ORIGINAL ARTICLE

Clinical predictors of facial nerve outcome after translabyrinthine resection of acoustic neuromas

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Abstract

Purpose: The translabyrinthine approach to acoustic neuroma resection offers excellent exposure for facial nerve dissection with 95% preservation of anatomic continuity. Acceptable outcome in facial asymptomatic patients is reported at 64-90%, but transient postoperative deterioration often occurs. The objective of this study was to identify preoperative clinical presentation and intraoperative surgical findings that predispose patients to facial nerve dysfunction after acoustic neuroma surgery.

Methods: The charts of 128 consecutive translabyrinthine patients were examined retrospectively to identify new clinical and intraoperative predictors of facial nerve outcome. Postoperative evaluation of patients to normal function or mild asymmetry upon close inspection (House-Brackmann grades of I or II) was defined as an acceptable outcome, with obvious asymmetry to no movement (grades III to VI) defined as unacceptable. Intraoperative nerve stimulation was performed in all cases, and clinical grading was performed by a single neurosurgeon in all cases.

Results: Among patients with no preoperative facial nerve deficit, 87% had an acceptable result. Small size ($P < 0.01$) and low intraoperative nerve stimulation of

< 0.10 mA ($P < 0.01$) were reaffirmed as predictive of functional nerve preservation. Additionally, preoperative tinnitus ($P = 0.03$), short duration of hearing loss ($P < 0.01$), and lack of subjective tumour adherence to the facial nerve ($P = 0.02$) were independently correlated with positive outcome.

Conclusions: Our experience with the translabyrinthine approach reveals the previously unestablished associations of facial nerve outcome to include presence of tinnitus and duration of hypoacusis. Independent predictors of tumour size and nerve stimulation thresholds were reaffirmed, and the subjective description of tumour adherence to the facial nerve making dissection more difficult appears to be important.

Surgery for the treatment of acoustic neuroma has undergone a paradigm shift from the early twentieth century when it was regarded as a life-saving intervention for what was often a large lesion. Cushing¹ and Dandy² initially described subtotal and gross-total removal of such acoustic neuromas respectively, but the advent of precise neuroimaging and the operating microscope

facilitated a meticulous operation on much smaller lesions.³ Mortality was attenuated and the feared complication became the morbidity associated with injury to the contiguous facial nerve.⁴ Cairns⁵ described the first case in which this nerve was surgically spared and the patient recovered its function postoperatively.

By virtue of its proximity to the vestibulocochlear nerve, the facial nerve is prone to damage by a variety of mechanisms.⁶ Although patients may have grossly normal facial function, preoperative electromyography may demonstrate subclinical preoperative facial nerve dysfunction, particularly in those with large tumours. During surgery, immediate injury can occur by physical means during nerve manipulation, stretch, or transection; as well as through thermal or vascular insult.⁶ The vascular supply to the facial nerve is from three sources – the labyrinthine artery branch of the anterior inferior cerebellar artery, the greater superficial petrosal branch of the middle meningeal artery, and the stylomastoid artery branch of the posterior auricular artery. Delayed dysfunction can result from nerve entrapment at the meatal foramen, edema in the nerve perineurium, or vasospasm.

The translabyrinthine approach for acoustic neuroma resection causes loss of hearing, but provides excellent exposure of the facial nerve with little cerebellar retraction. The approach requires wide removal of mastoid bone, circumferential exposure around the internal auditory canal, and exposure of both crests that quadrantize the canal.⁷ For appropriately selected patients, this approach facilitates early visualization of the facial nerve to avoid direct trauma. In addition, the labyrinthine segment of the facial nerve can be decompressed from the meatal foramen to the geniculate ganglion, thus decreasing the likelihood of evolving into delayed dysfunction from nerve swelling. Fagan *et al* demonstrated that this access to the cerebellopontine angle affords shorter operative depth to the tumour through the same-sized craniotomy than does the retrosigmoid approach and yields benefits of wider surgical access and less cerebellar retraction.⁸

Such protection does not remove the potential for injury to the facial nerve during mastoid drilling, or by direct trauma against the posterior petrous bone during surgical manipulation. Furthermore, a high incidence of cerebrospinal fluid (CSF) leak following translabyrinthine approach for acoustic neuroma resection has been reported,⁹⁻¹² predisposing patients to complications of meningitis and intracranial hypotension.

The literature is consistent in its identification, by multivariate regression, of small tumour size, low facial nerve stimulation threshold, and absence or short duration of antecedent facial nerve dysfunction as prognostic of the ultimate outcome of preserved facial muscle innervation.¹³⁻¹⁷ Large tumours can obscure the position of the nerve, distort the normal anatomy of the cerebellopontine angle, and make the dissection of the lesion more difficult. This study sought to assess other possible prognostic features specific to individual patients, including intraoperative findings.

Methods

From 1990 to 2003, 128 patients underwent acoustic neuroma resection using the translabyrinthine approach in a single neurosurgeon's practice at The Ottawa Hospital. Inclusion criteria for the study required patients to have unilateral lesions without neurofibromatosis, absence of salvageable hearing with a sensorineural pattern of hearing loss, and single-stage operation for gross-total resection. Continuous electromyographic recording with audible responses was performed to identify facial nerve fibres directly, and to detect areas on the tumour surface where safe dissection can be performed avoiding flattened nerve bundles. The operative technique included enucleation of the extrameatal tumour mass using an ultrasonic surgical aspirator to reduce pressure on the adjacent structures. Then, the tumour capsule was retracted and dissection was performed through the arachnoid plane, with the goal of avoiding sub-

TABLE 1. House-Brackmann Scale for Facial Nerve Function¹⁸

Grade	Description	Characteristics
I	Normal	Normal function
II	Mild dysfunction	Weakness at close inspection Slight synkinesis
III	Moderate dysfunction	Obvious asymmetry Noticeable synkinesis
IV	Moderately severe dysfunction	Obvious weakness Disfiguring asymmetry
V	Severe dysfunction	Barely perceptible motion
VI	Total paralysis	No movement

arachnoid microvascular blood supply to the facial nerve.⁶

Intraoperative facial nerve stimulus amplitudes were measured at the brainstem after tumour excision. For each case, the senior surgeon dictated the operative note and recorded whether the lesion was tightly adherent to the facial nerve. Facial nerve function was evaluated preoperatively, in the recovery room, and at latest follow-up using the House-Brackmann scale,¹⁸ (Table 1).

An acceptable outcome for postoperative facial nerve function was considered to be House-Brackmann Grade I or II. Multivariate regression was used to evaluate independent preoperative and intraoperative predictors of acceptable functional outcome at the 0.05 level of significance.

Results

Demographic data for the 128 patients are detailed in Table 2. Tumour size ranged from 0.5 to 7.0 cm (average 2.3 cm), with 74 lesions (58%) on the right side. No patients had undergone previous biopsy, surgery, or radiation therapy, and all patients received deliberate gross-total resection. The median duration of hypacusis at the time of surgery was 46 months. Ipsilateral tinnitus was present in 35% of patients for a median of 25 months with dysequilibrium in 59% of patients for a median of 15 months.

The status of preoperative facial nerve function was Grade I in 92 patients (72%), Grade II in 26 patients (20%), and between Grade III and VI in 10

TABLE 2. Preoperative Clinical Status

Symptom	Incidence	Duration Median	Duration Range	Duration < 24 months
Hearing Loss	100%	46 months	12-300 months	42%
Tinnitus	35%	25 months	0-288 months	40%
Vertigo	59%	15 months	0-120 months	58%
Trigeminal Dysfunction	12%			

patients (8%). Surgical complications not directly involving facial nerve function included cerebrospinal fluid leak requiring surgical correction in 6 patients (5%), comparable to literature reports of between 6 and 16%.⁹⁻¹² There was no incidence of stroke, trigeminal or abducens nerve injury, or death. None of the patients suffered intraoperative anatomic discontinuity of the facial nerve.

The median follow-up of patients was 17 months, with an interquartile range of 9 to 39 months. One patient was lost to follow-up after the two week postoperative visit, and the longest follow-up was 125 months. Acceptable outcome of facial nerve function was achieved in 87% of patients; 65% having Grade I and 22% having Grade II levels on the House-Brackmann scale. Potential preoperative predictors of facial nerve outcome are outlined in Table 3. Independent prognostic variables included duration of hypacusis ($P < 0.01$), tinnitus ($P = 0.03$), and tumour size ($P < 0.01$). The duration of tinnitus ($P = 0.38$), presence of vertigo ($P = 0.24$), or prominent headache ($P = 0.55$) were insignificant variables.

Intraoperative features that were interpreted for their predictive value are outlined in Table 4. Features included low intraoperative stimulation thresholds of < 0.1 mA after tumour resection ($P < 0.01$) and the subjective evaluation of low tumour adherence ($P = 0.02$).

Discussion

Predictors of postoperative facial nerve dysfunction in undifferentiated approaches to acoustic neuroma sur-

TABLE 3. Preoperative predictors and incidence of acceptable facial nerve outcome

Feature	Symptom		<i>P</i>	χ^2
	Present	Absent		
Tumour Size	continuous variable		< 0.01*	17.7
Hearing Loss duration < 24 mo	88%	50%	< 0.01*	7.07
Tinnitus duration < 24 mo	90%	63%	0.03*	4.25
	91%	86%	0.38	0.77
Vertigo duration < 24 mo	86%	68%	0.24	1.38
	88%	82%	0.61	0.26
Headache	73%	90%	0.55	0.36

* $P \leq 0.05$

gery have been consistent throughout the literature. Tumour size of less than 2.5 cm, post-resection threshold amplitude of facial nerve stimulation less than 0.1 mA, and severity and duration of antecedent facial nerve palsy have all been cited as prognostic of postoperative nerve salvage.^{13, 14, 19-21} Furthermore, Samii and Matthies²² described a series of 1000 patients in whom anatomical severing of the facial nerve was observed in 6% of cases, although the case complexity with a considerable number of revision patients may have overestimated that rate. This study reaffirms that tumour size is related to poor outcome of the facial nerve ($P < 0.01$). Intraoperative stimulation was an important prognostic indicator with 89% of patients with low stimulation thresholds (< 0.1 mA) having acceptable outcomes compared with only 50% of patients having higher thresholds ($P < 0.01$). More recently, the translabyrinthine approach was found to permit anatomic continuity in over 97.5% of patients with acceptable facial functional outcome in 65-90%. The retrosigmoid approach, which does not offer the same early identification and dissection of the facial nerve, has a 2.86-fold increase in the incidence of post-operative nerve dysfunction.²³

Additional poorly described, independent, preoperative predictors include the presence of tinnitus and the duration of antecedent hearing loss. Also tumour adherence to the facial nerve, albeit subjective, was independently suggestive of poorer outcome. Faced with these results, it is important to explore the physiological sense of these findings in the patient

TABLE 4. Intraoperative predictors and incidence of acceptable facial nerve outcome

Feature	Sign		<i>P</i>	χ^2
	Present	Absent		
Facial nerve stimulation current < 0.10 mA	89%	50%	< 0.01*	11.5
Subjective adherence	46%	92%	0.02*	5.4

* $P \leq 0.05$

with intact facial nerve function. The confined anatomy of the bony internal auditory canal has a mean diameter of 5 mm and length of 8-10 mm. It lies within the petrous bone and contains the facial nerve, the superior and inferior branches of the vestibular nerve, and the cochlear nerve – each in separate quadrants. Bill's bar, a vertical crest at the lateral end of the canal, separates the superior vestibular nerve posteriorly from the facial nerve anteriorly. The falciform crest separates these structures from the inferior components. The cochlear nerve lies inferior to the facial nerve and anterior to the inferior vestibular nerve.

Consequently, one theory relating to the etiology of tinnitus in the acoustic neuroma patient is the onset of ephaptic transmission from neighbouring intact demyelinated neurons.²⁴ In the absence of intact hearing, tinnitus, a symptom of preserved functional impulse transmission, could be a surrogate indicator of relatively less tumour pressure on all surrounding cranial nerves. This may account for the higher incidence of acceptable outcome (90% vs. 63%) in those patients presenting with tinnitus in the setting of unsalvageable hearing at the time of initial consultation.

Hypacusis associated with acoustic neuroma is thought to be caused by pressure compromising vascular supply to the cochlear nerve, or directly on the nerve leading to degeneration with associated secondary hair-cell loss.²⁵ In the confined space of the internal auditory canal, the duration of pressure on the cochlear nerve may again serve as a surrogate of the time over which the facial nerve is exposed in this confined space. Thus, the shorter duration of hearing loss may represent a lesser stage of threshold pressure on the entire system. Among those with hearing loss

of shorter duration, 88% had acceptable outcome, compared with 50% of those with a more prolonged deficit.

The concept of “tumour adherence” has been described sparsely, primarily among patients after antecedent radiotherapy, and is an additional prognostic factor that may be clinically relevant for primary cases: 92% of non-adherent tumours yielded acceptable outcomes compared with only 46% of adherent tumours. Consistency of outcome grading criteria was established by the senior surgeon performing all recovery room and long term facial nerve evaluations. However, this involvement of the primary surgeon may be a source of bias in a retrospective study, particularly with a subjective finding of tumor adherence to surrounding structures. Nevertheless, the quality of surgical dissection may guide intraoperative decision-making when there is ongoing debate about the long-term outcomes of gross total versus subtotal acoustic neuroma resection. These findings echo anecdotal reports by Nutik¹⁶ and Harner and coworkers²⁶ who describe easier dissection of the tumour to associate with lower likelihood of injury. Features that lead to more difficult dissection include tumour size, vascularity, firmness, and invasion into neural structures; and Lee and coworkers²⁷ described better results with moderately firm and avascular tumours. Similarly, tumours resected after stereotactic radiosurgery were associated with dense adherence resulting in much lower likelihood of facial nerve salvage.^{28, 29} Limb and coworkers³⁰ describe a series of nine such patients in whom they observed extensive fibrosis at the nerve-tumour interface, most prominently at the porus acusticus. In these patients, decompression of the internal acoustic canal dura and resection of the canalicular portion of the tumour was necessary to permit facial nerve identification and this resulted in longer operative time. Friedman and coworkers³¹ compared acoustic neuroma surgical outcomes among 38 previously-irradiated patients with 38 not previously treated patients. Tumour adherence to surrounding tissue was more prevalent in the irradiated group, with

consequent poorer facial function outcomes in the face of similar tumour mean size of 2.6 cm in each group. These studies suggest that patients should be counseled that post-radiotherapy surgical salvage, while feasible, may represent a more technically challenging and risky procedure.

Current research in the preservation of facial nerve function after acoustic neuroma resection involves the use of hydroxyethyl starch to decrease the hematocrit and nimodipine to improve intraneural microcirculation, impede calcium-induced neuronal apoptosis, improve axonal growth and remyelination.³²⁻³⁶ Clinical application of these findings has been described by Scheller and coworkers³⁷ who demonstrated the benefit for hearing and facial muscle function when nimodipine and hydroxethylstarch were administered prophylactically for eight days beginning the day before surgery. Benefit was also observed if vasoactive treatment was initiated at the onset of facial weakness when compared with no such pharmacological intervention.³⁸

Conclusion

The translabyrinthine approach to the acoustic neuroma resection offers a non-hearing preservation method by which the facial nerve is exposed early in the procedure, thereby lessening the chance of inadvertent injury. Some surgeons may decompress the labyrinthine facial canal in an attempt to protect against secondary delayed deterioration due to swelling. This study reaffirmed the prognostic value of small tumour size, low intraoperative stimulation threshold, and short duration of antecedent facial nerve dysfunction as predictive of acceptable postoperative facial muscle function. Additional independent associations include the presence of tinnitus and the duration of hypoacusis. Physiological credibility is lent to these correlations by virtue of the confined space in the internal auditory canal allowing them to act as surrogate markers of pressure on the facial nerve. Additionally, the subjectively expressed con-

cept of 'tumour adherence' is introduced as an independent predictor of outcome beyond the traditional prognostic features already described in the literature.

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