

# Tumor Nerve of Origin and Hearing Preservation Outcomes for Patients with Small Vestibular Schwannomas Undergoing Middle Fossa Craniotomy

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## Abstract

**Objective:** To evaluate hearing preservation (HP) outcomes based on tumor nerve origin for patients with small sporadic vestibular schwannomas (VS) undergoing microsurgical resection using the middle cranial fossa (MCF) approach.

**Methods:** Retrospective single-institution study of individuals 18 years or older with small sporadic VS ( $\leq 15$  mm) undergoing microsurgical resection. The primary outcome measure was HP, defined as word recognition score  $\geq 50\%$ .

**Results:** Of the 189 consecutive patients who underwent surgery, 164 (89%) of patients had intraoperative identification of tumor nerve of origin. Of those 164 patients, 88 (54%) patients had tumors originating from the inferior vestibular nerve (IVN), and 76 (46%) patients had tumors originating from the superior vestibular nerve (SVN). Hearing was preserved in 83% of patients with SVN tumors compared to 49% of patients with IVN tumors. When stratified by size, the rate of hearing preservation was highest (91%) for tumors of SVN origin  $\leq 5$  mm in size. On multivariate analysis, patients with SVN tumors  $\leq 5$  mm in size had an 8-fold increase (95% CI 1.81 – 36.3) in hearing preservation compared to patients with SVN tumors larger than 10 mm in size. Tumors of SVN origin were also associated with statistically significant reduction in operating time compared to tumors of IVN origin (mean difference 15.1 minutes, 95% CI 1.91 to 28.26). There was no significant difference in facial nerve outcomes between the two groups. At the time of last follow-up, 70 (92%) patients with SVN tumors and 83 (94%) patients with IVN tumors had a HB 1/2, respectively.

**Conclusion:** Patients with small SVN tumors have a significantly higher likelihood of hearing preservation as well as shorter operative time compared to IVN tumors, suggesting that in appropriate candidates, early surgical intervention may be beneficial.

## Introduction

In the era of magnetic resonance imaging (MRI), there has been an increase in the detection of small sporadic vestibular schwannomas (VS). For patients with small VS and serviceable hearing, management options include observation, stereotactic radiosurgery, or microsurgical resection with a middle cranial fossa (MCF) or retrosigmoid (RS) approach.

While the RS approach provides the surgeon with a wide corridor to the cerebellopontine angle, the MCF approach provides full visualization of the internal auditory canal. Hearing preservation rates for MCF microsurgical resection of VS are reported to range from 50-70%. Factors associated with hearing outcomes include tumor size, preoperative hearing, and tumor origin with superior vestibular nerve (SVN) associated with improved hearing outcomes compared to inferior vestibular nerve involvement (IVN). The primary objective of this study was to evaluate nerve of origin in patients with small VS ( $<1.5$  cm) undergoing microsurgical resection using an exclusive MCF approach and associated prognostic factors for hearing preservation at a high volume tertiary academic institution

## Methods and Materials

A single institution retrospective study was performed from November 2017 to December 2023 and approved by the University of California, San Diego Institutional Review Board. Inclusion criteria were individuals 18 years or older with a diagnosis of a small sporadic vestibular schwannoma, defined as  $\leq 15$  mm, who elected to undergo hearing preservation surgery via a MCF approach. Patients with poor baseline hearing were also offered hearing preservation surgery if they strongly desired it and with the understanding of the likelihood of hearing preservation. Patients were excluded if they had a history of prior surgery, radiation, and/or diagnosis of a meningioma or neurofibromatosis type 2 (NF-2). Tumor nerve of origin identified at the time of surgery. Patient demographics, clinical information, and surgical data were collected from review of the medical charts. The primary outcome measure was hearing preservation, which was defined as a word recognition score (WRS)  $\geq 50\%$ .

	Superior Vestibular Nerve n=76	Inferior Vestibular Nerve n=88	p-value
Age (years), mean (SD)	48.5 (9.9)	46.9 (10.4)	0.32
Gender, n (%)			
Male	28 (37)	36 (41)	0.59
Female	48 (63)	52 (59)	
Race, n (%)			0.75
White	62 (82)	66 (75)	
Asian	10 (13)	17 (19)	
Other	4 (5)	5 (6)	
BMI, mean (SD)	27.09 (5.22)	27.19 (4.46)	0.90
Presenting Symptoms			
Tinnitus, n (%)	58 (76)	59 (67)	0.25
Hearing loss, n (%)	52 (68)	64 (73)	0.55
Imbalance, n (%)	37 (49)	40 (46)	0.68
Vertigo, n (%)	33 (43)	42 (48)	0.58
Headache, n (%)	8 (11)	10 (11)	0.86
Preoperative PTA, mean (SD)	22.8 (15.1)	23 (15.6)	0.95
Preoperative WRS, mean (SD)	89.9 (16.4)	90.9 (14.5)	0.64
Preoperative AAO-HNSF			
Hearing Class, n (%)			0.80
A	50 (66)	57 (65)	
B	24 (32)	26 (30)	
C	1 (1)	2 (2)	
D	1 (1)	3 (3)	
Tumor laterality			0.15
Right, n (%)	32 (42)	41 (47)	
Left, n (%)	44 (58)	47 (53)	
Tumor size (mm), mean (SD)	8.7 (3.8)	9.8 (3.5)	0.06
0-5 mm, n (%)	22 (29)	12 (14)	
5.1-10 mm, n (%)	28 (37)	37 (42)	
10.1-15 mm, n (%)	26 (34)	39 (44)	
Presence of fundal cap, n (%)	39 (51)	44 (50)	0.93
Koos Grade			0.47
I	45 (59)	53 (62)	
II	31 (41)	33 (38)	

Table 1. Baseline patient demographics, audiometric data, and tumor characteristics

## Results

Of the 189 patients who underwent middle fossa surgery for VS resection during the study time period, 168 (89%) patients had the nerve of origin identified intraoperatively. Seventy-six (46%) patients had tumors identified to be of superior vestibular nerve origin and 88 (52%) of inferior nerve origin. Baseline characteristics are presented in Table 1. Overall, the mean (SD) age of the entire cohort was 47.9 (10.2) years. At baseline, the majority of patients had AAO-HNS Class A or B hearing (SVN=98%, IVN=95%) and there was no significant difference in pre-operative PTA or WRS between the two groups ( $p>0.5$ ) (Fig. 1). Tumors of SVN origin tended to be smaller with a mean size (SD) of 8.7 (3.8) mm compared to 9.8 (3.5) mm for IVN tumors; however, this difference was not statistically significant ( $p=0.06$ ). The majority of tumors were Koos Grade I (SVN=59%, IVN=62%) and a fundal cap was present in 51% and 50% of SVN and IVN tumors, respectively. Post-operatively, hearing was preserved in 63 (83%) of SVN tumors compared to 43 (49%) of IVN tumors. For patients with SVN tumors in whom hearing was preserved, the mean (SD) PTA and WRS scores were 26.6 (13.4) and 93.7 (9.3), respectively. For patients with IVN tumors with hearing preservation, the mean (SD) PTA and WRS scores were 25.9 (13.8) and 91.3 (11.3), respectively. Post-surgery, 66 (82%) patients with SVN tumors had Class A or B hearing, compared to 41 (47%) patients with IVN tumors (Fig. 2).

When stratified by size, the rate of hearing preservation was highest (91%) for tumors of SVN origin  $\leq 5$  mm. On univariate analysis, nerve origin was the strongest predictor for hearing preservation. Patients with SVN tumors had a 5-fold increase in likelihood of hearing preservation (95% CI 2.45 – 10.51) compared to patients with IVN tumors. Smaller tumors were also associated with increased hearing preservation. Compared to tumors  $> 10$  mm, tumors between 0-5 mm in size and 5.1 – 10 mm in size had a 3.47 (95% CI 1.40-8.61) and 2.51 (1.29-4.86) likelihood of hearing preservation, respectively. When combined, patients with small tumors and tumors of SVN origin had an even greater likelihood of hearing preservation. Patients with SVN tumors between 0-5 mm in size had an 8-fold increase (95% CI 1.81 – 36.3) in hearing preservation compared to patients with SVN tumors greater than 10 mm in size. Other variables of significance included the presence of preoperative hearing loss and preoperative PTA and WRS.

On multivariate analysis, nerve origin and tumor size remained the strongest predictors for hearing preservation. Patients with tumors of SVN origin up to 5 mm in size had the highest odds for hearing preservation (OR 7.47, 95% CI 1.60 – 34.93), followed by patients with tumors of SVN between 5 to 10 mm in size (OR 4.26, 95% CI 1.42-12.83). Preoperative PTA was also prognostic for hearing preservation with worse baseline PTA scores associated with decreased likelihood of hearing preservation (OR 0.97, 95% CI 0.93-0.99).

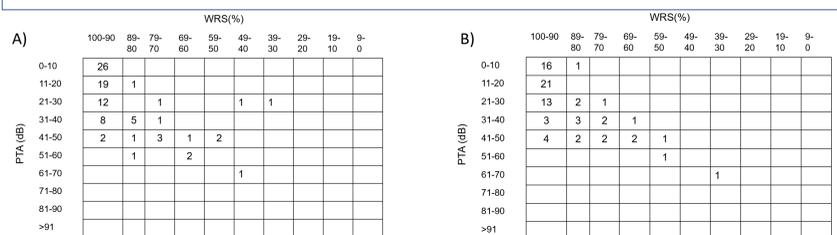


Figure 1. Baseline PTA and WRS for patients with IVN (A) and SVN (B) tumors.

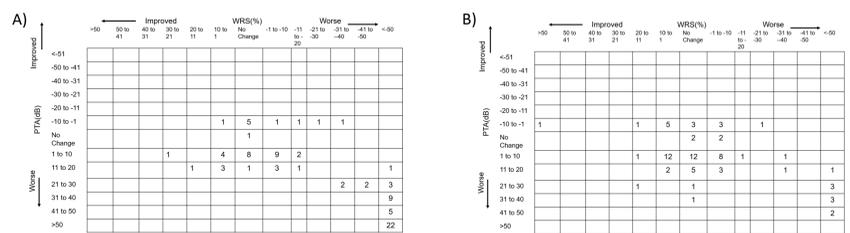


Figure 2. Post-operative change in PTA and WRS for patients with IVN (A) and SVN (B) tumors.

## Discussion

In this single-institution retrospective study of 189 consecutive patients with small VS undergoing middle fossa craniotomy for microsurgical resection, we report hearing preservation rates and post-operative outcomes based on tumor nerve of origin.

While our overall hearing preservation rate was 64%, consistent with the rates of 50-70% reported by other studies, there was a clear divergence in hearing preservation rates depending on nerve of origin. Overall, patients with SVN tumors had an 83% hearing preservation rate compared to 49% for patients with IVN tumors. When accounting for tumor size, patients with SVN tumors had significantly higher hearing preservation rates compared to patients with IVN tumors with SVN tumors less than 5 mm having the highest hearing preservation result (91%). Furthermore, nerve origin and tumor size had a combined positive prognostic effect on hearing preservation. On multivariate regression, patients with SVN tumors less than 5 mm in size had an 8-fold increase in the likelihood of hearing.

## Conclusions

While nerve of origin does not affect facial nerve outcomes, SVN tumors operated on via MFC approach are associated with a significantly higher hearing preservation rate.

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