Original article

Microsurgical removal of symptomatic vestibular schwannomas in the eighth decade of life

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SUMMARY: ***Aims***: *Older adults constitute an ever-growing cohort among patients affected by vestibular schwannoma. We conducted a retrospective analysis of clinical presentation and surgical outcomes of 30 patients aged ≥ 70, operated on in two neurosurgical centers for unilateral vestibular schwannoma.*
Materials and Methods: *American Society of Anesthesiology (ASA) grade I-II patients and grade III ones with life-threatening tumors were enrolled. The House-Brackmann (HB) scale was used to assess facial nerve postoperative functional outcome. Tumor size was categorized according to Koos' classification. A retrosigmoid approach was used in all the surgical operations. Extent of removal was described as total, near total (> 95%), subtotal (> 90%).*
Results: *Mean age within the cohort was 74 years; 53% ASA II, 47% ASA III. Mean tumor size was 2.7cm (range 1.5-4.2 cm). Gross-total or near-total resection was achieved in 80% of cases, subtotal totaling 20% of cases. Perioperative mortality - i.e., within one month of the operation - was zero. Long-term facial outcome at six months: HB I 50%, HB II 27%, HB III 23%. Transient complications occurred only in case of large tumors. The occurrence of remnant growth after subtotal resection was observed in 3 cases, but a second surgery was never deemed necessary.*
Conclusions: *In patients in good general conditions, age does not appear to be a major contraindication for microsurgical resection of vestibular schwannomas. Long-term facial nerve results are satisfactory in most patients in the eighth decade of life and complications are the same as observed among youngsters. Factors associated with higher complication rates are poor preoperative general condition (ASA III) and large tumors (Koos IV), especially when treated with surgical gross total resection.*

KEY WORDS: *Age, Facial nerve, Facial nerve position, Facial nerve preservation, Older adults, Retrosigmoid approach, Vestibular schwannoma.*

INTRODUCTION

Vestibular schwannoma is the most common tumor of the cerebello-pontine angle, ranging from 85 to 92% of tumors[3,15,25,26,33]. The clinical presentation correlates with the structures gradually compressed by the tumor. Over the past 40 years, the incidence of VS has increased steadily more than 10 times and the mean

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LIST OF ACRONYMS AND ABBREVIATIONS: **AAO-HNS** = American Academy of Otolaryngology - Head and Neck Surgery; **ABR** = Auditory Brainstem Responses; **ASA** = American Society of Anesthesiologists physical status classification system; **CSF** = CerebroSpinal Fluid; **CT** = Computed Tomography; **FN** = Facial Nerve; **GTR** = Gross Total Resection; **HB** = House-Brackmann; **HL** = Hearing Level; **i.e.** = id est (Latin for that is); **MRI** = Magnetic Resonance Imaging; **MS** = MicroSurgery; **NTR** = Near Total Resection; **RT** = Radiotherapy; **SDS** = Speech Discrimination Score; **SRS** = Stereotactic RadioSurgery; **STR** = SubTotal Resection; **VS** = Vestibular Schwannoma; **WW** = Watchful Waiting.

age at diagnosis has increased from approximately 49 to 60 years(2,5,17,21,22). The treatment of VS depends on the characteristics of both the patient and the tumor. Tumor size and growth pattern as well as patient age, symptoms and co-morbidities determine the treatment of choice among three main options: conservative therapy with watchful waiting, stereotactic radiosurgery, and microsurgery(25,26,33). The goal of modern management of VS is to improve quality of life and preserve neurological function while maintaining low mortality and morbidity rates.

Aims. In this study, we retrospectively analyzed the clinical and surgical data of a consecutive series of 30 symptomatic patients aged 70 or older with sporadic unilateral VS, operated at two different neurosurgical centers. We evaluated surgical outcome while highlighting the extent of tumor removal, postoperative nerve functions and complications.

☐ MATERIALS AND METHODS

■ **Patient population.** We retrospectively reviewed a series of 30 consecutive cases of vestibular schwannoma in patients aged 70 or older (eighth decade of life) who were operated on at two neurosurgical centers: the Neurosurgical Division of “San Filippo Neri” Hospital in Rome and the Federal Centre of Neurosurgery in Tyumen, between September 2010 and April 2019. General health conditions were graded according to the ASA score: only patients assessed as grades I, II and III were considered for surgery; all ASA grade III patients were affected by large and life-threatening VS.

Only patients with sporadic VS were included in the study. Clinical data such as patients’ age, sex, presenting symptoms, symptoms duration and tumor size were recorded. Preoperative neuroimaging studies included temporal bone CT and gadolinium-enhanced MRI for all patients.

Tumor size was measured according to the international standard - i.e. the largest extrameatal tumor diameter on post-contrast axial MRI(11). Large tumors were considered those with a maximal diameter ≥ 30 mm in the cerebellopontine angle, as opposed to small tumors with a maximal diameter < 30 mm. According to Koos et al.(12), tumors are classified into four grades in relation to maximal diameter and relation with contiguous anatomical structures.

Microsurgery via a retrosigmoid approach was performed in all cases.

The course of the FN was classified into four different patterns according to its position: anterior (or ventral) to tumor surface, anterior-inferior (or ventral-inferior), anterior-superior (or ventral-superior), and dorsal(14,24).

The preoperative audio-vestibular evaluation included pure tone audiometry, SDS assessment, caloric test and ABR. Hearing level was determined according to the AAO-HNS classification(1): Class A (SDS > 70%) and B (SDS > 50%) were categorized as bearing good hearing, while useful hearing preservation included Classes A, B and C (SDS < 50%). The location of the FN and its adherence to the tumor were evaluated by reviewing the radiological images and the surgical video records. FN function was assessed according to the HB grading system(8) and was evaluated preoperatively, at discharge and at the final follow-up (minimum 6 months). HB grades I and II were considered as a favorable outcome while grades III, IV and V were unfavorable. Other possible complications such as postoperative hemorrhage, CSF leak, infection, neurological defects of new onset and perioperative mortality rate - i.e. within one month of the operation - were recorded.

We graded the extent of tumor removal as gross total resection, near total (linear millimetric tumor remnant), subtotal (residual tumor volume < 10%) and partial (residual tumor volume > 10%). The extent of resection was evaluated on postoperative MRIs through a blind review by one member of our neurosurgical staff (E.C.) and a neuroradiologist. The blind evaluation was then compared with the impression of the surgeon as written in the operative report.

■ **Facial nerve intaoperative neuromonitoring.** The intraoperative nerve monitoring system (Nimbus i-Care 100 intraoperative neurophysiologic monitoring; Newmedic Division of Hemodia, Labège, France), with electrodes inserted in orbicularis oris and orbicularis oculi muscles, was routinely used intraoperatively to detect FN responsivity.

■ **Follow-up.** The long-term FN outcome evaluation was performed at six months postoperatively and assessed according to HB scale. Clinical and radiological follow-up was scheduled at six months postoperatively and then once a year. The follow-up period ranged between 12 and 115 months (mean 63; median 63.5).

☐ RESULTS

Thirty patients underwent microsurgical removal via a retrosigmoid approach for unilateral VS. Patient age ranged from 70 to 80 years old, with a mean age of 74 years. There were 13 female (43.3%) and 17 male (56.7%) patients. ASA score II was assigned in 16 cases (53%) and ASA III in 14 (47%). In 19 cases (63.3%) the tumor was left-sided, while in 11 cases it was on the right side. Major clinical symptoms included progressive sensorineural hearing loss, gait disturbance and facial paresthesia. The mean tumor size was 2.7 cm (range 1.5-4.2 cm). In 22 cases (73.3%), the maximum tumor diameter was ≥ 3 cm (Table 1).

The preoperative auditory assessment showed that 19 patients (63.3%) suffered from grade D hearing loss, 9 patients (30%) suffered from grade C hearing impairment, while 2 patients (6.7%) were assessed as grade B. According to the HB scale, preoperative HB IV FN palsy was present in 4 cases.

GTR or NTR was achieved in 24 cases (80%) and STR in 6 cases (20%). The cisternal segment of the FN was anterosuperior to the tumor in 14 (46.7%) cases, anterior in 10 (33.3%), and anteroinferior in 6 (20%). The follow-up ranging from 12 to 111 months demonstrated that a second surgery for re-growth of residual tumor was never necessary due to tumor remnant stability.

Hearing preservation was achieved in 1 patient out of two possible candidates (class B of AAO-HNS grading system). As shown in Table 2, excluding 4 cases with preoperative HB IV before and after surgery, at the final follow up (April 30, 2020), 13 out (50%), 8 (27%), and 5 (23%) patients showed a FN function of HB I, II and III, respectively. The 5 patients with a postoperative HB III FN result had a tumor with a maximum diameter larger than 3 cm (Koos IV): GTR or NTR was achieved in 4 cases, while STR removal in the remaining 2 cases.

The mortality rate was zero. CSF leak, wound infection and postoperative hydrocephalus were not observed. Postoperative transient complications were

Vestibular schwannoma in patients aged ≥ 70 years		
Sex	Female	13 (*43.3%*)
	Male	17 (*56.7%*)
Mean age ± SD (years)	74 ± 3.8 (range: 70-80)	
Side	Left	19 (*63.3%*)
	Right	11 (*36.7%*)
Mean diameter (cm)	2.7 (range: 1.5-4.2)	
ASA score	II	16 (*53%*)
	III	14 (*47%*)
Koos grade	II	6 (*20%*)
	III	12 (*40%*)
	IV	12 (*40%*)
AAO-HNS hearing function	B	2 (*6.7%*)
	C	9 (*30%*)
	D	19 (*63.3%*)
Preoperative HB grade	I	26 (*86.7%*)
	IV	4 (*13.3%*)

Table 1. Preoperative clinical and radiological characteristics of the study population. *Legend:* AAO-HNS = American Academy of Otolaryngology - Head and Neck Surgery; HB = House-Brackmann; SD = Standard Deviation.

Facial nerve outcome and postoperative complications		
FN outcome at 6 months	HB I	13/26 (*50.0*%)
	HB II	8/26 (*30.8*%)
	HB III	5/26 (*19.2*%)
	HB IV	4 (*stable as preoperative*)
Mortality	null	
Permanent complications	null	
Transient complications (observed only in Koos IV - ASA II VS)	Imbalance	10 (*33.3*%)
	Dizziness	9 (*30.0*%)
	Hemiparesis	4 (*13.3*%)
	Diplopia (abducens nerve palsy, recovered after three months)	1 (*3.3*%)
Second surgery for growing tumor remnant	null	

Table 2. Facial nerve outcome and postoperative complications. *Legend:* ASA = American Society of Anesthesiologists; FN = Facial Nerve; HB = House-Brackmann; VS = Vestibular Schwannoma.

present only in patients with Koos IV VS and ASA III: imbalance in 10 cases (33.3%), dizziness in 9 (30%), hemiparesis in 4 (13.3%), and diplopia in one case (3.3%), which was caused by abducens nerve paralysis and lasted 3 months.
A second operation for recurrence was not performed on any patient.
Re-growth of residual tumor after STR removal was observed in 3 cases, 2 treated with SRS and one observed with seriated MRI scans.

□ DISCUSSION

Older population is currently increasing around the world. Diffusion and development of MRI have allowed for the incidental and intentional diagnosis of VS in patients aged 70 years old or older.
Decision-making regarding surgery in the elderly population is never easy and in certain cases represents a challenge, as several co-morbidities and short life expectancy should be balanced against the surgical benefit in this group of patients. On the other hand, most elders have a better life expectancy and quality of life than in the past. Additionally, surgery is safe, and postoperative intensive care improves patient recovery(6,16,18-20,23,27,31). Consequently, the surgeon is called to perform surgical treatment for older adults ever more frequently.
Treatment options for elders are the same as those used among youngsters: "wait and watch" management; microsurgery and stereotactic radiosurgery.
Patients with small-sized VS (Koos I and II grades) in their eighth decade of life, without contact with the brainstem, tumor growth or disabling symptoms must be managed conservatively and followed up with contrast-enhanced MRI first at 6 months-1 year from diagnosis(16,18). Tumor growth may be extremely variable, from no growth to a few millimeters per year. In other cases, it is possible to observe tremendous neoplasm enlargement with brainstem compression and severe neurological impairment. Nuseir et al.(16) reported a mean growth rate of 2 mm per year. Perry et al.(18) in a series of 41 older patients affected by VS, observed tumor growth in 51.2% during a median follow-up of 24 months, with a growth rate of 3.2 mm per year. On the other hand, Roehm and Gantz(23) reported a median tumor growth per year of 1,4 mm in 114 VS.
In a series of 232 VS, Nuseir et al.(16) suggested microsurgery in elderly patients with small-sized tumors (Koos I-II) associated with severe persistent vertigo or in case of rapid growth observed during WW. Microsurgery was also indicated in patients with large-sized tumor (Koos III-IV) compressing the brainstem(16).
Roehm and Gantz(23), in their series of 270 patients aged over 65 affected by VS, decided for MS based on: tumor size (diameter > 2.5), tumor growth, symptoms (most commonly vertigo or imbalance), the pos-

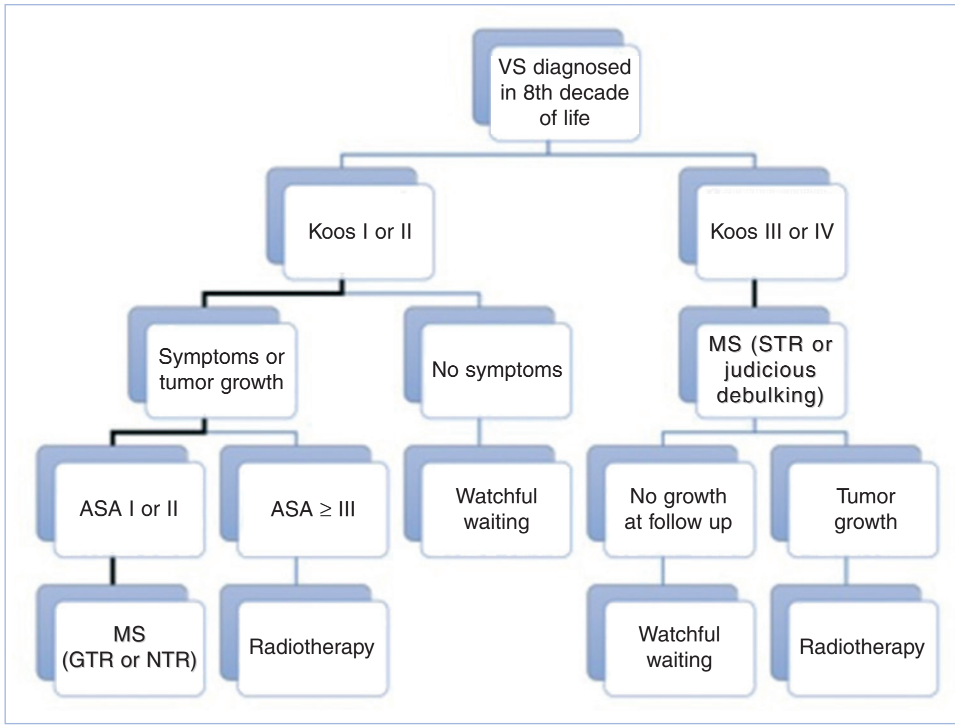

Figure 1. Treatment algorithm for vestibular schwannoma in the eighth decade of life. The paths leading to surgery are emphasized to clarify the main indications for microsurgical removal. *Legend*: ASA = American Society of Anesthesiologists; GTR = Gross Total Resection; MS = MicroSurgery; NTR = Near Total Resection; STR = SubTotal Resection; VS = Vestibular Schwannoma.

sibility of attempting hearing preservation, brainstem contact or compression, and patient request[23].
In our series of 30 elderly patients (mean age > 70 years), we used an algorithm inspired by the clinical reasoning of previously cited Authors, for decision-making (Figure 1).
Tumor features that prevented the surgeon from attempting GTR was Koos grade III or IV or cystic tumors, especially in patients with preoperative ASA grade III. Microsurgery aiming at GTR or NTR is recommended in symptomatic or growing Koos I or II VS in elderly patients with a preoperative satisfactory physical status. For cases of Koos III or IV VS, brainstem compression symptoms themselves generally compromise a patient's physical status so that the ASA score cannot be a fixed parameter for decision-making for a surgical procedure. Instead, microsurgery should aim at relieving symptoms and decompressing the brainstem while preserving neurological functions. While evaluating the surgical benefits and risks, in these cases we preferred STR with a goal of careful debulking. Conversely, other studies recommended SRS for patients with a poor general condition or after subtotal or partial tumor resection[16,31].
Some other Authors[28,32] proposed radiotherapy (gamma-knife, proton beam, and fractionated SRS) as a substitute for WW, for small and medium-sized VS, to counteract the unpredictability of tumor growth in such instances. Indeed, Shirato et al.[28] reported a growth rate of 0.75 mm per year in RT-treated patients versus a growth rate of 3.87 mm per year in the observational control group.
According to Samii and Matthies[25], the hearing preservation rate in the irradiated group was similar to that within the control group treated surgically. Considering these findings and the -though rare- possibility of eventual malignant transformation of VS, it has been argued that SRS should not be the treatment of choice in small and medium-sized growing and symptomatic tumors[18].
In elderly patients treated with elective STR, tumor remnant growth rate is higher than that observed among younger patients (38% versus 19%)[31]. Considering these findings, several Authors[16,31] recommend adjuvant RT after STR among elders. Our standpoint regarding SRS is to reserve such treatment in case of post-operative remnant progression after STR and after adequate postoperative neuroradiological follow-up. SRS may play a role as a primary treatment option in cases of Koos I-II VS affecting severely compromised patients (ASA III-IV).
The outcome of elderly patients affected from VS treated with MS has been described by several Authors.

Samii et al.[27], in 1992, first reported factors predictive of postoperative outcome in a series of 61 older adults operated on by a retrosigmoid approach. Their results showed that three factors seemed to influence the outcome: preoperative ASA score; preoperative Karnofsky score, and tumor size.

Sylvester et al.[29] performed a retrospective analysis of the National Inpatient Sample for patients undergoing VS surgery that included 4,137 people. They compared the in–hospital complication rate between older and younger patients. Elders had a longer hospital stay (6.5 *versus* 5.4 days) but not greater hospital charges. The elderly cohort showed a significantly higher postoperative rate of transitory complications consisting of cerebellar signs or consequences of prolonged immobilization in bed - i.e., deep venous thrombosis, pneumonia. FN palsy, other cranial nerve deficits, and CSF leak did not have a greater incidence among the elders. The in-hospital mortality rate among the elderly population was greater than among younger patients, and even if quite low, was in line with other Authors[16,18,31]. In our series, a poor postoperative course was associated with poor preoperative physical status rather than the age or surgical procedure, per se. Furthermore, after stratification based on the extent of tumor resection, complication rates among cases of GTR were higher than in cases of NTR or STR. Therefore, STR or debulking was planned preoperatively in most cases of large tumors, especially in ASA III patients.

Some Authors reported worse FN outcomes in the elderly population as compared to younger patients[7,16, 18,31]. They predicted that unfavorable FN results were due to a decreased tissue regeneration ability caused by atherosclerotic disease in vasa nervorum vessels[16,18,31].

Another complication observed in the elderly population is postoperative imbalance. In our series, it was observed in one-third of patients after surgery. The vestibular system has a less functional reserve in older patients and consequently struggles with attempts to compensate for both tumor-induced and/or iatrogenic damages[10]. In addition, the elderls have comorbidities that impact their balance function; in particular, less visual acuity diminishes proprioception and cerebellar functions[31].

However, rehabilitation therapy reinforces the central compensatory mechanisms that account for a better vestibular outcome in case of peripheral vestibular damage. Although no randomized clinical trials are available in this field regarding the elderly population[13], vestibular rehabilitation seems to normalize balance function even in patients up to 99 years[4]. Intensive pre- and postoperative vestibular training featuring visual biofeedback is an instrument in accelerating recovery after VS microsurgery[9,30]. In such context, the administration of preoperative intratympanic gentamicin as a means of prehabilitation has demonstrated efficacy in terms of preoperative vestibular deafferentation, which lets the patient elaborate compensatory mechanisms even before surgery[30]. Elderly patients have a good chance of benefiting from VS surgery in terms of quality of life and dizziness/vertigo resolution. Therefore, surgical treatment should not be precluded based only on age per se.

CONCLUSIONS

Based on our limited experience and that of the international literature, age itself does not seem to represent a major contraindication against microsurgical removal of VS, especially in patients in good general condition. Long-term FN results are satisfactory in most patients in the eighth decade of life and complications are the same as observed among youngsters. Factors associated with higher complication rates are poor preoperative general condition (ASA III) and large tumors (Koos IV), especially when treated with surgical GTR.

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