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Facial and Cochlear Nerve Complications following Microsurgical Resection of Vestibular Schwannomas in a Series of 221 Cases

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
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Background: Despite improvements in microsurgical technique and the use of intraoperative electrophysiological monitoring, the potential for facial and cochlear nerve injury remains a possibility in the resection of vestibular schwannomas (VS). We reviewed a series of 221 cases of VS resected via a retrosigmoid approach at our institution from October 2008 to April 2014 and determined the incidence of postoperative facial and cochlear deficits.

Material/Methods: A total of 221 patients – 105 (47.5%) male and 116 (52.5%) female – with a mean age of 46.1 years (range 29–73 years), with VS ≥3 cm (n=183, 82.8%) and <3 cm (n=38, 17.2%) underwent surgical resection via a retrosigmoid approach and were evaluated for postoperative facial and cochlear nerve deficits.

Results: Near-total resection (>95% removal) was achieved in 199 cases (90%) and subtotal resection (>90% removal) in 22 cases (10%). At 6 month follow-up, House-Brackmann grades I–III were observed in 183 cases (82.8%), grade IV in 16 cases (7.2%), and grade V in 22 cases (10%). Of the 10 patients that had preoperative functional hearing, 3 (33%) retained hearing postoperatively. Cerebrospinal fluid leakage occurred in 6 patients (2.7%), lower cranial nerve palsies in 9 patients (4.1%), and intracranial hematomas 3 cases (1.4%).

Conclusions: The observed incidence of persistent postoperative nerve deficits is very low. Meticulous microsurgical dissection of and around the facial and cochlear nerves with the aid of intraoperative electrophysiological nerve monitoring in the retrosigmoid approach allows for near-total resection of medium and large VS with the possibility of preservation of facial and cochlear nerve function.

MeSH Keywords: Cochlear Nerve • Facial Nerve • Neuroma, Acoustic • Vestibular Nuclei

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Background

Vestibular schwannomas (VS) are slowly growing benign tumors that arise from the Schwann cells of the vestibulocochlear nerve (cranial nerve [CN] VIII) [1–3]. Widely known as acoustic neuromas, VS typically exert mass effect onto the surrounding neurovasculature resulting in initial clinical presentations of tinnitus and hearing loss or deafness [1,3]. Treatment options for VS include active observation; radiosurgery, including CyberKnife, gamma knife, and stereotactic radiotherapy; and microsurgical resection [1–3]. However, the optimal treatment modality for VS remains controversial and microsurgical resection remains an important treatment option.

Selection of an optimal surgical approach for the resection of VS is based on the size and location of the lesion and the state of preoperative hearing [1,4]. The translabyrinthine, middle fossa, and retrosigmoid approaches are all commonly utilized in VS resection [1,4]. The retrosigmoid approach allows for resection of most sizes of VS, is less technically challenging than the translabyrinthine approach, and may be considered in patients with mostly intact hearing who have tumors of up to 1 cm that do not breach the fundus of the internal auditory canal (IAC).

Despite improvements in microsurgical technique and the use of intraoperative electrophysiological monitoring, the potential for facial (CN VIII) and cochlear nerve injury remains [1,5]. To better understand the incidence of postoperative facial and cochlear deficits following microsurgical VS resection using the retrosigmoid approach, we reviewed a series of 221 cases treated at our institution from October 2008 to April 2014.

Material and Methods

Patient selection

A retrospective review of 221 consecutive patients surgically treated at our institution for VS from October 2008 to April 2014 was conducted. Cases included in the cohort consisted of VS where the majority of the mass was located within the cistern with minimal extension into the internal acoustic meatus, and where the primary goal of the procedure was facial and cochlear nerve preservation. Medical records were reviewed for patient demographics, medical history, initial clinical presentation, tumor size and location, intraoperative findings, and postoperative deficits. Patients with neurofibromatosis or recurrent VS were not included. All patients underwent postoperative assessment for facial nerve function and were graded using the House-Brackmann scale [6]. This study was approved by our institutional review board and all ethical standards were closely adhered to.

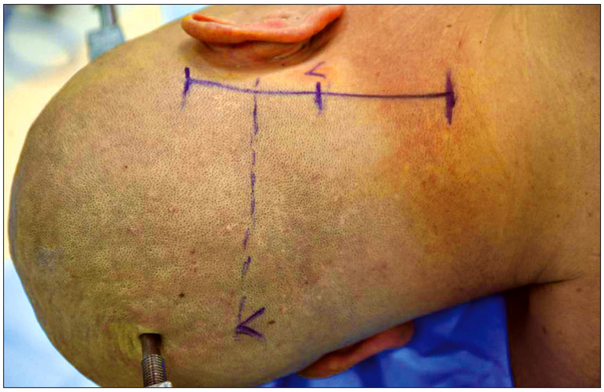

Figure 1. A 10-cm curvilinear incision was placed beginning 3 cm superior to the asterion and terminated 2 cm inferior to the level of the digastric groove to expose the squama of the occipital bone.

Retrosigmoid approach procedures

All patients underwent VS resection via a suboccipital retrosigmoid approach [1,4,7–13]. Each patient was positioned laterally with the mastoid at the highest point [7]. A 10-cm curvilinear incision was placed beginning 3 cm superior to the asterion and terminated 2-cm inferior to the level of the digastric groove (Figure 1) [7]. The squama of the occipital bone was exposed and a 4×5 cm craniotomy was fashioned to expose the transverse sinus superiorly, the sigmoid sinus anterolaterally, and the inferior nuchal line caudally [7,8]. The posterior wall of the internal acoustic meatus was removed and the dura was slowly incised to allow for the release of cerebrospinal fluid and the subsequent reduction in intracranial pressure. To mitigate the risk of cerebellar herniation in cases of large VS, a 2-cm dural incision was placed near the foramen magnum and general pressure was applied to the posterior portion of the cerebellum to reveal the arachnoid of the cisterna magna. The arachnoid was then incised to slowly release cerebrospinal fluid and the dura was subsequently incised. The lateral side of the cerebellum was gently retracted posteriorly and inferiorly to expose the cerebellopontine angle and reveal the tumor. An electrophysiological probe was placed on the dorsal aspect of the tumor to exclude the presence of CN VII and a Cavitron ultrasonic surgical aspirator was then used to debulk the tumor. During dissection of the tumor, the brainstem was gently retracted away from the tumor under direct vision and while monitoring the vital signs. If any change in the vital signs was observed, dissection was ceased and residual tumor was left *in situ*.

The inferior margin of the tumor in most cases did not adhere to the lower cranial nerves and was therefore easily dissected. Significant adhesion between the tumor and the brainstem did, however, occur in several cases. The facial nerve was found emanating from the brainstem at the ventral part

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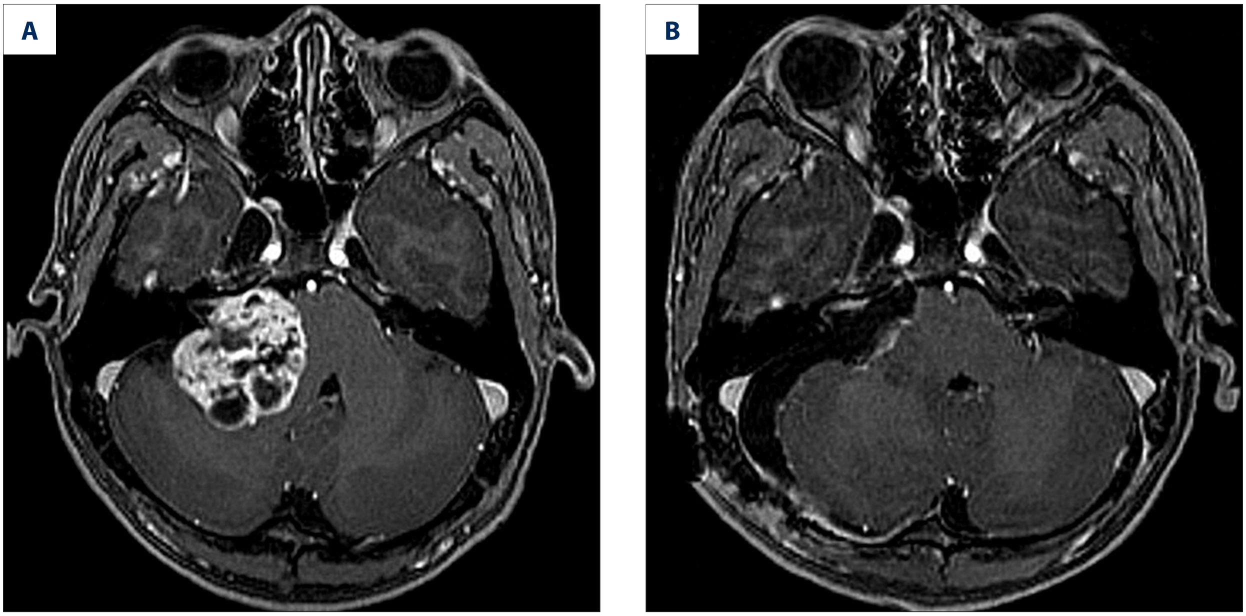

Figure 2. Preoperative (**A**) and postoperative (**B**) MRI of a large vestibular schwannoma nearly totally resected using a retrosigmoid approach.

of the pontomedullary junction, from which the superior aspect of the tumor was traced and dissected. The cochlear nerve was identified inferolateral to the facial nerve [4]. The tumor was debulked in a medial to lateral direction to avoid injury to the cochlear nerve at its exit from the IAC [4]. The labyrinthine artery was carefully preserved and the cerebellopontine segment of the facial nerve was in most cases identified on the ventral aspect of the tumor [4,8]. Tumor inside and adjacent to the internal auditory meatus was finally dissected and removed. In some cases where tumor was closely adhered to CN VII, a small amount of tumor was left in place to avoid injury to the nerve.

Electrophysiological monitoring

Intraoperative facial and trigeminal nerve monitoring was performed in all cases using electromyography (Axon Epoch XP, Axon Systems; New York, USA) with probes inserted into the orbicularis oculi, orbicularis oris, and masseter. In patients with preoperative serviceable hearing, auditory brainstem response was also monitored intraoperatively.

Postoperative hearing assessment

Pure tone audiometry and speech recognition were performed on all patients postoperatively. Patients with a pure tone audiometry <50 dB and a speech recognition rate ≥50% were considered to have functional hearing and thus postoperative hearing preservation [14]. Patients were followed up by clinic visits up to 6 months.

Results

Patient characteristics

A consecutive cohort of 221 VS patients, including 105 (47.5%) males and 116 (52.5%) females with a mean age of 46.1 years (range 29–73 years), underwent surgical resection via a retrosigmoid approach and were evaluated for postoperative facial and cochlear nerve deficits. This cohort of patients had a mean disease course of 40.2 months (range, 3 months to 10 years) and all had unilateral lesions. Primary clinical presentation included unilateral hearing loss (n=199, 90%) and tinnitus (n=95, 43%). Other symptoms at presentation included headache, facial numbness, ataxia, and nausea/vomiting.

Preoperative magnetic resonance imaging (MRI) and computed tomography (CT) of the internal auditory meatus were performed in all patients. The lesions appeared hypo- to isointense on T1 and hyper- to isointense on T2 weight imaging. Hydrocephalus was documented in 135 cases (61%) and cystic lesions were noted in 81 cases (36.6%). Tumor size was ≥3 cm in 183 cases (82.8%) and <3 cm in 38 cases (17.2%). A dilated internal auditory meatus was noted on CT in 195 cases (88.2%).

Surgical resection

For the purposes of this study, near-total resection was defined as removal of greater than 95% of the tumor and subtotal resection as removal of greater than 90% of the tumor [15]. Near-total resection was achieved in 199 cases (90%) and subtotal resection in 22 cases (10%) (Figure 2).

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Table 1. Postoperative complications.

Complication	n (%)
Facial nerve palsy	20 (17.2)
Transient lower CN palsy	9 (4.1)
Cerebrospinal fluid leak	6 (2.7)
Intracranial hematoma	3 (1.4)

Postoperative complications

At 6 month follow-up, facial nerve function was graded in each case using the House-Brackmann scale. House-Brackmann grades I–III were achieved in 183 cases (82.8%), grade IV in 16 cases (7.2%), and grade V in 22 cases (10%). Only 10 patients had preoperative functional hearing, of which 3 patients (33%) retained hearing postoperatively.

No perioperative deaths occurred. Postoperative complications included cerebrospinal fluid leak, lower cranial nerve palsy, and intracranial hematoma (Table 1). Cerebrospinal fluid leakage occurred in 6 patients (2.7%), 3 of which were successfully managed conservatively while the remaining 3 required surgical repair. Facial nerve palsy was observed in 20 cases (9%). Transient lower cranial nerve palsies were observed in 9 patients (4.1%), all of whom recovered without deficit at 6 month follow-up. Intracranial hematomas were documented in 3 cases (1.4%) and were all managed surgically.

Discussion

The treatment strategies for VS include active observation, stereotactic radiosurgery, and microsurgical resection [1–4]. Novel neuroimaging techniques have significantly increased the detection rate of VS and our understanding of the tumor's biology and behavior [16,17]. Previous studies have reported that the growth rate of VS is closely associated with tumor size [16,17]. After long-term follow-up, only 17% of the tumors involving the internal auditory meatus showed growth, whereas 29% of tumors mainly located in the cistern showed growth [17]. Growth rates of VS have been reported at 1–2 mm/year [17]. Therefore, active observation has been advocated for small VS with regular evaluation of auditory function. More aggressive treatment options are often employed once hearing loss or tumor growth is observed.

Stereotactic radiosurgery has been shown to have a mean tumor control rate of 94% and a hearing preservation rate of 57% [18]. A second study by the same group reported a facial nerve functional preservation rate of 96.2% in patients treated with stereotactic radiosurgery [19]. Despite these promising results, stereotactic radiosurgery is only indicated for patients with medium-sized (<2 cm in diameter) VS, recurrent tumors, or postoperative residual tumor. Additionally, in our experience VS tend to exhibit significant adhesion to the facial nerve during surgery in patients initially treated with radiosurgery.

Our goal in the treatment of large VS (>3 cm in diameter) is to maximize tumor resection while minimizing postoperative facial and cochlear nerve deficits. Tumor size is generally negatively correlated with the preservation rate of nerve function [1,11,19–21]. However, no significant differences in 5 and 10 year recurrence rates were found between total, near-total, and subtotal surgical resections [22]. Therefore, more surgeons have approached VS cases with the primary goal of preserving facial and cochlear nerve function, rather than achieving gross-total tumor resection. This strategy may help to improve the postoperative quality of life. In cases of recurrent tumor, stereotactic radiosurgery may be considered as an option as well as repeat surgery.

In recent years, improvements in microsurgical technique and the use of intraoperative electrophysiological monitoring have allowed for increased preservation of anatomical integrity and facial and cochlear nerve function. Previously reported facial nerve preservation rates ranged from 73% to 93% [20–22]. In this study, we achieved comparable results and had a facial nerve functional preservation rate of 82.8%. Cochlear nerve preservation rates have been reported from 18% to 82% [15,20,23], and in this study an 33% hearing preservation rate was achieved. Tumor size has been suggested to be closely associated with postoperative hearing preservation and in patients with a tumor diameter of <1 cm, a hearing preservation rate of 70% has been reported, while in patients with a tumor size of >1 cm only a 20–40% hearing preservation rate was observed [24]. In this series only 10 patients had functional preoperative hearing and of those only 3 patients (33%) retained function postoperative hearing.

Cerebellar retraction remains a disadvantage of the retrosigmoid approach, though proposed endoscopic-assisted combined approaches may help to reduce retraction and mitigate the associated risks [7].

Conclusions

In this series of patients, the incidence of persistent postoperative nerve deficits was very low. Meticulous microsurgical dissection of and around the facial and cochlear nerves with the aid of intraoperative electrophysiological nerve monitoring in the retrosigmoid approach allows for nearly total resection of medium and large VS with the possibility of preservation of facial and cochlear nerve function.

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