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Surgical Outcomes Following Vestibular Schwannoma Resection in Patients over the Age of Sixty-five

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Abstract

Objective Vestibular schwannoma (VS) are benign, often slow growing neoplasms. Some institutions opt for radiosurgery in symptomatic patients of advanced age versus surgical resection. The aim of the study is to analyze surgical outcomes of VS in patients over the age of 65 who were either not candidates for or refused radiosurgery.

Methods This includes retrospective analysis of VS patients between 1988 and 2020. Demographics, tumor characteristics, surgical records, and clinical outcomes were recorded. Patient preference for surgery over radiosurgery was recorded in the event that patients were offered both. Facial nerve outcomes were quantified using House-Brackmann (HB) scores. Tumor growth was defined by increase in size of >2 mm.

Results In total, 64 patients were included of average age 72.4 years (65–84 years). Average maximum tumor diameter was 29 mm (13–55 mm). Forty-five patients were offered surgery or GKRS, and chose surgery commonly due to radiation aversion (48.4%). Gross total resection was achieved in 39.1% ($n = 25$), near total 32.8% ($n = 21$), and subtotal 28.1% ($n = 18$). Average hospitalization was 5 days [2–17] with 75% ($n = 48$) discharged home. Postoperative HB scores were good (HB1–2) in 43.8%, moderate (HB3–4) in 32.8%, and poor (HB5–6) in 23.4%. HB scores improved to good in 51.6%, moderate in 31.3%, and remained poor in 17.1%, marking a rate of facial nerve improvement of 10.9%. Tumor control was achieved in 95.3% of cases at an average follow-up time of 37.8 months.

Conclusion VS resection can be safely performed in patients over the age of 65. Advanced age should not preclude a symptomatic VS patient from being considered for surgical resection.

Keywords
- vestibular schwannoma
- advanced age
- microsurgery
- radiosurgery

Introduction

Vestibular schwannoma (VS) are benign skull base neoplasms arising from the eighth cranial nerve. Patients with sporadic VS often present with any of the combination of hearing loss, tinnitus, dizziness, and/or gait instability. Converging evidence suggests a rising incidence affecting upward of 20 per 100,000 person-years in persons aged 70 years or older, possibly driven by increasing neuroimaging study rates.[1] Management of VS must account for facial nerve function, hearing preservation, quality of life, and factor in age at the time of presentation. As there is no clear gold standard, management of VS must be approached on a case by case basis and ideally performed by experienced

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surgeons in high volume centers. Current management paradigms for VS often incorporate either microsurgical resection or stereotactic radiosurgery (SRS), however, in older patients especially, observation with serial monitoring may be a preferred strategy due to the tumor's relatively indolent nature.[2–4]

The best available data suggests that the treatment-naive VS have an average estimated annual volumetric growth rate of 33.5% per year.[5] Based on the same volumetric analysis, only one-third of the tumors remain stable in size. The approach to VS in patients of advanced age must balance risk/benefit considerations of intervention, given actuarial life expectancy predictions versus anticipated tumor growth rates. It is for this reason that many high-volume centers elect to observe smaller tumors that are either asymptomatic or mildly symptomatic, and tend to treat larger, symptomatic tumors preferably using SRS in this older age demographic. Although SRS can achieve tumor control in 94% of patients at 10 years, only 69% achieve tumor control if the VS demonstrates growth of >2.5 mm per year prior to treatment.[6,7]

We hypothesize that, when warranted or preferable, microsurgical resection of VS in older patients can be performed with acceptable tumor control and facial nerve outcomes. Further, some lesions are not optimal for radiosurgical intervention due to size or volumetric constraints and proximity to the brainstem or cochlea. There is a paucity in the literature detailing surgical outcomes of elderly patients undergoing microsurgical resection of VS. We report amongst the largest surgical series focusing on outcomes of microsurgical resection of VS in patients of advanced age.

Materials and Methods

A retrospective analysis of a prospectively maintained, institutional review board (IRB) approved database was performed to identify sporadic (non-NF2) VS patients aged 65 years or older undergoing microsurgical resection from 1988 to 2020. All patients provided consent to be included in the database. A cohort of the same age demographic undergoing radiosurgery as the primary means of intervention was constructed for comparison. Patient demographics, presenting symptoms, prior intervention, tumor characteristics, surgical records, complications, disposition information, and follow-up data were recorded.

Patients presenting to our institution with VS are treated by a multidisciplinary team composed of otolaryngology, neurosurgery, and radiation oncology. Patients presenting with incidentally found tumors, or presenting with minor symptoms, are offered observation, radiosurgery, or surgical resection depending on tumor and patient factors. Symptomatic patients are typically offered microsurgical resection versus radiosurgery. VS with diameter >30 mm and/or those with a large cystic component are usually not considered for radiosurgery. Patients in this series with tumor dimensions amenable to radiosurgery were offered GKRS or surgery, but opted for surgical resection following extensive counseling. Patient reasoning for preference of surgery over radiosurgery was recorded when available.

Extent of resection was defined by comparing operative records with postoperative magnetic resonance imaging at 3 months follow-up. Gross total resection (GTR) was defined by complete microscopic removal of tumor with no evidence of disease on MRI. Near total resection (NTR) was defined if residual tumor no greater than 25 mm^2 and 2 mm thick along the facial nerve or brainstem was present, as described by Bloch et al.[8] All other forms of incomplete resection were deemed subtotal resections (STR). In agreement with most large reported case series, we defined recurrence as tumor growth of >2 mm on follow-up imaging.[9,10]

Facial nerve outcomes were defined using the House Brackmann (HB) scale and subcategorized as "good" outcomes being HB1–2, "moderate" HB3–4, and "poor" HB5–6. HB scores were obtained within the first week postoperatively prior to the time of discharge, and again at the time of most recent follow-up. Rates of facial nerve improvement were defined by improvement of subcategory from the time of discharge compared with the most recent clinical follow-up. A linear regression was performed in RStudio using the "glm" function to test for correlation between facial nerve outcomes and tumor size.

Results

Demographics and Presentation

Sixty-four patients met inclusion criteria and were identified for analysis. There were another 62 VS patients of the same age demographic opting for radiosurgery as opposed to microsurgical resection. Average age at the time of surgery was 71.2 years, ranging from 65 to 84 years. The cohort was composed of 62.5% women ($n = 40$) and 37.5% men ($n = 24$). Presenting symptoms included 84.4% hearing loss ($n = 54$), 48.4% vertigo ($n = 31$), 10.9% gait ataxia from brainstem compression ($n = 7$), 3.1% facial numbness ($n = 2$), and 1.6% trigeminal neuralgia ($n = 1$). These results are summarized in ►**Table 1**.

Surgical Outcomes

Microsurgical resection was the primary means of intervention in all patients. Patients with tumor diameter exceeding

Table 1 Patient demographics and presentation

Surgical cohort ($n = 64$)	
Average age (years)	71.2 [65–84]
Sex	
Male	37.5% ($n = 24$)
Female	62.5% ($n = 40$)
Presentation	
Hearing loss	84.4% ($n = 54$)
Vertigo	48.4% ($n = 31$)
Gait imbalance	10.9% ($n = 7$)
Facial numbness	3.1% ($n = 2$)
Trigeminal neuralgia	1.6% ($n = 1$)

Table 2 Surgical data, tumor characteristics, and extent of resection

Surgical outcomes	
Tumor size (maximum diameter, cm)	29 [13–55]
Cystic	28.1% ($n = 18$)
Indication for Surgery	
Refused GKRS	48.4% ($n = 31$)
"Surgical cure"	9.4% ($n = 6$)
Large (>3cm)	42.2% ($n = 27$)
Intratumoral hemorrhage	1.6% ($n = 1$)
Approach	
Translabyrinthine	73.4% ($n = 47$)
Retrosigmoid	26.6% ($n = 17$)
EOR	
GTR	39.1% ($n = 25$)
NTR	32.8% ($n = 21$)
STR	28.1% ($n = 18$)

Abbreviations: EOR, extent of resection; GTR, gross total resection; NTR, near total resection; STR, subtotal resection.

Table 3 Hospital course, ultimate disposition, and resultant complications

Clinical course	
Length of stay (days)	5 [2–17]
Disposition	
Home	75%($n = 48$)
ARU	18.8%($n = 12$)
SNF	4.7% ($n = 3$)
Morgue	1.5% ($n = 1$)
Complication	
Sinus injury	3.1% ($n = 2$)
Cerebellar infarct	3.1% ($n = 2$)
Wound infection	3.1% ($n = 2$)
CSF leak	3.1% ($n = 2$)
Respiratory distress	1.6% ($n = 1$)
Hemorrhage	1.6% ($n = 1$)
Death	1.6% ($n = 1$)

Abbreviations: ARU, acute rehabilitation unit; CSF, cerebrospinal fluid leak; SNF, skilled nursing facility.

30 mm (42.4%, $n = 27$) were typically not considered for radiosurgery. Similarly, patients with a large cystic component were rarely offered radiosurgery based on our institutional experience and preference (28.1%, $n = 18$). Nearly three-quarters ($n = 45$) of patients in this series were offered radiosurgery or surgical resection, and ultimately opted for surgery. The most common patient reasoning for electing surgery included preference to not undergo radiation ($n = 31$, 48.4%). A small subset of patients desired a "surgical cure" in hopes of receiving an expedited relief of symptoms ($n = 6$, 9.4%). One patient was not offered radiosurgery as he presented with acute symptom onset due to intratumoral hemorrhage necessitating surgical resection.

Mean maximum tumor diameter was 29 mm, ranging from 13 to 55 mm. A translabyrinthine approach was used in 73.4% ($n = 47$) of cases, with the remaining 26.6% ($n = 17$) performed via a retrosigmoid approach. GTR was achieved in 39.1% ($n = 25$) of cases, NTR in 32.8% ($n = 21$), and STR in 28.1% ($n = 18$). These results are summarized in ►**Table 2**.

Clinical Course

The average hospital length of stay was 5 days, ranging from 2 to 17 days. Only one patient remained hospitalized over 1 week due to an aspiration event requiring reintubation and eventual tracheostomy. Ultimate disposition at the time of discharge was home in 75% ($n = 48$), acute rehabilitation unit in 18.8% ($n = 12$), skilled nursing facility in 4.7% ($n = 3$), and one mortality (1.5%). Complications included: dural sinus injury in 3.1% ($n = 2$), cerebellar infarct 3.1% ($n = 2$), wound infection in 3.1% ($n = 2$), cerebrospinal fluid leak in 3.1% ($n = 2$), respiratory distress in 1.5% ($n = 1$) requiring reintubation, and one postoperative hemorrhage resulting in emergent evacuation. The patient developing postoperative hemorrhage occurred during the first postoperative night and resulting in a devastating neurological injury with ultimate withdrawal of care on postoperative day five. These results are summarized in ►**Table 3**.

Facial Nerve Outcomes and Tumor Control

Average postoperative time of follow-up was 37.8 months. Tumor control was achieved in all but three case (95.3%). All patients with notable postoperative tumor growth were referred for SRS. Two patients were referred for adjuvant CyberKnife and one for GKRS due to residual tumor along the facial nerve and brainstem at 4 months after resection. These results are summarized in ►**Table 4**.

Initial postoperative HB scores were assigned within the first week after surgery prior to discharge. Postoperative week 1 HB scores were good (HB1–2) in 43.8% ($n = 28$) of patients, moderate (HB3–4) in 32.8% ($n = 21$), and poor (HB5–6) in 23.4% ($n = 15$) of cases. At the time of follow-up, patients demonstrated good HB scores in 51.6% ($n = 33$), moderate HB in 31.3% ($n = 20$), and poor HB in 10.9% ($n = 7$). When comparing facial nerve function from the first postoperative week to the time of follow-up, only 10.9% ($n = 7$) made any form of improvement. These results are summarized in ►**Table 4**. There was no correlation between tumor size and facial nerve outcomes (►**Fig. 1**).

Radiosurgery

During the same time period, an additional 62 VS patients of the same age demographic opted for Gamma Knife radiosurgery as the primary means of intervention. Average age at time of radiosurgery was 73 years, ranging from 65 to 86 years. The cohort had a female predominance at 59.7%

Table 4 Follow-up data, tumor control, adjuvant radiosurgery, and facial nerve outcomes

Follow-up data	
Follow-up duration (months)	
Mean	37.8 [1–264]
Tumor control	
Yes	95.3% ($n=61$)
No	4.7% ($n=3$)
Adjuvant SRS	
GKRS	3.1% ($n=2$)
CyberKnife	3.1% ($n=2$)
HB (post-op week 1)	
Good [1–2]	43.8% ($n=28$)
Moderate [3–4]	32.8% ($n=21$)
Poor [5–6]	23.4% ($n=15$)
HB (most recent)	
Good [1–2]	51.6 ($n=33$)
Moderate [3–4]	31.3% ($n=20$)
Poor [5–6]	17.1% ($n=11$)
Facial nerve improvement	10.9% ($n=7$)

Abbreviations: GKRS, gamma knife radiosurgery; HB, House Brackmann; SRS, stereotactic radiosurgery.

($n=37$). Mean maximum tumor diameter was significantly smaller than the microsurgical cohort at 18.9 mm, ranging from 5 to 37 mm ($p<0.001$). All patients were treated at a dose of 12 to 13Gy. The most common presenting symptom was hearing loss in 80.6% ($n=50$), followed by gait instability in 17.7% ($n=11$), facial numbness in 4.8% ($n=3$), or as an incidental finding in 4.8% ($n=3$). Only 6.5% ($n=3$) had a cystic component to the tumor at the time of treatment. Average postoperative time of follow-up was 30.8 months. Tumor control was achieved in all but three case (95.2%). These results are summarized in ►**Table 5**.

Discussion

Our findings from a large series of surgical resection of VS from a high volume, tertiary care center suggest that, despite age, most patients can undergo resection with low rates of complications, standard lengths of hospitalization, and a majority able to be discharged home. In the current age of radiosurgery, many institutions preferably employ SRS for tumor control in elderly patients.[11] We reject the notion that patients of advanced age should be universally precluded from consideration of surgical resection, and show that in selected cases favorable outcomes may be achieved in this patient population. We advocate that symptomatic patients that are otherwise reasonable surgical candidates should be

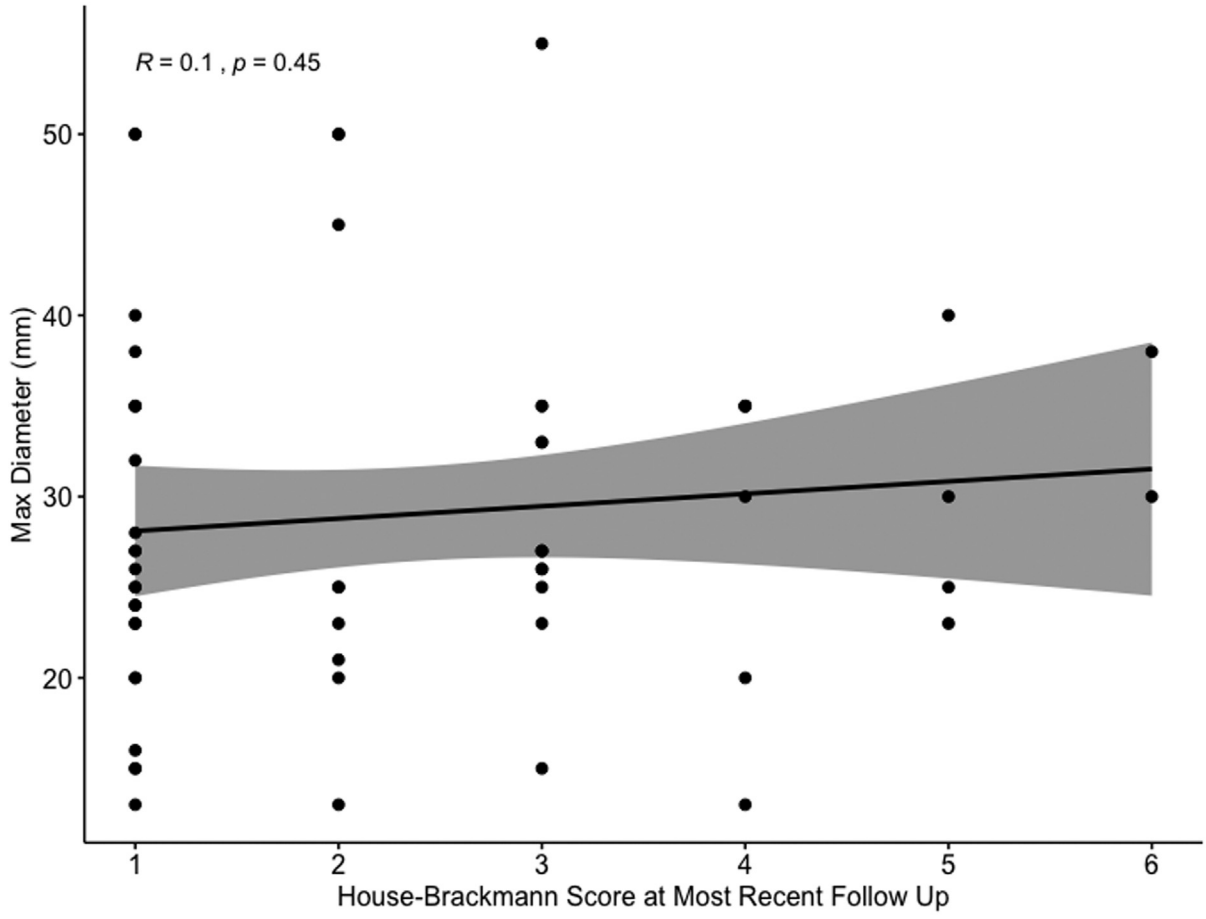

Fig. 1 Linear regression demonstrating no significant correlation between presenting tumor size and facial nerve outcomes.

Table 5 Demographics, tumor characteristics, dosing, presenting symptoms, and follow-up duration of the radiosurgery cohort being treated from 1988 to 2020

Radiosurgery cohort ($n = 62$)	
Average age (years)	73 [65–86]
Sex	
Male	40.3% ($n = 25$)
Female	59.7% ($n = 37$)
Average tumor size (maximum diameter, cm)	18.9 [5–37]
Dose	12–13Gy
Presentation	
Hearing loss	80.6% ($n = 50$)
Gait instability	17.7% ($n = 11$)
Facial numbness	4.8% ($n = 3$)
Incidental	4.8% ($n = 3$)
Cystic	6.5% ($n = 3$)
Follow-up duration (months)	
Mean	30.8 [1–154]
Tumor control	
Yes	95.2% ($n = 59$)
No	4.8% ($n = 3$)

offered both radiosurgery and microsurgical resection. This highlights the importance for VS being managed at high volume tertiary institutions, where an emphasis on safety, adjuvant treatment, and multidisciplinary care can tailor treatment plans based on patient preferences and risk considerations.

There have been previous VS surgical series dedicated to reviewing outcomes in older patients, though the majority of prior work was published prior to the widespread availability and use of SRS. Silverstein et al[12] argued that large, symptomatic VS are best treated by STR to decompress the brainstem while minimizing damage to the facial nerve and reduce postoperative morbidity. Samii et al[13] advised that elderly patients can still undergo GTR with excellent outcomes, and that age was not correlated with outcomes. Van Abel et al,[14] Bowers et al,[15] and Jiang et al[16] agreed by concluding that although older patients had poorer health at the time of surgery, there was no resultant increase in morbidity profile. Our results are congruent with previous reports in that we do not find increasing age to pose an elevated risk profile. The complication profile of our current series is comparable to our previous VS surgical series comprised of patients of all ages.[17] One recent study by McCutcheon et al[18] draws contrast to other works by finding older age to be associated with increased morbidity, including stroke or respiratory failure. Older studies do exist that describe a correlation between increasing age and morbidity/mortality, but many such studies are at or prior to the widespread use of radiosurgery. In such series, surgeons did not have the luxury of foregoing aggressive resections with reliance on radiosurgery for tumor control.[19] As such, it is not unexpected that older patients would have experienced worse outcomes resulting from more extensive resections. We did not find weaning the ventilator or airway considerations to be major difficulties in most of our patients, with the exception of one patient requiring re-intubation in the early postoperative period.

All patients included in our series were symptomatic at the time of presentation. Our institution will offer surgical resection or radiosurgery to symptomatic patients who are surgical candidates in the event that tumor maximum diameter does not exceed 3 cm. Outside of the patients included in this study, another 62 VS patients of the same age demographic presenting to our institution opted for radiosurgery as opposed to microsurgical resection. Thus, of the 126 patients presenting with symptomatic VS over the age of 65 offered both radiosurgery or surgical resection, patients were equally as likely to pick either option. The primary reason for the surgical cohort to opt for resection was due to an aversion to radiosurgery or the desire to have more rapid relief of symptoms, particularly gait imbalance, offered by surgical debulking. On the other hand, the majority of patients preferring radiosurgery presented with hearing loss only or had smaller tumors, often purely intracanalicular in nature. The average size of tumor at the time of presentation was at the threshold for consideration for radiosurgery while the patients opting for radiosurgery tended to have smaller tumors, or purely intracanalicular tumors. Our institutional philosophy favors resection in tumors >2.5 cm in maximum diameter, especially as a surgical approach offers an expedited relief of symptoms caused by larger tumors. While there have been studies supporting effective tumor control of VS >3 cm in a single dimension, or $>10\ cm^3$, tumor volume exceeding $15\ cm^3$ is a significant predictive factor for poor tumor control following radiosurgery, in addition to adverse radiation effects to the brainstem.[20] Interestingly, a quarter of our patients in this age demographic presented with a cystic component. These patients would undergo a surgery mostly to relieve acute symptom onset due to rapid expansion of the cyst causing mass effect on the brainstem.

There has been a great deal of interest in the quality of life as it pertains to VS patients in recent years. The diagnosis of VS, as opposed to treatment modality chosen, seems to have the biggest impact on the quality of life.[21,22] Symptoms most influential on lowering quality of life were ongoing headaches and dizziness with facial nerve function and hearing loss less siginficant.[23] Patients experience improved quality of life following GTR as compared with having residual tumor.[24] The culmination of these studies underscore the importance of appropriate patient counseling and advocates for intervening on symptomatic patients in which an intervention can be reasonably expected to relieve symptoms. This notion is perhaps most evident in the elderly population, as the quality of life improvement from the relief of symptoms outweighs to the burden of undergoing surgical resection.

Any discussion of VS treatment modalities and resultant outcomes must consider tumor control and facial nerve preservation. The approach to an older patient with VS will have somewhat different goals of surgery compared with a younger patient with longer life expectancy. With respect to tumor control, the goals of surgery for large tumors should be to decompress the brainstem to relieve symptoms and preserve neurological function. Our institution achieved 64.3% rates of GTR across all VS cases performed across the time span on this study; however, in the older patients we reserve more aggressive resection to have rates of GTR or NTR as 39.1 and 32.8%, respectively. Less aggressive attempted resections in our advanced age cohort perhaps also, at least partially, explain why our linear regression did not find correlation between tumor size and facial nerve outcomes. There have been multiple multivariate analyses failing to show a correlation between age at the time of surgery as an independent risk factor for poor facial nerve recovery.[25–27] In our series, very few patients had a meaningful improvement in their HB score from the time of discharge to follow-up. Considering facial nerve function is a determinant of postoperative quality of life, significant effort should be placed on maintaining the integrity of the nerve.[28]

Limitations

This study is limited by its small sample size. However, it represents one of the largest single center surgical series of VS patients over the age of 65 undergoing microsurgical resection. Further, the follow-up duration of three years is short when discussing VS. Some patients have less than a 1 year follow-up as the resections were performed within the year of this study. However, the primary narrative of our findings is that surgery can be performed in the advanced age demographic with good facial nerve outcomes and a comparable short-term clinical course compared with younger patients. We have no reason to suspect that long-term tumor control following STR would behave differently due to patient's age. Lastly, we have omitted hearing outcomes from our analysis. The query of institutional databases demonstrated incomplete records or inconsistent methods of describing hearing status making meaningful analysis difficult.

Conclusion

We report a single institution's surgical series suggesting VS patients of advanced age can still undergo microsurgical resection with very good outcomes. Surgical resection in elder patients has the option of opting for less aggressive resections to decompress the brainstem and preserve facial nerve function, as most tumors will not exhibit growth in the patients' remaining lifetime. We reject the notion that elderly patients with VS should not be considered for surgical candidacy and thus receive radiosurgery as the primary means of intervention.

Conflict of Interest
None declared.

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