included (►**Table 6**).

Results

The 80 patients who underwent surgical treatment for Koos grades 1 and 2 vestibular schwannomas included 45 females and 35 males (mean age at surgery: 47 years). Presenting symptoms included 74 patients (92%) with hearing loss, 37 patients (46%) with varying degrees of tinnitus, 29 patients (36%) with disequilibrium, 2 patients (3%) with headache, and 1 patient with a HB II facial nerve palsy. Time from presentation to surgical treatment averaged 21.4 months, and 43% of patients were observed for at least 1 year before surgery.

Surgical Treatment

Tumor resections included retrosigmoid craniectomy with drilling of the internal auditory canal in 41 patients (52%), translabyrinthine approach in 33 patients (40%), and middle fossa approach in 6 patients (8%) (►**Table 2**). As evidenced by postoperative MRI, gross total resection was achieved in 71 patients (89%); of the 9 patients (11%) who had near total resection, 2 then received postoperative radiation when growth of the residual tumor was seen on subsequent MRIs.

Our 12% overall complication rate included delayed wound healing issues in two patients (5%) after the retrosigmoid approach, six patients (18%) after the translabyrinthine approach, and two patients (33%) after a middle fossa craniotomy (►**Table 5**). Four patients (three translabyrinthine and one retrosigmoid approach) were reoperated on for cerebrospinal fluid (CSF) leak repair and/or repair of the fistula. For the remaining three patients (one retrosigmoid and two middle fossa), a lumbar drain was inserted and drained for an average of 4 days with resolution of the leak.

On pathologic examination of 80 specimens, 78 (97.5%) were World Health Organization (WHO) grade I vestibular schwannomas and two (2.5%) were WHO grade I meningiomas. Postoperative follow-up averaged 34 months.

Table 1 Demographics and presenting symptoms for 80 patients with small vestibular schwannomas

Patients	No.	Mean age, y	No. (%) presenting symptoms				
			Hearing impairment (%)	Tinnitus (%)	Disequilibrium (%)	Headache (%)	Facial weakness (%)
Female	45	51	43 (96)	20 (44)	19 (42)	1 (2)	1 (2)
Male	35	42	31 (89)	17 (49)	10 (29)	1 (3)	0 (0)
Total	80	47	74 (92)	37 (46)	29 (36)	2 (2)	1 (1)

Facial Nerve Preservation and Hearing Outcomes

All patients had anatomical preservation of the facial nerve. At last examination, 76 patients (95%) had good facial nerve function (HB I or II) and one patient had a HB VI grade. Of 39 patients (49%) who presented with serviceable hearing, 35 underwent a retrosigmoid craniectomy and 4 patients underwent a middle fossa approach for resection. At last examination, 14 patients (36%) retained serviceable hearing (►**Table 3**).

For a subgroup of 29 patients (36%) who presented with complaints of imbalance/ disequilibrium, 17 patients underwent a retrosigmoid approach, 3 patients underwent a middle fossa approach, and 9 patients underwent a translabyrinthine approach. At last follow-up, 27 (93%) reported resolution of their vertigo postoperatively (►**Table 4**).

Discussion

Although radiosurgery and observation have evolved to be the main treatment strategies for small vestibular schwannomas, our findings update contemporary results of surgical treatment. Specifically, our patients had 97.5% tumor control, 95% good facial nerve function, 36% hearing preservation, and 12.5% overall complication rates. Optimal treatment for each patient with a small tumor remains elusive and multifactorial governed by patient age, symptom intensity, functional impairment, and posttreatment expectations. However, the compilation of contemporary surgical data focused on small vestibular schwannomas also provides some clarification to the plethora of information that patients access while they decide on treatment for their tumors (►**Table 6**).

Tumor Control

Over the past 5 years, several studies assessed the natural history of vestibular schwannoma.[6–10] In the largest and most often cited study, Stangerup et al described Denmark's centralized referral for all newly diagnosed vestibular schwannomas.[8] Of 729 patients observed for a mean follow-up of 3.2 years, the authors reported that 552 patients had more than one MRI, which showed only 17% of intrameatal tumors grew to become extrameatal and 28.9% of extrameatal tumors grew by > 2 mm on subsequent imaging. Challenging the notion that all tumors grow, these authors championed observation as an important option for patients diagnosed with a new tumor. We strongly agree with the concept of observation for small tumors and also add one interpretation of their conclusions: their study included only a minority of the patients who presented with the new diagnosis of vestibular schwannoma because most patients in their overall cohort were treated primarily surgically. Advanced age, medical comorbidities, and very small tumor size were the reported reasons that were used historically for not offering surgery upfront as treatment.

Contrary to the very low rates of growth reported in the Stangerup et al study, other natural history studies have shown significantly higher growth rates. Of 325 patients observed during a 3-year period, Bakkouri et al found 42% of tumors growing and 61% of intracanalicular tumors were becoming extracanalicular.[6] While following 124 patients with an average tumor volume of 1.2 cm^3 who underwent observation, Breivik et al reported volumes doubled over 3.3 years, and 63 patients underwent treatment because of growth at 5 years.[7] Finally, in a meta-analysis of 34 observational studies that consisted of 982 patients, Sughrue et al reported a mean growth rate of 2.9 ± 1.2 mm/year with a follow-up of 26 to 52 months.[9] This data in aggregate would argue that most small tumors indeed grow and require treatment with time.

The radiosurgical literature has reported, in medium-term follow-up, high tumor control rates of 92 to 98% that were defined either as radiographic growth arrest or no need for further treatment.[23–29] In a 2007 study from the University of Pittsburgh, Chopra et al reported 98.3% tumor control defined as absence of further intervention and 90.8% growth arrest on imaging studies.[1] Long-term radiosurgical results are emerging indicating tumor control rates of 92% even beyond 5 years mean follow-up.[1–3,30,31] Given the chronic nature of the disease, the patients who exhibit persistent growth following radiosurgery were faced with a difficult clinical problem because both microsurgery after radiosurgery and repeat radiosurgery carry significant additional morbidity to the facial nerve.[32–34] In our series, we achieved an 89% rate for

Table 2 Surgical approach and extent of resection defined as gross total resection or near-total resection

Approach	Patients, *n*	GTR, %	NTR, %
Retrosigmoid	41	89	11
Translabyrinthine	33	88	12
Middle fossa	6	100	0
Total	80	89	11

Abbreviations: GTR, gross total resection; NTR, near-total resection.

Table 3 Surgical approach and hearing preservation before and after surgery

Approach	Preoperative GR I or II	Postoperative GR I or II (% preservation)
Retrosigmoid	35	13 (37)
Translabyrinthine	–	–
Middle fossa	4	1 (25)
Total	39	14 (36)

Abbreviation: GR, Gardner-Robertson classification.

gross total resection and 97.5% for tumor control (i.e., cure and growth arrest). In two patients with near-total resection, evidence of residual tumor growth on follow-up MRI imaging then triggered further treatment by radiation. Thus with respect to tumor control, our results appear similar to those of radiosurgery.

Hearing Preservation

Hearing preservation is often a significant but elusive goal of vestibular schwannoma treatment. In the large meta-analysis, Sughrue et al showed that conservative management has been associated with hearing preservation in up to 54% of patients.[9] However, they also found that when growth exceeded 2.5 mm per year, hearing preservation was significantly lower at 32%. Even when tumors do not show significant growth during observation, Pennings et al reported that long-term hearing significantly decreased over time.[35]

Stereotactic radiosurgery at doses of 12 to 13 Gy is associated with hearing preservation rates that range from 56 to 88%.[1–5,23–26,29–31,36] In surgical series focusing on small vestibular schwannomas, the hearing preservation rates ranged from 33 to 87%.[11–20] Our 36% rate of hearing preservation rate was comparable with other contemporary surgical series yet significantly lower than radiation results. For patients who cannot afford to lose hearing in the involved ear, such as those with absent contralateral hearing or voice professionals, an improved chance of hearing preservation seems to be afforded with radiation therapy. As longer term follow-up from radiosurgery becomes available, whether the observed early primacy of hearing preservation following any type of radiation treatment holds true or weans with time remains to be seen.

Table 4 Surgical approach and disequilibrium

Approach	No. preoperative disequilibrium	No. (%) postoperative resolution disequilibrium (% resolution)
Retrosigmoid	17	16 (94)
Translabyrinthine	9	9 (100)
Middle fossa	3	2 (67)
Total	29	27 (93)

Facial Nerve Preservation

Facial nerve weakness is rare in patients at presentation and after conservative management. In a review of nerve function among patients treated conservatively, Sughrue et al noted a $< 3\%$ rate of facial dysfunction, which appeared to be independent of tumor growth rate.[9] After radiosurgery, facial nerve functional preservation has improved significantly following the dose deescalation from 18 Gy to 12 to 13 Gy, with rates of good facial nerve function improving from 33 to 86% to 98%.[5] Although not well established, impairment of long-term facial nerve function after radiosurgery appears to be somewhat worse: that is, up to 5% beyond 5 years after radiosurgery.

In two prospective trials that compared radiosurgical versus microsurgical treatment of small- to midsize vestibular schwannomas, functional outcomes favored radiosurgical treatment.[37,38] At 2 years posttreatment, Mysreth et al reported poor facial nerve function in 46% after microsurgery (HB grades III–VI) and 2% after radiosurgery.[37] Pollock et al reported a similar but more modest differences in good facial nerve function: 83% after microsurgery compared with 96% after stereotactic radiosurgery (mean follow-up: 3.5 years).[38]

Results of long-term good facial nerve function from our patients and other series of small vestibular schwannomas averaged higher than those reported in these two prospective studies that ranged between 83% and 96%[11–21] (►**Table 6**). Our series achieved rates of 100% anatomical preservation and 95% functional facial nerve preservation (HB I and II); these rates are similar to the other surgical series but also comparable with radiosurgical long-term functional outcomes.

Disequilibrium

Vestibulopathy, a common presenting symptom of vestibular schwannomas, was present in 36% of our patients. Unlike facial nerve and hearing outcomes, relatively little literature exists on the often disabling symptom of disequilibrium and the efficacy of the various treatment modalities for its resolution. In a comparison of functional outcomes after radiosurgery or surgery for patients with small acoustic neuromas without ipsilateral hearing, Coelho et al noted significant improvement in five of six patients with preoperative disequilibrium who underwent a translabyrinthine tumor resection[39]; this was statistically significantly better than the radiosurgical results in that same study.

Our patients achieved a 93% subjective resolution of vestibular dysfunction at last examination. This stands to reason because resection of a vestibular schwannoma includes sectioning of the vestibular nerve, which is argued by many as the most effective treatment for peripheral vestibulopathy. Our strategy is that surgery remains the preferred treatment option for significant vestibular dysfunction in patients with small tumors.

Risks and Complications

Risks associated with surgical resection of small vestibular schwannomas, other than the facial nerve weakness and hearing loss already discussed, include infections in 3.4 to

Table 5 Operative approach and complications

Approach	Patients	CSF leaks	Wound infections	No. (%) patients with complications	No. (%) patients returned to operating room
Retrosigmoid	41	2	0	2 (5)	1 (2.4)
Translabyrinthine	33	3	3	6 (18)	3 (9)
Middle fossa	6	2	0	2 (33)	0 (0)
Total	80	7	3	10 (12.5)	4 (5)

Abbreviation: CSF, cerebrospinal fluid.

Table 6 Surgical series of > 25 patients with small vestibular schwannomas or subgroups[a] of > 25 patients within a larger series that included all tumor sizes

Study	Patients, *n*	Size	HB I and II, %	Hearing class A and B, %
Colletti et al[11]	70	Intracanicular	83	46
Fayad and Brackmann[20]	271	< 1 cm	94	NR
Ginzkey et al[12]	89	Stage I and II	96	74
Gjurić et al[13]	311	< 1 cm	94	
Irving et al[14]	73	< 1 cm	90	44
Koos et al[15]	115	Grade 1 and 2	88	78
Magnan et al[16]	91	< 1 cm	93	30
Nadol et al[17]	71	< 1 cm	93	25
Rowed and Nedzelski[18]	26	Intracanicular	96	50
Falcioni et al[21,a]	444	< 1 cm	86	NR
Samii et al[19]	40	Class 1 and 2	87	55
Current series	80	Grade 1 and 2	95	36

Abbreviations: A and B, American Academy of Otolaryngology-Head and Neck Surgery classification; HB, House-Brackmann score; NR, not reported.

4.3%, CSF leaks in 6.9 to10%, neurologic deficit in 7.9 to 9.3%, and vascular injury in 0.75 to 1.2% of patients.[40,41] Our patients experienced a 12.5% overall complication rate that included 5% of patients returning to the operating room for cerebrospinal leak repair or wound revision. No strokes, permanent disability, or deaths were observed in our series.

Pathology

In two patients, presumed vestibular schwannomas based on preoperative imaging were later determined to be meningioma by pathologic diagnosis. Therefore, despite great advances in imaging technology and neuroradiologic review of all our patients' scans, radiographic diagnosis of small enhancing internal auditory canal (IAC) lesions can be challenging. Because the radiosurgery dose differs between small IAC lesions and that for meningioma and vestibular schwannoma, a wrong presumptive radiographic diagnosis can hold important clinical implications.

Study Limitations

Of our several limitations, first is the inherent bias of a retrospective study design of consecutively treated patients. Our overall surgical technique and philosophy of goals of treatment have remained relatively constant, whereas our cases spanning this 10-year period represents a time frame of evolving experiences and outcomes. Although functional preservation determined by the primary surgeons and reported for the long term is well accepted, a more nuanced view of overall outcomes undoubtedly would include patient perceptions of facial function, temporary dysfunction results, and quality-of-life metrics. Balance dysfunction can be measured quantitatively; however, in the absence of such a process, our patients' reports of vertigo are potentially inaccurate because of recall and treatment biases. Although our patients had small tumors with high rates of gross total resection, volumetric analysis of radiographs were not used, and some inaccuracy in extent of resection may result. Finally, our mean 34-month follow-up for this slow-growing tumor is limited, possibly leading to an overestimation of control rates.

Conclusions

Our study provides a contemporary view of surgical results and a more nuanced approach for refining the treatment algorithm as only the second large series of surgical treatment of small vestibular schwannomas within the past 5 years. We found the

rates of facial weakness and tumor control afforded by microsurgery rival those of radiosurgery. In the presence of vestibular dysfunction, we would advocate that microsurgery is the optimal treatment. Although observation and radiosurgery have well-established roles in the treatment of small vestibular schwannomas, our results reinforce that microsurgery can remain a viable, safe option for a subgroup of patients.

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