

Facial Nerve Outcome after Vestibular Schwannoma Resection: A Comparative Meta-Analysis of Endoscopic versus Open Retrosigmoid Approach

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Abstract

The minimal access retrosigmoid endoscopic approach to vestibular schwannoma (VS) resection has been used with promising results. However, it has not been compared with the standard open approach in the literature. We performed a meta-analysis review for all articles describing both approaches for VS from 1996 to 2011. We found 1861 articles. After review and discussion, we narrowed our study to 25 articles, 4 endoscopic and 21 open. The total number of patients was 3026 for open and 790 for endoscopic. The mean tumor sizes in the open and endoscopic series were 2.5 cm and 2.7 cm, respectively. Good facial nerve outcome was achieved in 67% of the open series patients and in 94% of the endoscopic series patients. Other outcomes in the open and endoscopic series were the following: gross total resection, 91% versus 97%; functional hearing, 22.6% versus 46%; wound infection, 1.3% versus 2.6%; and recurrence, 5.4% versus 2.2%. We acknowledge the limitations of our study, but we can state that the endoscopic approach is not inferior to the standard open approach. In expert hands the endoscopic approach can offer as good a result as the open, with potential benefits such as less pain and a shorter length of stay in the hospital. There is a need for more controlled studies for a definitive comparison.

Keywords

- ▶ vestibular schwannoma
- ▶ endoscopic surgery
- ▶ retrosigmoid approach
- ▶ facial nerve

Introduction

Vestibular schwannoma (VS) is a benign nerve sheath tumor arising most commonly from the superior vestibular nerve, at the entrance to the internal acoustic meatus. According to the National Institutes of Health, 2000 to 3000 cases are diagnosed per year in the United States and represent 6 to 10% of all primary brain tumors, and 70 to 90% of all cerebellopontine angle (CPA) tumors. The first successful removal of VS was probably performed by Sir Charles Balance in 1894. During the last few decades, the remarkable improvement in tech-

nology has shifted the focus from survival to facial nerve preservation, preservation of serviceable hearing, and gross total resection (GTR) of the tumor. The three classic approaches to VS are retrosigmoid, translabyrinthine, and middle fossa. Of these approaches, the retrosigmoid is the most popular among the neurosurgical community. Endoscopy is relatively novel and a rapidly growing surgical advance that provides excellent visualization with minimal access. This has resulted in a transformation of open surgical approaches to minimally invasive approaches. The best example is transphenoidal approaches for lesions of the sella and skull base.

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Some surgical groups have adapted the minimally invasive technique for VS, specifically the minimal access endoscopic retrosigmoid approach, with promising results. However, there has been no study reported in the literature comparing the minimally invasive and the standard open retrosigmoid approach.

Our goal was to determine whether patient outcomes and complications differ between the two surgical approaches for the removal of VS: minimal access endoscopic or open retrosigmoid resection.

Methods

The primary outcome is the difference in the rate of facial nerve preservation between the two approaches with this null hypothesis: “there is no difference between the two surgical modalities with regard to facial nerve preservation.” Secondary outcomes include rates of hearing preservation, GTR, cerebrospinal fluid (CSF) leak, wound infection, recurrence, and death. All these outcomes were collected for meta-analysis. The mean tumor size in each of the two groups were also collected and put into the analysis to get a better comparison. We explored the possibility of addressing other outcomes such as hospital length of stay (LOS) but were unable to do so due to inconsistent reporting. We performed a thorough search on the and Ovid databases for all studies about VS, without any other limiting keywords, from 1996 to 2011. For endoscopic series, we also used the references for each article, due to the limited number of studies in the literature. The inclusion and exclusion criteria were established a priori and are as follows.

Inclusion Criteria

- Case series with ≥ 20 patients. This sample size was suggested by the senior author, to get the most expert and higher volume cases series.
- Utilization of endoscope or microscope for resection.
- Retrosigmoid incision and craniotomy.
- Adult patients.
- English-language publication.

Exclusion Criteria

- Studies describing other open approaches (i.e., translabyrinthine, middle fossa).
- Animal, cadaver, and basic science studies.
- Studies not addressing the primary outcome (i.e., facial nerve function).
- Comparative studies due to difficulty to extract accurate data.

We use the House-Brackmann (HB) classification for facial nerve outcome.¹ For ease of analysis, we combined grades 1 and 2 and labeled these as good, 3 and 4 as moderate, and 5 and 6 as poor. With regard to hearing outcome,² we include “serviceable” and “some” (i.e., pure tone audiometry [PTA] < 80 dB and speech discrimination > 20%); in one group, we

call it functional or meaningful hearing. Two independent observers (A.A. and M.A.) reviewed all articles, first by title and abstract and then the entire article if needed. We assumed between-study heterogeneity due to the limitations inherent in the nature of the study design (case series). Percentages with 95% confidence intervals (CIs) are reported. StatsDirect software (StatsDirect.com, Altrincham, United Kingdom) was used for the calculations.

Results

We found 1861 articles. Both observers (A.A. and M.A.) excluded 1730 articles, and both of them included 44 articles. Disagreements were resolved by discussion among the two reviewers with advice from the senior author (K.R.). Finally we included 25 articles: 4 endoscopic and 21 open (►Table 1). The total population of patients was 3026 for the open approach and 790 for the endoscopic approach. The mean maximum tumor diameters in the open and endoscopic series were 2.5 cm and 2.7, respectively. ►Table 2 summarizes the results of the meta-analysis with 95% CIs. A higher rate of good facial nerve outcome appeared to be observed in the endoscopic series (94% versus 67%) (►Figs. 1 and 2). Higher rates of GTR and meaningful hearing also seemed to be achieved in the endoscopic series (97% versus 91%, and 46% versus 22.6%, respectively) (►Figs. 3 and 4). With regard to negative outcomes, the endoscopic retrosigmoid approach seemed to have a lower rate of CSF leak (4.6% versus 8.2%) and recurrence (2.6% versus 5.4%) but a higher rate of wound infections (2.6% versus 1.3%). The difference in mortality rate was minimal.

Discussion

To the best of our knowledge, the first publication utilizing endoscope for VS surgery was by Valtonen et al in 1997.³ The authors used an endoscope to visualize the deep-seated air cells, after drilling the posterior wall of the internal acoustic meatus (IAM), in an effort to decrease the CSF leak rate after microscopic resection. Since the initial publication, a small but growing number of surgeons have reported their experiences using the endoscope as an adjunct to the surgical microscope and microsurgical techniques. Shahinian and colleagues were the first to describe a fully endoscopic approach to the VS⁴ in 2004.

To date, the biggest series on fully endoscopic minimal access retrosigmoid approach to VS was conducted by Shahinian et al⁵ in 2011. The patient population consisted of 527 cases with unilateral VS; patients with neurofibromatosis type 2 were excluded. Tumors ranged from 0.3 to 5.8 cm; most tumors were < 4 cm in diameter (mean: 2.8 cm). Tumors were removed via 2.0-cm retrosigmoid craniotomies. All cases utilize electromyographic facial nerve monitoring. The completeness of tumor removal was judged by surgical records (intraoperative digital pictures) and postoperative magnetic resonance imaging. GTR was achieved in 94% of the cases. Anatomical preservation of the facial nerve was achieved in 100% of the cases, as judged by the operating

Table 1 Final studies included in the analysis

	Study	No. of patients included in final analysis
Open approach	Samii et al ⁷⁻¹⁰	962
	Colletti and Fiorino ¹²	103
	Moffat et al ¹³	50
	Jung et al ¹⁴	30
	Mazzoni et al ¹⁵	150
	Tonn et al ¹⁶	508
	Strauss ¹⁷	22
	Lassaletta et al ¹⁸	65
	Maw et al ¹⁹	40
	Yamakami et al ²⁰	50
	Darwish et al ²¹	97
	Zhang et al ²²	105
	Samii et al ²³	200
	Sinha and Sharma ²⁴	58
	Veronezi et al ²⁵	20
	Yang et al ¹¹	110
	Chen et al ²⁶	103
	Chen et al ²⁷	145
	Zhao et al ²⁸	89
Di Maio et al ²⁹	47	
Gerganov et al ³⁰	53	
Endoscopic approach	Göksu et al ³¹	32
	Magnan et al ³²	119
	Kabil and Shahinian ³³	112
	Shahinian and Ra ⁵	527

surgeon. One year after tumor removal, facial nerve function was reassessed. Of 527 patients with anatomically preserved facial nerves, 93% showed good facial nerve function (HB grade 1 or 2); 4% showed moderate function (HB grade 3 or 4);

and 3% showed poor function (HB grade 5 or 6). Preoperatively, there were 374 patients with functional hearing, defined as a PTA < 80 dB and speech discrimination > 20%. Postoperatively, 213 of those 374 (57%) maintained or gained better hearing function. The length of stay (LOS) ranged from 1 to 6 days (mean: 2.4 days).

Another endoscopic series worth mentioning that was not available at the time of analysis was conducted by Pieper and colleagues.⁶ Over 5 years, their center performed 147 endoscopic posterolateral approaches: 110 procedures for cranial nerve microvascular decompressions and neurectomies and 37 for tumor resections, 23 specifically for VS tumors. For tumor cases, they used dissectors that provide constant stimulation to monitor the facial nerve while removing the tumors. There was a clinically significant decline in hearing in three patients (8%); all of them occurred in VS tumors (13%). There were no occurrences of facial nerve weakness in any of the VS patients. There was one case of a delayed CSF leak that was repaired surgically. Two wound infections required removal of the hydroxyapatite cement. Most patients are in the hospital for 24 to 72 hours. Those patients who did not experience any vertigo postoperatively were able to return to work within 2 weeks of surgery.

We have summarized the open series data (► **Table 2**), but we will describe two of the studies in some detail, one prior to the 2000 and the other one after 2000. Over almost 2 decades, 1000 Vs were removed from 962 patients using the open retrosigmoid approach by Samii et al.⁷⁻¹⁰ Of the 1000 VS cases, in 979 (97.9%) GTR was achieved. The facial nerve was anatomically preserved in 929 cases (93%). Facial nerve function, graded according to the HB scale within 2 weeks after surgery, was grade 1 in 47%, grade 2 in 12%, grade 3 in 14%, grade 4 in 6%, grade 5 in 10%, and grade 6 in 11% of the patients. The 11% with grade 6 included 7% of the cases of facial nerve discontinuity and 4% of paralysis despite nerve continuity. Most of the patients with paralysis despite nerve continuity showed recovery within the first postoperative year. Of the 1.7% who did not improve at 10 to 12 months, 11 patients were treated by reanimation procedures, and a few underwent plastic surgery because they refused nerve reconstruction. So in summary, of patients with anatomical

Table 2 Summary of meta-analysis comparing open series with minimal access endoscopic series with 95% confidence interval

	Open retrosigmoid, % (95% CI)	Minimal access endoscopic retrosigmoid, % (95% CI)
Good facial nerve outcome (HB 1 or 2)	67.0% (61–73%)	94% (92–95%)
GTR	91% (80–98%)	97% (92–99%)
Meaningful hearing (PTA < 80 dB and speech discrimination > 20%)	22.6% (10.4–37.6%)	46% (38–54%)
CSF leak	8.2% (4.8–12.3%)	4.6% (2.3–7.2%)
Wound infection	1.3% (0.6–2.3%)	2.6% (1.5–4.0%)
Recurrence	5.4% (1.8–10.1%)	2.2% (1.3–3.4%)
Death	0.9% (0.3–2%)	0%

Abbreviations: CSF, cerebrospinal fluid; GTR, gross total resection; HB, House-Brackmann (scale); PTA, pure tone audiometry.

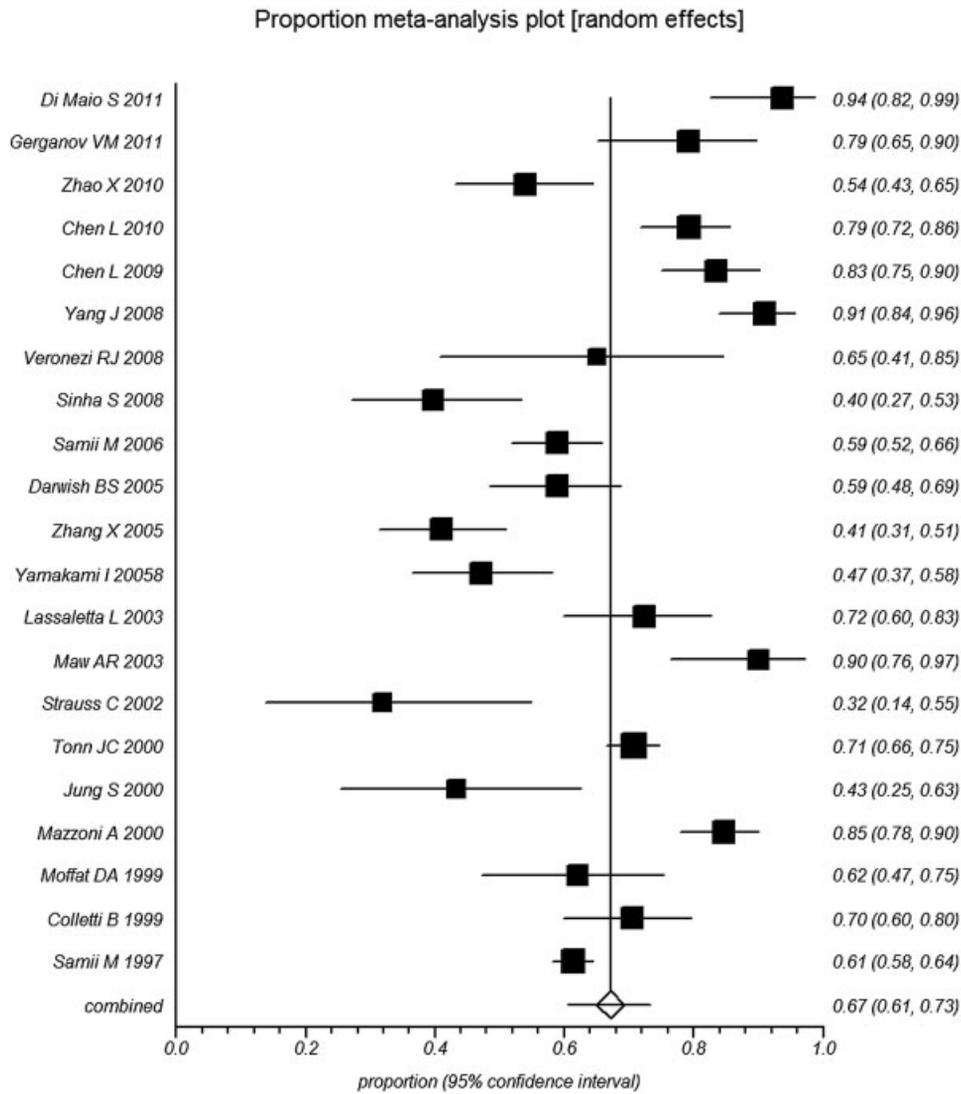


Fig. 1 Forest plot for good facial nerve outcome (House-Brackmann scale 1 or 2) in the open series.

preservation, 64% had good facial nerve function (HB 1 or 2) well documented in the 2- to 8-week postoperative period. In the final 200 cases, there was more preservation of the facial nerve (likely due to more frequent use of neurophysiologic

monitoring). Larger and cystic tumors appeared to have a lower rate of facial preservation. With regard to hearing, of a total of 732 cases with some preoperative hearing, anatomical cochlear nerve preservation was achieved in 580 cases (79%)

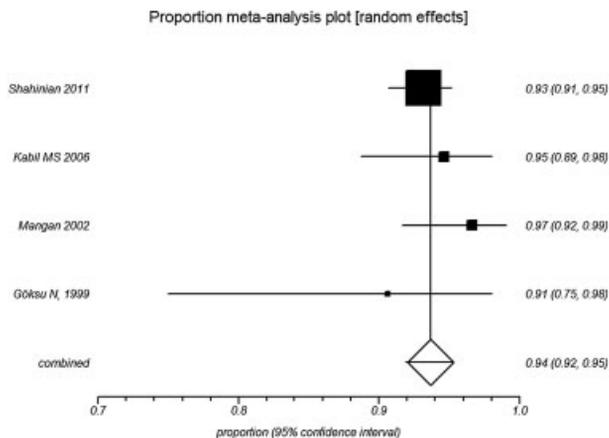


Fig. 2 Forest plot of good facial nerve outcome (House-Brackmann scale 1 or 2) in the endoscopic series.

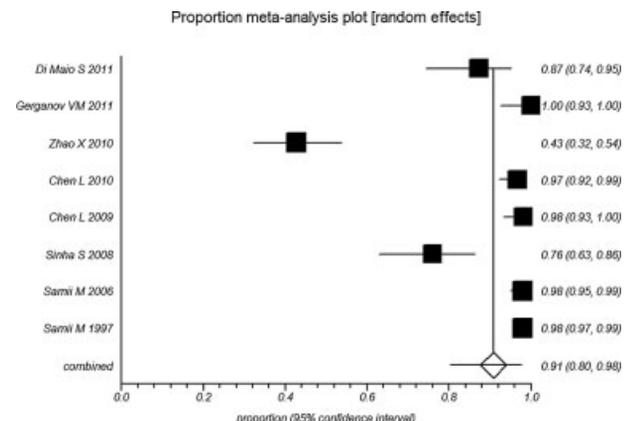


Fig. 3 Forest plot for gross total resection rate in the open series.

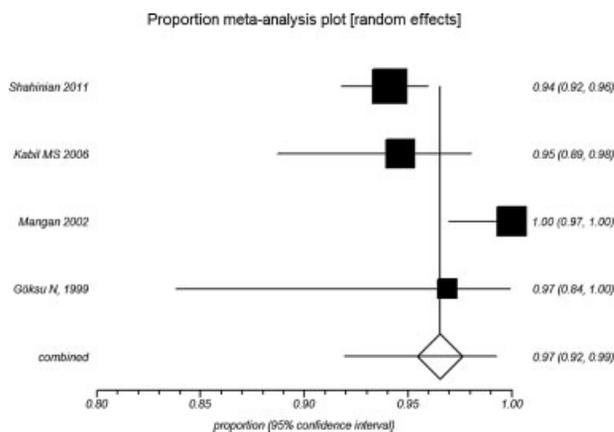


Fig. 4 Forest plot for gross total resection rate in the endoscopic series.

and functional cochlear nerve preservation in 289 (39.5%); analysis over time revealed an actual preservation rate of 47% in the most recent 200 cases. The LOS in the hospital ranged from 8 to 14 days.

In 2008, Yang et al¹¹ presented their experience with 110 open retrosigmoid approaches for VS. The mean tumor size (including the intracanalicular portion of the tumor) was 15 mm (range: 8–25 mm). The preservation of a good facial function (HB grade 1 or 2) was achieved in 91% of patients at 1- to 2-year follow-up after surgery. Among patients with a preoperative class A or B in the American Academy of Otolaryngology-Head and Neck Surgery, AAO-HNS (99 patients), a postoperative useful hearing (classes A, B, and C) was achieved in 44%. Hearing preservation appeared to be influenced by tumor size and preoperative hearing status.

In our study with specific inclusion and exclusion criteria and outcomes that were set forth a priori, we examined the literature systematically and attempted to extract raw data to achieve the best possible comparison between the two surgical techniques. Because there were no studies directly comparing the open retrosigmoid with the endoscopic retrosigmoid approach, the classic meta-analysis was not possible, thus resulting in a systematic review based on available raw data from each group.

There seemed to be better facial nerve preservation in the endoscopic series. Given the significant limitations of this study, we can only speculate about the causes. Two possible causes may be considered. First, the vast majority of endoscopic series are relatively new, so the improved facial nerve outcome may be attributable to early detection, improvement of surgical technique in general, and better availability of intraoperative neurophysiologic monitoring. Two other authors^{5,6} stated that by using an endoscope (including a rigid angled endoscope), better visualization of CPA structures can be achieved with early visualization of the facial nerve course in its entirety. These speculations may also be applied to explain the better hearing preservation and GTR found in our analysis. The lower CSF leak rate is probably due to better visualization that helps to

locate and block the deep-seated air cells after drilling the IAM.³ However, there was a higher infection rate in the endoscopic series, which could be due to variability in reporting the infection rates in the literature. Although it was not included in our analysis, there seemed to be a tendency to a shorter LOS in the endoscopic series. These data were not consistently extractable from the studies to perform any valid comparisons. That could be due to a smaller craniotomy and minimal cerebellar retraction in the endoscopic cases.⁵

We acknowledge the following limitation in our study:

- The significant heterogeneity in between retrospective studies
- Poor availability of comparable data
- Different definitions and scales, particularly for audition
- Crossover of patient population between some studies
- The bulk of the endoscopic cases came from one surgeon's series⁵
- Significant difference in the size of the groups and the fact that the two groups were really performed at different time periods so the open series are disadvantaged in this analysis

Conclusion

We have performed a systematic analysis of available data and must acknowledge its serious limitations. The results seem to suggest that the minimal access endoscopic retrosigmoid approach is not inferior to the standard open approach. It appears that in the hands of an expert, the endoscopic approach to VS may offer results as good as the open approach with potential benefits including better pain control, shorter LOS, and other possible outcomes. There is a significant need for better experience with the endoscopic approach from different parts of the world that may enable better comparative studies.

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