Otology & Neurotology
40:226–235 © 2018, Otology & Neurotology, Inc.

Facial Nerve Outcomes Following Total Excision of Vestibular Schwannoma by the Enlarged Translabyrinthine Approach

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Objective: To study the early and late facial nerve (FN) outcomes in different tumor classes in addition to determining the predictive factors for the same.
Study Design: A retrospective clinical study.
Setting: A quaternary referral otology and skull base center.
Patients and Methods: A retrospective study of 1983 cases of vestibular schwannomas (VSs) with preoperative normal FN function, undergoing total excision with anatomical preservation of the nerve by enlarged translabyrinthine approach (ETLA) were included. FN status was recorded postoperatively at day 1, at discharge, and at 1-year follow-up and were analyzed in different tumor sizes.
Results: At 1 year, 988 patients with House–Brackmann (H–B) grade I and II FN at day 1 after surgery, 958 (96.9%) maintained their status up-to 1 year. Of the 216 patients with H–B grade III at day 1 after surgery, 113 (52.3%) improved to H–B grade I and II. Similarly, of the 779 patients with H–B grade IV and VI FN function at day 1 after surgery, improvement to H–B III and H–B I and II were noted in 442 (56.7%) and 80 (10.3%) of patients, respectively. Intrameatal and extrameatal tumors upto 2 cm showed better recovery from H–B grade III to H–B I and II and from H–B grade IV and VI to H–B I and III when compared with extrameatal tumors >2 cm ($p = 0.001$).
Conclusion: Tumors of smaller sizes have good immediate postoperative FN results and recover well at the end of 1 year while more than 3 cm have poor outcomes and recover poorly at the end of 1 year. When the VSs reaches more than 1 cm, the HB I and II outcomes drop significantly.
Key Words: Enlarged translabyrinthine approach—Facial nerve—Vestibular schwannomas.

Otol Neurotol **40:**226–235, 2019.

The facial nerve (FN) function is of paramount importance cosmetically and specially in surgeries for vestibular schwannoma (VS) the anatomical preservation of nerve alone does not guarantee good FN function postoperatively. In such a scenario, counseling the patient before the surgery regarding the possible postoperative outcome is not easy. Moreover, altering FN grades postoperatively till a certain point of time depends on numerous factors including the tumor size. This could often be the cause for concern both for the patient and surgeon. It is observed that the outcomes normally tend to improve over a period of one year (1–5).

The FN preservation in VSs surgery remains a significant operative challenge despite improvements in preoperative imaging, operative visualization, intraoperative FN monitoring (6,7), refinements in surgical techniques and growing surgeon experience (5,8). When the FN is anatomically preserved, the factors that affect functionality of nerve are extent and direction of nerve displacement by tumor (7), pressure during tumor manipulation, thermal damage due to drilling, and effects of bipolar coagulation for maintenance of hemostasis (9).

In this study, which is one of the largest in recent literature, we present our analysis of FN outcomes over a long-term follow-up with special emphasis on tumor size, and correlation between immediate and long-term outcomes. In addition, the knowledge of progression of FN outcomes over a long-term is important in deciding the timing of restitution procedures like VII to XII and VII to V anastomosis in case of poor FN outcomes.

MATERIALS AND METHODS

In the present retrospective observational study, records of all patients with VSs who underwent excision using the ETLA between January 1987 and May 2016 (2,455 cases) were collected and analyzed. Inclusion criteria were 1) normal preoperative FN function, 2) total excisions (operative notes and imaging at 3 mo), 3) intact FN after surgery, and 4) minimum follow up 1 year. Exclusion criteria were 1) neurofibromatosis (differ from sporadic VS), 2) revision cases, 3)

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Financial disclosure: no finances involved.
This manuscript has not been submitted elsewhere.
The authors disclose no conflicts of interest.
DOI: 10.1097/MAO.0000000000002068

patients who underwent pre- or postoperative radiotherapy, 4) patients lost to follow up, 5) incomplete data, 6) cystic tumors (adherent nature over nerves), and 7) cases operated by middle cranial fossa approach and retrosigmoid approach. A total of 1,983 cases satisfied the criteria. The rationale of ETLA was to obtain lateral access to internal auditory canal and the cerebellopontine-angle (CPA), thus allowing removal of CPA lesions without cerebellar retraction. The enlarged form of approach overcomes the anatomical limits represented by middle cranial fossa dura, sigmoid sinus, and the jugular bulb. The extensive bone removal over these structures allows them to be retracted during surgery and thereby enables removal of tumor irrespective of the size (1,10). Ethical clearance from the Institutional Ethical Committee has been obtained for the study. At our center, the patient consent taken before surgery also includes consent for the use of clinical data for scientific purposes.

The preoperative and postoperative FN function was recorded and graded according to the House–Brackmann (H–B) grading system (11). At our center, to avoid the subjective bias, we evaluate the FN function by taking color photographs of the face in four positions (facial muscles at rest, tight closure of eyes, raised eyebrows, smiling, and pouting lips) during the preoperative work-up and during every visit postoperatively. In addition, the evaluator was blinded to the size of the tumor while compiling the data. The H–B grades I, II were considered good, grade III as acceptable, and grade IV, V, VI as poor outcomes (1). FN status was recorded at day 1 after surgery, at discharge (mean: 6.5 d) and at 1-year follow-up. The FN outcome in reanimation surgeries were followed up for a minimum period of 2 years. For detailed analysis of comparison of FN function outcomes between two points of time, 1 day after surgery and at 1 year have been considered. This was done keeping in mind the possibility of prognostication of the FN outcome at the earliest period after surgery.

The VSs were measured and classified as per the recommendations of the ''New and modified reporting systems from the consensus meeting on systems for reporting results in vestibular schwannoma'' (12). Tumors were divided into the following classes: intrameatal (IM) tumor, Class I tumor: 1 to 10 mm extrameatal (EM) tumor diameter; Class II tumor: 11 to 20 mm EM tumor diameter, Class III tumor: 21 to 30 mm EM tumor diameter, Class IV tumor: 31 to 40 mm EM tumor diameter, and Class V tumor: more than 40 mm EM tumor diameter, also called giant VSs. Tumor size was measured by linear measurements on magnetic resonance imaging, of the largest EM diameter.

Other parameters recorded were age and sex of the patient, laterality, methods of restitution of the FN for unrecovered FN palsy (after 1 year).

Statistical Analysis

Data analysis was done by SPSS 24 (IBM, New York, NY) statistical package. Jonckheere–Terpstra test was used for deriving p values for independent samples of ordinal nature for non-parametric data. Wilcoxon matched pairs test was used to test the difference in the mean of paired observations. A p value <0.05 was considered statistically significant (95% confidence interval). Spearman's correlation-coefficient analysis was used to conduct the correlation analysis.

RESULTS

A total of 1,983 cases satisfied the inclusion and exclusion criteria; 1,032 (52%) were women and 951 (48%) were men. The right CPA was affected in 956 (48.2%) cases while left side in 1,027 (51.8%) cases. The age ranged from 10 to 79 years with a mean of 50.73 ± 11.8 years.

Tumor Class

The maximum tumor size in our series was 7 cm. The mean size observed was 1.68 ± 1.10 cm. Class II tumors (669, 33.7%) were most common followed by Class I (583, 29.3%) (Table 1). A total of 155 (7.8%) were intrameatal tumors and 162 (8.1%) of the tumors were class IV to V VSs.

Overall FN Outcomes

The tumor size was a principal factor in influencing the outcome. At 1 year follow up, H–B I and II were seen in 92.9 and 81% of the class 0 and class I tumors, respectively. The same was 56.2% in class II tumors and was progressively worse till it reached 12.2% in class V tumors.

The FN function showed significant variation when it was analyzed at three different time points: day 1 after surgery, at discharge and at 1-year of follow up. The mean FN function deteriorated between the immediate postoperative period till the point of discharge and eventually improved, at the end of 1 year. (Table 2).

At the end of 1 year, an overall increase in the good and acceptable FN outcomes (H–B I, II and H–B III) and reduction in poor FN outcomes (H–B IV, V, VI) were observed, as shown in Figure 1.

FN grades after surgery at day 1, at discharge and at 1-year were analyzed for correlation using Spearman's correlation coefficient. These grades correlated positively at a significance level of 0.01 (two tailed), indicating in all the combinations of FN grade points of time.

Pattern of Recovery of FN Function

Across tumor classes, of the 988 patients with H–B grade I and II FN function at day 1 after surgery, 958 (96.9%) continued to maintain their status up to 1 year. Deterioration was mainly seen in higher tumor classes. Of the 216 patients with H–B grade III FN function at day 1 after surgery, 113 (52.3%) improved to H–B grade I and II. None of the patients with H–B grade III at day 1 after surgery deteriorated to lower H–B grades at 1 year. Similarly, of the 779 patients with H–B grade IV to VI FN function at day 1 after surgery, improvement to H–B III and H–B I, II were noted in 442 (56.7%) and 80 (10.3%) of patients, respectively. Overall deterioration of H–B grade I to II to H–B grade III and to H–B grade IV to VI was noted in 27 (2.7%) and 3 (0.3%) cases respectively at 1 year.

When this was analyzed between tumor classes (Table 3), classes 0, I and II showed better rates of recovery from H–B grade III to H–B I and II (90.9, 56, 51.7%, respectively) when compared with tumor classes III to V (43.2, 43.8, and 50%, respectively). Similarly, classes 0, I, and II showed better rates of recovery from H–B grade IV to VI to H–B I to III (72.7, 77.7, 68%, respectively) when compared with classes III to V (46.8, 51.7, and 51.5%, respectively).

TABLE 1. *FN function at 1 year follow up in relation to the size of the tumor*

Tumour Size Grades	FN Outcomes at 1 Year			Total
	H–B I, II	H–B III	H–B IV,V,VI	
Grade 0 (IM)	144 (92.9%)	8 (5.2%)	3 (1.9%)	155 (100%)
Grade I (0.1–1 cm EM)	472 (81.0%)	87 (14.9%)	24 (4.1%)	583 (100%)
Grade II (1–2 cm EM)	376 (56.2%)	208 (31.1%)	85 (12.7%)	669 (100%)
Grade III (2–3 cm EM)	129 (31.2%)	196 (47.3%)	89 (21.5%)	414 (100%)
Grade IV (3–4 cm EM)	25 (20.7%)	53 (43.8%)	43 (35.5%)	121 (100%)
Grade V (>4 cm EM)	5 (12.2%)	20 (48.8%)	16 (39.0%)	41 (100%)
Total	1151 (58%)	572 (28.8%)	260 (13.1%)	1983 (100%)

Jonckheere–Terpstra test; $p = 0.001$.
EM indicates extrametal; FN, facial nerve; H–B, House–Brackmann grading; IM, intrameatal.

TABLE 2. *Comparison of grades of facial nerve at day 1 after surgery, at discharge and at 1-year time points by Wilcoxon matched pairs test*

Groups	Time Points	Mean FN Grade	p-Value ($p < 0.05$)
1	Day 1 after surgery	3.18	0.0001
	At discharge	3.29	
2	Day 1 after surgery	3.18	0.0001
	At 1 year	2.23	
3	At discharge	3.29	0.0001
	At 1-year	2.23	

FN indicates facial nerve.

Delayed Onset FP

There was another set of patients whose FN function deteriorated between postoperative day 1 and at the time of discharge. 75 (3.77%) patients with normal FN function developed varying grades of FN paralysis at the time of discharge with 11 (14.6%) patients having poor FN function. Their recovery pattern is shown in the Figure 2. Good recovery was observed in lower FN grades, with 86.9% of H–B II recovering to H–B I and 94.4% of H–B III to H–B I and II. The deterioration in FN function

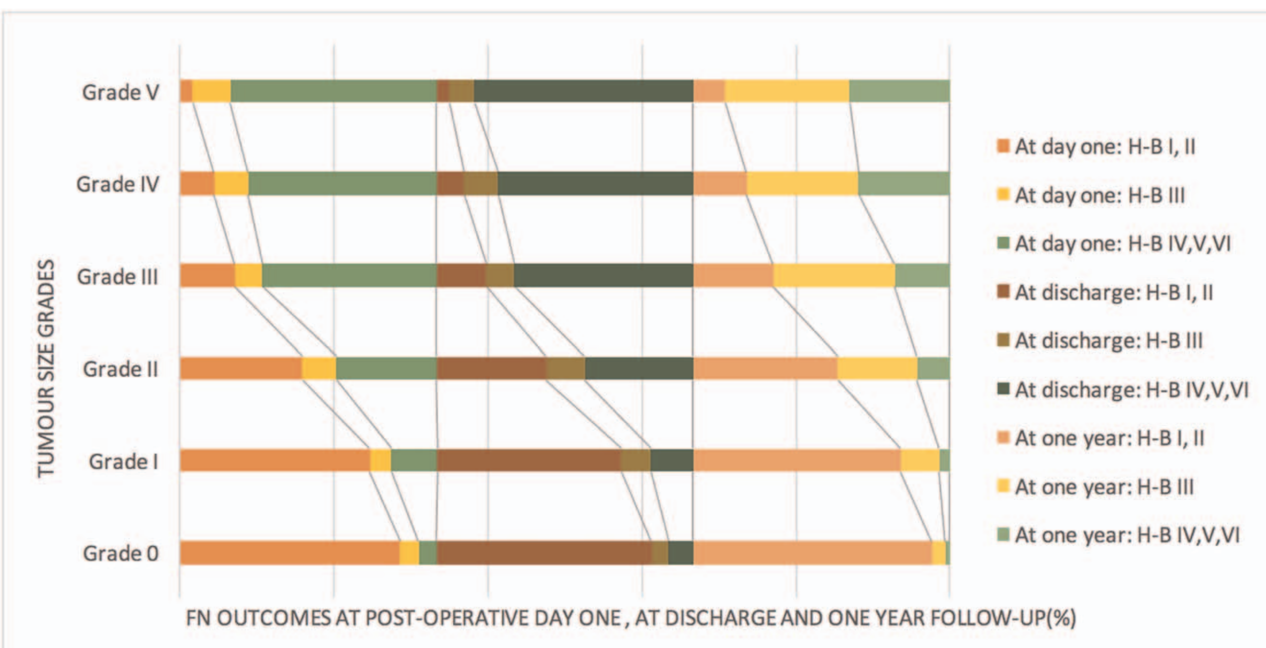

FIG. 1. Good (H–B I, II), acceptable (H–B III), and poor (H–B IV, V, VI) FN outcomes at next day after surgery, at discharge, and at 1 year. FN indicates facial nerve; H–B, House–Brackmann.

TABLE 3. *FN status at postoperative day 1 and at 1 year versus tumor grade*

		FN Outcome at 1 Year			
Tumor Grades	FN Outcome at Postoperative Day 1	H–B I, II (%)	H–B III (%)	H–B IV–VI (%)	Total (%)
Grade 0 (IM)	H–B I, II	132 (99.2)	1 (0.8)	0 (0)	133 (100)
	H–B III	10 (90.9)	1 (9.1)	0 (0)	11 (100)
	H–B IV–VI	2 (18.2)	6 (54.5)	3 (27.3)	11 (100)
	Total	144 (92.9)	8 (5.2)	3 (1.9)	155 (100)
Grade I (0.1–1 cm EM)	H–B I, II	422 (98.1)	7 (1.6)	1 (0.2)	430 (100)
	H–B III	28 (56)	22 (44.09	0 (0)	50 (100)
	H–B IV–VI	22 (21.4)	58 (56.3)	23 (22.3)	103 (100)
	Total	472 (81)	87 (14.9)	24 (4.1)	583 (100)
Grade II (1–2 cm EM)	H–B I, II	303 (95)	15 (4.7)	1 (0.3)	319 (100)
	H–B III	46 (51.7)	43 (48.3)	0 (0)	89 (100)
	H–B IV–VI	27 (10.3)	150 (57.5)	84 (32.2)	261 (100)
	Total	376 (56.2)	208 (31.1)	85 (12.7)	669 (100)
Grade III (2–3 cm EM)	H–B I, II	85 (96.6)	2 (2.3)	1 (1.1)	88 (100)
	H–B III	19 (43.2)	25 (56.8)	0 (0)	44 (100)
	H–B IV–VI	25 (8.99	169 (59.9)	88 (31.2)	282 (100)
	Total	129 (31.29	196 (47.3)	89 (21.5)	414 (100)
Grade IV (3–4 cm EM)	H–B I, II	15 (93.8)	1 (6.3)	0 (0)	16 (100)
	H–B III	7 (43.8)	9 (56.3)	0 (0)	16 (100)
	H–B IV–VI	3 (3.4)	43 (48.3)	43 (48.3)	89 (100)
	Total	25 (20.7)	53 (43.8)	43 (35.5)	121 (100)
Grade V (>4 cm EM)	H–B I, II	1 (50)	1 (50)	0 (0)	2 (100)
	H–B III	3 (50)	3 (50)	0 (0)	6 (100)
	H–B IV–VI	1 (3)	16 (48.5)	16 (48.5)	33 (100)
	Total	5 (12.2)	20 (48.8)	16 (39)	41 (100)
Grand total		1151 (58.1)	572 (28.8)	260 (13.1)	1983 (100)

EM indicates extrametal; FN, facial nerve; H–B, House–Brackmann grading; IM, intrameatal.

between postoperative day 1 and at 1-year follow-up was limited only to H–B grade I and no cases of H–B II and above showed any deterioration in the said period.

Relation Between FN Outcome and the Age of the Patient

The FN outcomes were not significantly related to the age.

Rehabilitation of FN Paralysis

There was a reduction in the number of H–B VI and H–B V from 676 cases to 160 (4.22:1) and 60 to 23 (2.60:1) from the time of discharge to 1 year. However, the number of cases of H–B IV almost remained the same (74 and 77 cases). Of the 183 cases of H–B V to VI at 1 year who were offered the option of XII to VII anastomosis, 31 cases underwent the same. A total of 16 of 31 cases recovered to H–B IV and 10 cases to H–B III. There was no improvement noted in five cases of which two cases underwent temporalis muscle transfer who achieved satisfactory outcomes. Tarsorrhaphy was performed in 64 cases of which 48 were before 1 year follow up time.

DISCUSSION

FN outcome can significantly affect the quality of life and preservation of its motor function remains a major concern in VSs surgery. There have been several refinements both in terms of surgical approach and instrumentation which have helped the preservation of FN. The modified ETLA is the safest approach for FN preservation as it allows FN visualization both proximal and distal to the tumor (1,13). Furthermore, advancements in FN monitoring like direct electric stimulation techniques, free running electromyogram, FN evoked potentials, and processed electromyogram have also contributed to better FN outcomes (3,13,14). The size of the tumor has proved to be a single most entity responsible for the long-term FN outcome. The present study being one of the largest in the literature (Table 4) predicts the FN function from the day after surgery till a year in various classes of VS.

In our center, the ETLA was considered when the tumor was more than 1.5 cm irrespective of preoperative hearing status; the only hearing ear and selective cases of NF2 being the exceptions. Generally, it is almost always impossible to preserve useful hearing when the tumor is large. Again, the same approach was considered in tumors less than 1.5 cm with PTA more than 30 dB and speech discrimination score worse than 70% (10).

Surgical Factors that Affect FN Outcomes

Despite the improvements in surgical techniques and instrumentation, there are several factors that influence the postoperative FN results. Anatomical preservation of

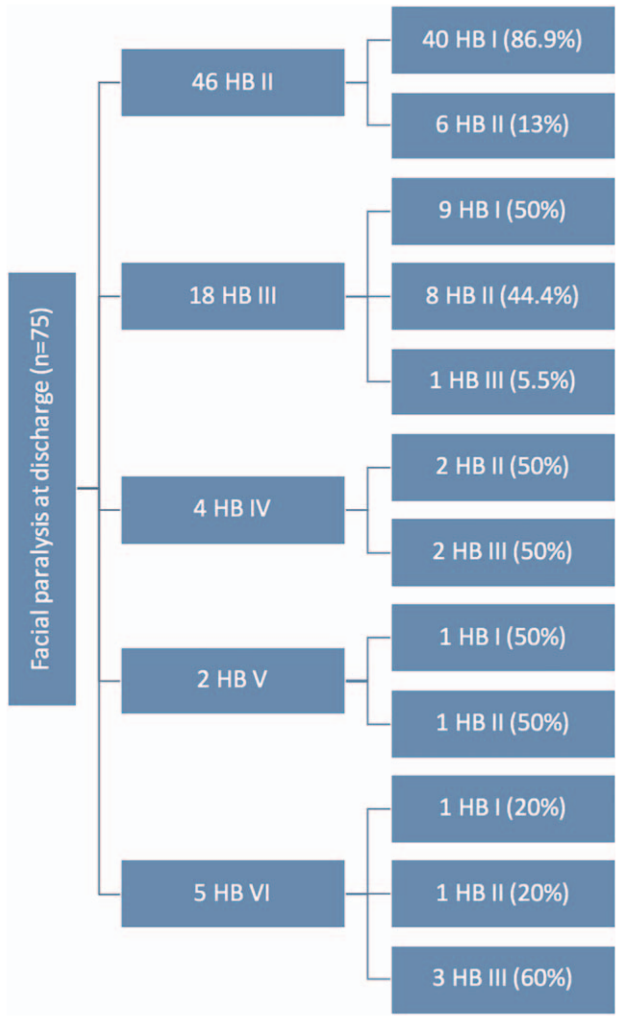

FIG. 2. Delayed onset facial paralysis at the time of discharge and their outcomes at 1 year.

the FN does not always ensure good postoperative FN outcomes. In the current study, despite the preservation of anatomical integrity of the nerve, H–B I and II facial function was noted in 58.1% of cases, while previous studies have a reported a range of 56.3 to 80.9% (6,15–19,22–24). Tos et al. (9), studied 46 consecutive video recordings of their translabyrinthine surgeries to seek intraoperative events leading to possible damage to FN. They recorded cauterization, suction, stretching, pushing, and other instrumental trauma at the fundus, porous, cerebellopontine angle, and brainstem segments of the FN. They attributed the unsatisfactory recovery of FN to numerous factors like motor neuron death, defective nerve regeneration, misdirection of regenerating axons, or denervation-related alterations of affected facial muscles (25–28).

We have described several technical refinements to the ETLA to avoid injury to the FN (1,10). Identification of the superior ampullary nerve in its canal is the first step to identifying the FN without identification of Bill's bar before this step. The FN lies behind the superior ampullary nerve and is protected by the Bill's bar and hence provides extra safety to the nerve during its identification. Preservation of the arachnoid layer which forms a natural cleavage plane between the tumor and nerve, is also important in obtaining better FN outcomes (1). Although desirable to retain neural vasculature, it may not be possible in certain cases due to tumor adherence, fibrous nature of tumor, or varying degrees of inflammation in long standing cases. The use of Vesalius® (Telea Electronic Engineering, Vincenza, Italy) bipolar coagulation that works on the technology of quantum molecular resonance generation reduces thermal collateral dissipation which is very useful. The advantages due to these refinements are well reflected in the high incidence of anatomical preservation of FN (95.7%) among a total of 2,455 operated cases by modified ETLA, which is at the higher end of the range of FN preservation (80.8–97.7%) reported by other authors. (3,4,15,17,18,21,24,29,30)

TABLE 4. *Facial nerve outcomes of the major series published in the literature by translabyrinthine approach*

Series	Total Number of TLAs	Follow-Up Period (in mo)	Tumor Classification and Size (no, %)	Mean Size of Tumor (cm)	Anatomical Integrity of FN Maintained (%)	H–B Grades (no, %) Versus Tumor Size
Glasscock et al., (15) 1986	437	12	Unclassified 66 (15.1), 296 (67.8), 75 (17.2) in <1.5 cm, 1.5–2.9 cm and >3 cm tumors, respectively)	NA	55, 92, 94 (in large, medium, and small tumors, respectively)	NA; FN injury in six (1.37%), 24 (5.5%), 33 (7.5%) in <1.5 cm, 1.5–2.9 cm, >3 cm tumors, respectively
Sterkers et al., (3) 1994	573	1	Jackler's classification 107 (18.6), 200 (34.9), 199 (34.7), 197 (34.3) in <10 mm, 11–25 mm, 26–40 mm, and >40 mm tumors, respectively	NA	91–95.5	H–B I–II: 120 (83.3), H–B III: 15 (10.4), H–B IV–VI: 9 (6.3) in 0–25 mm tumors H–B I–II: 112 (55.7), H–B III: 48 (23.9), H–B IV–VI: 41 (20.4) in 26–40 mm tumors H–B I–II: 17 (34), H–B III: 11 (22), H–B IV–VI: 21 (44) in >40 mm tumors
Tos et al., (4) 1998	703	12	Jackler's classification 107 (15.2), 200 (28.4), 199 (28.3), 197 (28) in <10 mm, 11–25 mm, 26–40 mm and >40 mm tumours respectively	NA	97.7	H–B I–II: 120 (89), H–B III: 15 (5), H–B IV–VI: 9 (6) in 0–25 mm tumors H–B I–II: 112 (71), H–B III: 48 (12), H–B IV–VI: 41 (16) in 26–40 mm tumors H–B I–II: 17 (41), H–B III: 11 (11), H–B IV–VI: 21 (47) in >40 mm tumours
Mass et al., (16) 1999	258	12	Unclassified 11 (4.2), 113 (43.7), 105 (40.6), 29 (11.2) in grade 0, small, medium, and large tumors, respectively	1.86	NA	H–B I–II: 120 (100), in grade 0 tumors H–B I–II: 112 (83.2), H–B III: 48 (8.8), H–B IV–VI: 41 (8) in small tumors H–B I–II: 17 (86.7), H–B III: 11 (12.4), H–B IV–VI: 21 (13.3) in medium tumors H–B I–II: 17 (44.8), H–B III: 11 (24.1), H–B IV–VI: 21 (30.9) in large tumors
Darrouzet et al., (17) 2004	229	12	TCMS 39 (9.7), 122 (30.5), 87 (21.8),152 (38) in Grades I, II, III, IV respectively	NA	96.3	H–B I–II: 38 (97.4), H–B III: 0 (0), H–B IV–VI: 1 (2.6) in grade I tumors H–B I–II: 108 (88.5), H–B III: 3 (2.4), H–B IV–VI: 11 (9) in grade II tumors H–B I–II: 55 (63.2), H–B III: 5 (5.7), H–B IV–VI: 27 (31) in grade III tumors H–B I–II: 51 (33.5), H–B III: 10 (6.6), H–B IV–VI: 91 (59.9) in grade IV tumors
Brackmann et al., (18) 2007	512	12	Unclassified 79 (15.4), 172 (33.5), 105 (20.5), 36 (7.0) in <1.5 cm, 1.5–2.5 cm, 2.5–3.5 cm, >3.5 cm respectively	2.4	97.5	H–B I–II: 72 (91), H–B III: 2 (3), H–B IV–VI: 5 (6) in <1.5 cm tumors H–B I–II: 142 (83), H–B III: 13 (8), H–B IV–VI: 17 (11) in 1.5–2.5 cm tumors H–B I–II: 84 (80), H–B III: 11 (10), H–B IV–VI: 10 (10) in 2.5–3.5 cm tumors H–B I–II: 19 (53), H–B III: 6 (17), H–B IV–VI: 11 (31) in >3.5 cm tumors

(Continued on next page)

TABLE 4 *(Continued)*

Series	Total Number of TLAs	Follow-Up Period (in mo)	Tumor Classification and Size (no, %)	Mean Size of Tumor (cm)	Anatomical Integrity of FN Maintained (%)	H–B Grades (no, %) Versus Tumor Size
Springborg et al., (19) 2012	1152	12	TCMS 13 (1),149 (12.9), 363 (31.5), 336 (29.2), 157 (13.6), 134 (11.6) in Grades 0, I, II, III, IV, V respectively	2.5	93.5	H–B I–II: 12 (92.3), H–B III: 1 (7.7) in grade 0 tumors H–B I–II: 123 (89.3), H–B III: 7 (4.7), H–B IV–VI: 8 (5.4) in grade I tumors H–B I–II: 301 (83), H–B III: 29 (8), H–B IV–VI: 27 (6.1) in grade II tumors H–B I–II: 232 (68.7), H–B III: 35 (10.4), H–B IV–VI: 64 (18.7) in grade III tumors H–B I–II: 81 (51.6), H–B III: 21 (13.4), H–B IV–VI: 53 (33.7) in grade IV tumors H–B I–II: 52 (38.8), H–B III: 17 (12.7), H–B IV–VI: 65 (48.5) in grade V tumors
Aristegui Ruiz et al., (20) 2015	341	12	TCMS 40 (11.6%), 56 (16.4%), 99 (29%), 98 (28.8%),32 (9.3%),16 (4.7%) in Grades 0, I, II, III, IV, V, respectively	NA	96.2	H–B, I–II: 41 (83.6), H–B III: 7 (14.2), H–B IV–VI: 1 (2.0) in grade 0 tumors H–B I–II: 62 (91.1), H–B III: 3 (4.41), H–B IV–VI: 3 (4.3) in grade I tumors H–B I–II: 89 (76.6), H–B III: 24 (20.6), H–B IV–VI: 3 (2.5) in grade II tumors H–B I–II: 70 (61.3), H–B III: 22 (19.2), H–B IV–VI: 22 (19.2) in grade III tumors H–B I–II: 15 (40.5), H–B III: 11 (29.7), H–B IV–VI: 11 (29.7) in grade IV tumors H–B I–II: 5 (27.7), H–B III: 1 (5.4), H–B IV–VI: 12 (66.6) in grade V tumors
Zhang et al., (21) 2016	517 (TLA + TO)	71	Unclassified 37 (7.15%), 249 (48.1%), 276 (53.4%), 186 (35.9%) in IM, <1.5 cm, 1.5–3, >3 cm, respectively	NA	97.7%	H–B, I–II: 450 (87%), H–B III: 62 (11.9), H–B IV–VI: 5 (0.9%) overall in all grades
Present study	1983	12	TCMS 155 (7.8), 583 (29.39), 669 (33.7), 414 (20.8), 121 (6.1), 41 (2) in Grades 0, I, II, III, IV, V, respectively	1.68	95.7 (of a total of 2,455 cases of ETLA)	H–B, I–II: 144 (92.9), H–B III: 8 (5.2), H–B IV–VI: 3 (1.9) in grade 0 tumors H–B I–II: 472 (81), H–B III: 87 (14.9), H–B IV–VI: 24 (4.1) in grade I tumors H–B I–II: 376 (56.2), H–B III: 208 (31.1), H–B IV–VI: 85 (12.7) in grade II tumors H–B I–II: 129 (31.2), H–B III: 196 (43.8), H–B IV–VI: 89 (21.5) in grade III tumors H–B I–II: 25 (20.7), H–B III: 53 (43.8), H–B IV–VI: 43 (35.5) in grade IV tumors H–B I–II: 5 (12.2), H–B III: 20 (48.8), H–B IV–VI: 16 (39) in grade V tumors

% indicates percentage; cm, centimeters; ETLA, enlarged translabyrinthine approach; FN, facial nerve; H–B, House–Brackmann grading; HL, hearing loss; mm, millimetres; NA, not available; no, number; TCMS, Tokyo Consensus Meeting System for Reporting on Vestibular Schwannoma; TLA, translabyrinthine approach; TO, transotic.

Tumoral Factors that Affect FN Outcomes

Tumor size has clearly been a risk factor and strong predictor of both immediate and long-term FN outcomes (5,17,22,31,32). The incidence of both anatomical preservation and good FN function decreases with increasing tumor size, as reported by several authors previously (3,33,34). Dissection of the tumor capsule from the FN may interrupt the vascular supply to the nerve thereby leading to the loss of neural function. Poor FN outcomes in large tumors could be attributed to greater level of tumor adherence to FN in large tumors as compared with the smaller ones (35). The prospect of nerve manipulation between the two fixed points of origin from CPA to labyrinthine segment increases nerve vulnerability during tumor manipulation, particularly in cases of large or adherent tumors. In our series, H–B I, II outcomes were better in Class 0, I, and II, respectively (92.9, 81, 56.2%) when compared with (31.2, 20.7, 12.2%) in class III, IV, and V, respectively.

It is generally considered that tumors larger than 2 cm EM yield poor FN outcomes (3,4,16,17). A recent study determined the cut-off tumor size to be 1.6 cm to minimizing the risk of an impaired facial function (36). We found that H–B I, II significantly dropped from 81 to 56% (by nearly 25%) when the size of the tumor was more than 1 cm. Therefore, this could be considered as the critical size for predicting FN outcomes.

Another factor that has been implicated in adverse postoperative FN outcomes is the tumor consistency with a more fibrous consistency reported to have poorer outcomes as compared with softer tumors, at least in early postoperative period (37).

Delayed Onset FP

The definition of delayed FP is varied and there is no consensus on the same. While some authors have defined it to be deterioration of FN function after postoperative day 1 from the normal status immediately after surgery, others have defined it to be deterioration of FN function after day 3 from normal or near normal FN function of H–B I, II (38–41). In fact, due to the same reason there are varying incidence of delayed onset facial palsy ranging from 4.8 to 41% in literature (40,42). The exact etiology for the same is unknown and it has been attributed to the neural edema (43), recrudescence of the varicella zoster virus (44–46). However, we have considered delayed onset FP cases to be the H–B I at 1 day after surgery and the deterioration noted at the time of discharge due to the retrospective nature of study as per the database available. This included 75 (3.77%) cases with 11 (14.6%) patients having poor FN function. Their recovery pattern is shown in the Figure 2. Good recovery was observed in lower FN grades, with 86.9% of H–B II recovering to H–B I and 94.4% of H–B III to H–B I and II. The deterioration in FN function between postoperative day 1 and at 1-year follow-up was limited only to H–B grade I and no cases of H–B II and above showed any deterioration in the said period.

Predicting FN Outcomes

Stabilization of the FN function takes time and hence H–B grading at 1 year postoperatively can be deemed as an adequate parameter of success. Improvement in FN function has been shown to be between 17 and 37% at 1 year (34). Sterkers et al. (3), observed that if H–B I or II is not achieved either immediately after the surgery or by 1 month, long-term outcomes could be limited, indicating some degree of neurotmesis with resultant regeneration and misrouting of axons. They further observed a suboptimal FN function and some degree of synkinesis in patients displaying grade III or worse at 1 month of surgery, hence emphasizing the need for achieving good early results (3).

In our study, the mean postoperative FN grades at day 1, at discharge and at 1 year were 3.18, 3.29, and 2.23, respectively. FN outcomes at day 1 after surgery, at the time of discharge, and at 1 year correlated positively. Across tumor classes, 96.9% of the patients with H–B grade I and II FN function at day 1 after surgery, continued to maintain their status up to 1 year. Deterioration was mainly seen in higher tumor classes which was also noted by Springborg et al. (19) who reported similar observations in their study involving 1,244 cases operated by TLA. It is important to note that while none of our patients with H–B grade III at day 1 after surgery deteriorated to lower H–B grades at 1 year, improvement to H–B grade I and II was seen in 52.3% and similar findings have been observed in previous studies (18,19). Similarly, of the patients with H–B grade IV and VI FN function at day 1 after surgery, most of them improved to H–B grade III (56.7%) and a small percentage (10.3%) improved to H–B I and II. The knowledge of alteration of H–B grades with respect to the size of the tumor can be used to predict probable outcome. In our series, we found recovery of FN function to be better with lesser tumor classes (class 0–II versus class III–V).

Other factors which have been attributed with predicting postoperative outcomes of FN irrespective of tumor staging were the absence or the desynchronization of homolateral auditory brainstem responses, audio-vestibular signs of brainstem compression, tumor inflammation, and positive p53 protein positive immunostaining of more than or equal to 10% nuclei which have not been studied in the present paper (47).

Poor FN outcomes which accounted for 40% at the time of discharge dropped to 12.7% after 1 year of which more than half were over 2 cm sized EM tumors. Of this group majority of the cases were grade VI which accounted for 34% at discharge and dropped to 7.6% after 1 year. These are the candidates who might require facial rehabilitation surgery.

Facial Nerve Rehabilitation:

In an intact FN following surgery, it is our policy to wait till 1 year before contemplating to perform facial-hypoglossal anastomosis in patients having poor FN function. This is also justified by a significant drop in the number of HB V to VI cases from the time of discharge to 1 year in the present study. However, the option of tarsorrhaphy was considered in patients with poor FN function any time following surgery to prevent possible corneal injury.

Drawback of the Study

Intraoperative FN monitoring is a better predictor of postoperative FN function and the present study does not take that into account due to the retrospective nature of the study. In addition, the evaluator reporting the FN function from the photographs could be different from the actual patient examination grades.

CONCLUSION

FN outcome immediately after surgery could be used as a predictor of long-term FN function. H–B grade I and II usually maintain their grades at the end of 1 year. Tumor class 0 to III have good immediate postoperative FN results and recover well at the end of 1 year. Tumor class IV and V have poor outcomes and recover poorly at the end of 1 year. When the VSs reaches more than 1 cm, the good FN outcomes drop significantly and decision to intervene is of paramount importance. About a third of poor outcomes seen at the time of discharge specially in large tumors might eventually be the candidates for facial rehabilitation surgeries subsequently.

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