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Prognostic Factors for the Outcome of Translabyrinthine Surgery for Vestibular Schwannomas

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Objective: To identify predictors of tumor recurrence and postoperative facial nerve function after translabyrinthine surgery for unilateral vestibular schwannomas.
Study Design: Retrospective study.
Setting: Tertiary referral center.
Patients: Between 1996 and 2017 a total of 596 patients with unilateral vestibular schwannoma underwent translabyrinthine surgery. Pre- and postoperative clinical status, radiological, and surgical findings were evaluated.
Intervention(s): Translabyrinthine surgery.
Main Outcome Measure(s): Potential predictors for tumor recurrence and facial nerve outcome were analyzed using Cox regression and ordinal logistic regression, respectively.
Results: The extent of tumor removal was total in 32%, near-total in 58%, and subtotal in 10%. In 5.5% (33/596) of patients the tumor recurred. Subtotal tumor resection ($p = 0.004$, hazard ratios [HR] = 10.66), a young age ($p = 0.008$, HR = 0.96), and tumor progression preoperatively ($p = 0.042$, HR = 2.32) significantly increased the risk of recurrence, whereas tumor size or histologic composition did not. A good postoperative facial nerve function (House–Brackmann grade 1–2) was achieved in 85%. The risk of postoperative facial nerve paresis or paralysis increased with tumor size ($p < 0.001$, OR = 1.52), but was not associated with the extent of tumor removal, histologic composition, or patient demographics.
Conclusions: Translabyrinthine surgery is an effective treatment for vestibular schwannoma, with a good local control rate and facial nerve outcome. The extent of tumor removal is a clinically relevant predictor for tumor recurrence, as are young patient age and preoperative tumor progression. A large preoperative tumor size is associated with a higher risk of postoperative facial nerve paresis or paralysis.
Key Words: Facial nerve—Prognostic factors—Recurrence—Translabyrinthine surgery—Vestibular schwannoma.

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Vestibular schwannomas are benign tumors arising from Schwann cells of the vestibular nerve. The tumor is located in the internal auditory canal and/or the cerebellopontine angle. The clinical incidence rate is 1 to 1.5 per 100,000 per year (1,2). Vestibular schwannomas usually cause unilateral hearing loss, tinnitus, and/or balance disorders. The growth pattern of vestibular schwannomas is variable and ranges from rapid growth to spontaneous involution (3). Frequently, the tumor remains stable for many years or progresses slowly with a growth rate of 1 to 2 mm/yr (4). Because of the often indolent growth pattern, active surveillance is in many cases preferred as the initial management option over radiotherapy or surgery, especially when symptoms are mild and the tumor size is limited. Radiotherapy or surgery are generally considered in case of tumor progression, a large tumor at presentation, and/or increasing symptoms. In vestibular schwannoma surgery there are three different approaches: the translabyrinthine, the retrosigmoid, and the middle cranial fossa approach. The translabyrinthine approach offers the most extensive access to the internal auditory canal, but the labyrinth is inevitably sacrificed. The retrosigmoid and the middle cranial fossa approach offer the benefit of potential preservation of hearing, but the middle cranial fossa approach offers limited access to the cerebellopontine angle (and is therefore less suitable for larger tumors) and the retrosigmoid approach offers limited access to the fundus of the internal auditory canal.

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In vestibular schwannoma surgery the aim is maximal tumor removal with minimal recurrence and complication rates. Total tumor removal is not always feasible without jeopardizing facial nerve integrity because of adherence of the tumor to the facial nerve. Since it is a benign tumor, preservation of facial nerve function is sometimes prioritized over complete tumor removal. Naturally, incomplete tumor resection increases the risk of recurrent disease, and long-term follow-up is therefore necessary. Here, we describe a large patient cohort that underwent translabyrinthine surgery for a vestibular schwannoma and a long mean follow-up, with a focus on tumor recurrence, facial nerve outcome, and their predictors.

MATERIALS AND METHODS

The study was performed with consent of the local medical ethical committee. The need for informed consent was waived, due to the retrospective nature, and size of the study.

Patient Selection

The data of patients operated for vestibular schwannoma between 1996 and 2017 at the Leiden University Medical Center, Leiden, The Netherlands, a tertiary referral center, were extracted from the patient medical files and analyzed. All patients were elected for surgery by the Leiden University Medical Center Skull Base Team, a dedicated multidisciplinary team comprising neuroradiologists, neurotologists, neurosurgeons, and radiotherapists. All types of vestibular schwannoma surgery (translabyrinthine, retrosigmoid, and middle cranial fossa approaches) are performed at our center, the choice for a specific approach was made by the surgical team (neurosurgeons and neurotologists) and was generally based on the extension of the tumor in the cerebellopontine angle and/or internal auditory canal and the preoperative hearing levels.

A total of 661 patients with a unilateral vestibular schwannoma underwent translabyrinthine surgery. Exclusion criteria were: combined or extended surgical approaches (n = 14), previous radiotherapy (n = 12), incomplete follow-up (n = 32), and neurofibromatosis type 2 (n = 7). In all, 596 patients were included in the analysis.

Diagnosis and Follow-up

The diagnosis of vestibular schwannoma was made using T2 and/or gadolinium enhanced T1 weighted magnetic resonance imaging (MRI). The presence of cystic degeneration was defined as the occurrence of inhomogeneous areas within the tumor on MR imaging. Preoperative tumor size was defined as the largest extrameatal diameter, excluding the intracanalicular component. The tumor size was categorized according to Kanzaki et al. (5), into: intracanalicular (no extension extrameatally), small (1–10 mm extrameatally), medium (11–20 mm), moderately large (21–30 mm), large (31–40 mm), and giant (>40 mm). Significant tumor progression was defined as more than 2 mm increase in maximal extrameatal diameter on sequential MRIs within 12 months of follow-up (6).

The extent of tumor removal was assessed at the end of surgery and defined as total (all tumor tissue removed), near-total (<2% of original tumor remaining), or subtotal (>2% of original tumor remaining). For assessment of residual tumor and postoperative tumor progression all patients underwent routine MRI follow-up at 6 to 12 months postoperatively, and subsequently at regular intervals dictated by the size and progression rate of the residual tumor if present. Tumor control was deemed adequate if residual tumor could not be identified or did not require additional treatment. Conversely, recurrence was defined as a regrowth of tumor or progression of a residual tumor requiring additional treatment, either through surgery or radiotherapy. The duration of follow-up was calculated from the date of surgery to the date of the imaging that showed a recurrence, or to the date of the latest available MRI. The most recent MRI was deemed the most reliable endpoint of follow-up. This inadvertently shortened the average follow-up duration because it does not account for the disease free follow-up of patients that are discharged from follow-up because of long-standing absence of recurrent disease.

Facial nerve function was evaluated using to the House–Brackmann (HB) grading system (7). HB 1–2 was considered a good facial nerve outcome, HB 3–4 as fair, and HB 5–6 as poor. Postoperative facial nerve function was evaluated at hospital discharge, and subsequently at the outpatient clinic after 3 to 6 months, 6 to 12 months, and more than 12 months.

Other complications related to the surgical treatment were considered a major complication when it adversely affected the recovery of the patient and/or required surgical reintervention. Minor complications were defined as not affecting the recovery or functional outcome of the patient. Mortality due to surgery was defined as mortality within 6 weeks following surgery.

Statistical Analysis

Continuous variables were summarized with means and standard deviations; categorical variables were summarized with frequency tables. The differences between groups without correction for covariates were calculated using a χ^2 test for binary variables and unpaired t tests for continuous variables. Identification of factors affecting the incidence of tumor recurrence was performed using Cox regression with recurrence free survival as survival endpoint and time scale chosen as time since surgery. Recurrence free survival was also analyzed using a Kaplan–Meier survival analysis and the Log-Rank test for comparison of groups. Ordinal logistic regression analysis was performed to study the effect of potential predictors on facial nerve outcome, accounting for the ordinal nature of the HB grading scale. When building the regression models the following covariates where considered: age, sex, tumor size, surgical indication, histologic composition, and extent of tumor resection. Associations were summarized with hazard ratios (HR) for tumor recurrence and odds ratios (OR) for facial nerve outcome with 95% confidence intervals (CI) for both outcome measures. All OR reflect the chance of a good postoperative facial nerve outcome. A value of $p < 0.05$ was considered statistically significant. Statistical analysis was performed with IBM SPSS Statistics for Windows, version 25.0 (Armonk, NY: IBM Corp.).

RESULTS

Patient Characteristics

The study comprised 264 male (44%) and 332 female patients. Mean age at the time of diagnosis was 51.5 years with a mean follow-up of 12.9 months before surgery (Table 1). The mean age at the time of surgery was 52.8 years (range, 15–81 yr). The mean preoperative extrameatal tumor size was 21.1 mm (median, 20.0; range, 2–66; SD, 9.8 mm), and 268 patients (45%) had a moderately large to giant vestibular schwannoma

TABLE 1. *Patient characteristics based on preoperative tumor size*

		Intracanalicular	Small, 1–10 mm	Medium, 11–20 mm	Moderately Large, 21–30 mm	Large, 31–40 mm	Giant, >40 mm	Total
Number of patients (%)		40 (6.7)	93 (15.6)	195 (32.7)	179 (30.0)	72 (12.1)	17 (2.9)	596
Sex, n (%)								
Male		13 (32.5)	41 (44.1)	93 (47.7)	76 (42.5)	33 (45.8)	8 (47.1)	264
Female		27 (67.5)	52 (55.9)	102 (52.3)	103 (57.5)	39 (54.2)	9 (52.9)	332
Side, n (%)								
Left		24 (60.0)	49 (52.7)	89 (45.6)	99 (55.3)	39 (54.2)	10 (58.8)	310
Right		16 (40.0)	44 (47.3)	106 (54.4)	80 (44.7)	22 (45.8)	7 (41.2)	286
Mean age at surgery, yrs		55.0	54.5	54.5	51.7	50.5	39.4	
Mean extrameatal tumor diameter, mm		0	8.2	15.8	25.6	34.9	45.9	
Histologic composition, n (%)								
Solid		37 (92.5)	79 (84.9)	121 (62.1)	70 (39.1)	20 (27.8)	5 (29.4)	332
Cystic		1 (2.5)	12 (12.9)	64 (32.8)	108 (60.3)	51 (70.8)	12 (70.6)	248
No data		2 (5.0)	2 (2.2)	10 (5.1)	1 (0.6)	1 (1.4)	0 (0.0)	16
Extent of resection, n (%)								
Total		33 (82.5)	54 (58.1)	63 (32.3)	28 (15.6)	9 (12.5)	3 (17.6)	190
Near-total		7 (17.5)	35 (37.6)	107 (54.9)	132 (73.7)	53 (73.6)	11 (64.7)	345
Subtotal		0 (0.0)	4 (4.3)	25 (12.8)	19 (10.6)	10 (13.9)	3 (17.6)	61
Mean follow-up time, mo		55.0	43.8	55.8	50.6	40.6	51.1	
Recurrence, n (%)		0 (0.0)	1 (1.1)	18 (9.2)	5 (2.8)	7 (9.7)	2 (11.8)	33
Facial nerve integrity, n (%)								
Anatomical and electrophysiological		40 (100)	91 (97.8)	184 (94.4)	154 (86.0)	57 (79.2)	15 (88.2)	541
Anatomical, not electrophysiological		0 (0.0)	2 (2.2)	3 (1.5)	7 (3.9)	7 (9.7)	1 (5.9)	20
Disrupted		0 (0.0)	0 (0.0)	5 (2.6)	5 (2.8)	3 (4.2)	1 (5.9)	14
No data		0 (0.0)	0 (0.0)	3 (1.5)	13 (7.3)	5 (6.9)	0 (0.0)	21
Facial nerve function at 1 year postoperative, n (%)								
Good	HB 1	36 (90.0)	73 (78.5)	148 (75.9)	123 (68.7)	39 (54.2)	8 (47.1)	427
	HB 2	1 (2.5)	11 (11.8)	26 (13.3)	27 (15.1)	15 (20.8)	2 (11.8)	82
Fair	HB 3	2 (5.0)	7 (7.5)	17 (8.7)	18 (10.1)	10 (13.9)	4 (23.5)	58
	HB 4	1 (2.5)	1 (1.1)	2 (1.0)	7 (3.9)	4 (5.6)	2 (11.8)	17
Poor	HB 5	0 (0.0)	1 (1.1)	1 (0.5)	1 (0.6)	1 (1.4)	0 (0.0)	4
	HB 6	0 (0.0)	0 (0.0)	1 (0.5)	3 (1.7)	3 (4.2)	1 (5.9)	8
Complications, n (%)		6 (15.0)	15 (16.1)	54 (27.7)	63 (35.2)	20 (27.8)	8 (47.1)	166

(Table 1). Most patients in this study were indicated for surgery because of a large tumor at presentation (43%), or progressive tumor growth (31%) on sequential MR imaging. The estimated extent of tumor resection was total in 190 patients (32%), near-total in 345 patients (58%), and subtotal in 61 patients (10%). On the first postoperative MRI, at 11 months after surgery on average, 183 patients (31%) showed residual tumor, usually small, and in 60% no residue could be identified. The preoperative tumor size groups, as categorized in size groups according to Kanzaki et al. (5), was significantly correlated to the extent of the resection as estimated at the end of surgery ($p < 0.001$, $\chi^2 = 116.129$).

Tumor Control

Tumor control was achieved in 563 patients (94.5%), a recurrence occurred in 33 patients (Fig. 1). Mean follow-up after surgery was 50 months (median, 36; range, 3–209 mo) and 199/596 patients had a follow-up exceeding 5 years. Mean follow-up until the diagnosis of recurrence was 46 months (median, 39; range, 6–131 mo). Salvage treatment for recurrences consisted of second surgery in eight patients and radiotherapy in 25 patients. Second surgery was performed via a translabyrinthine approach in six patients, a retrosigmoid approach in one patient and a combined translabyrinthine and retrosigmoid approach in one patient. Tumor control after salvage treatment for recurrence was 79% (26/33 patients), in seven patients additional salvage therapy was indicated. Regrowth not necessitating salvage treatment occurred in 43 patients, mainly after a near-total resection (37 patients), followed by a subtotal resection (four patients) and a total resection (two patients).

Tumor control rates decreased with increasing preoperative tumor size. Tumor control was 100% in intracanalicular, 99% in small, 91% in medium, 97% in moderately large, 90% in large, and 88% in giant vestibular schwannomas (Table 1). However, no significant correlation between tumor size and recurrence rate was found when the extrameatal diameter was analyzed as a continuous variable (in mm) in multivariate analysis.

The recurrence rate after total tumor resection was 1%, 6% after near-total resections, and 15% after subtotal resections. Subtotal tumor resections were significantly correlated with increased risk of tumor recurrence compared with total resections (15% versus 1%, $p = 0.004$,

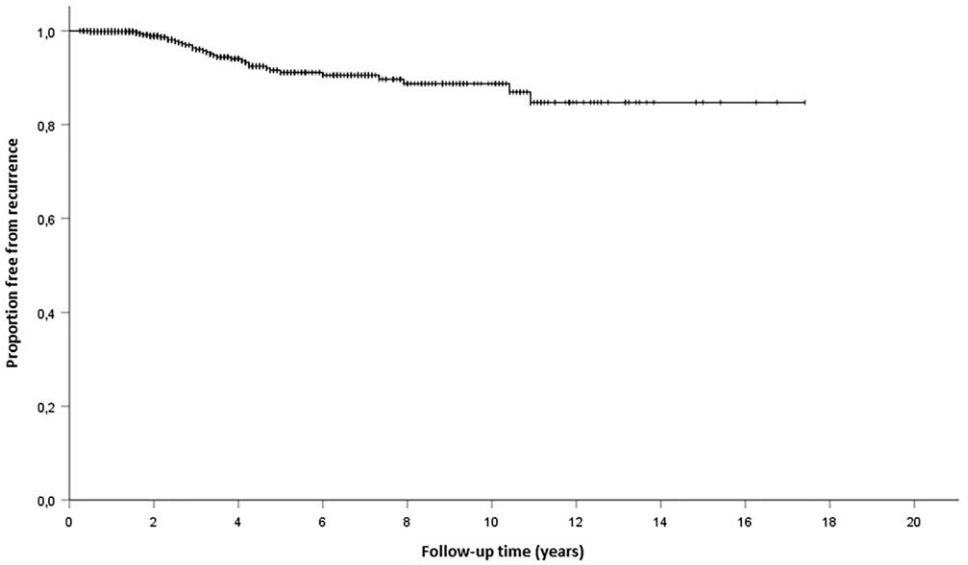

FIG. 1. Kaplan–Meier curve showing the proportion of recurrence free survival for all patients.

HR = 10.662) and near-total resections (15% versus 6%, $p = 0.021$, HR = 4.063). The recurrence free survival after total, near-total, and subtotal resections differed significantly ($p < 0.001$, $\chi^2 = 20.1$) (Fig. 2). Mean estimated recurrence free survival was 16.9 years after total resections (standard deviation [SD] ±0.373, 95% CI 16.166–17.628), 13.3 years after near-total resections (SD ± 0.317, 95% CI 12.718–13.961), and 9.8 years after subtotal resections (SD ± 0.747, 95% CI 8.293–11.220).

The second factor significantly associated with the risk of recurrence was preoperative tumor progression ($p = 0.042$, HR = 2.322). In addition, patients with recurrence were younger at time of primary surgery (45.9 yr) than patient without recurrence (53.2 yr), and patient age was statistically significant related to recurrence risk ($p = 0.008$, HR = 0.957). No association was found for cystic degeneration and sex on the risk of recurrence in this series (Table 2). Preoperative tumor size was not found to be significantly correlated with risk of recurrence. Although an indirect effect is suspected, as preoperative tumor size and extent of resection are significantly correlated, and the regression coefficients and *p*-values of the extents of resection are effected by

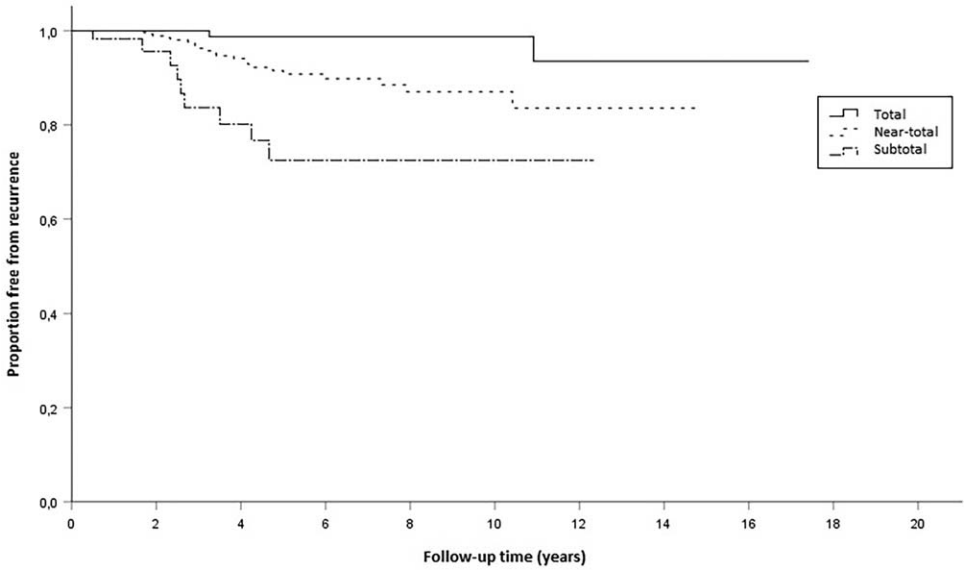

FIG. 2. Kaplan–Meier curve showing the proportion of recurrence free survival related to the extent of tumor resection as judged by the surgeon at the end of surgery. The differences in recurrence risk for total, near-total, and subtotal resections of vestibular schwannomas are statistically significant: $p < 0.001$, $\chi^2 = 20.1$.

TABLE 2. *Cox regression analysis of predictors of tumor recurrence after translabyrinthine surgery*

Predictor	β	SE β	p	HR (e^{β})	95% CI
Gender	0.268	0.362	0.460	1.307	0.642–2.660
Age at time of surgery	−0.044	0.017	0.008	0.957	0.927–0.989
Largest diameter (mm)	0.198	0.211	0.349	1.219	0.806–1.844
Near-total resection	1.402	0.753	0.063	4.063	0.928–17.781
Subtotal resection	2.367	0.817	0.004	10.662	2.151–52.849
Cystic degeneration	0.454	0.400	0.256	1.575	0.719–3.449
Preoperative growth	0.842	0.415	0.042	2.322	1.030–5.237

β indicates the regression coefficient representing the impact of the covariates; CI, confidence interval; eβ, exponent of the regression coefficient (β); HR, hazard ratio; p, statistical significance; SE, standard error.

including the preoperative tumor size in the regression analysis.

Facial Nerve Outcome

Anatomical and electrophysiological facial nerve integrity during surgery was preserved in 541/575 patients (94%) with a detailed registration of the facial nerve integrity in the surgical report (Table 1). A good facial nerve function (HB 1–2) 12 months after surgery was achieved in 509 patients (85%), and was significantly correlated with an anatomical and electrophysiological intact facial nerve at the end of surgery ($p < 0.001$, OR = 18.669).

In 14 patients (2%) the facial nerve was anatomically disrupted during surgery. A direct end-to-end coaptation of the facial nerve was performed in five patients, and three patients were immediately reconstructed with a sural nerve graft. A staged facial-hypoglossal nerve transfer was performed in nine cases, three of these patients had an anatomically intact facial nerve at the end of vestibular schwannoma surgery.

In 20 patients (4%), the electrophysiological stimulation was lost even though the facial nerve was anatomically intact at the end of surgery. Of these patients, 8/20 had a good facial nerve function (HB 1–2), 11/20 had a fair facial nerve function (HB 3–4), and only one patient had a poor facial nerve function 12 months postoperatively (HB 6).

Ordinal regression showed a statistically significant inverse relation between the preoperative tumor size and the facial nerve outcome ($p < 0.001$, OR = 1.516) (Fig. 3). The extent of resection was not related to the

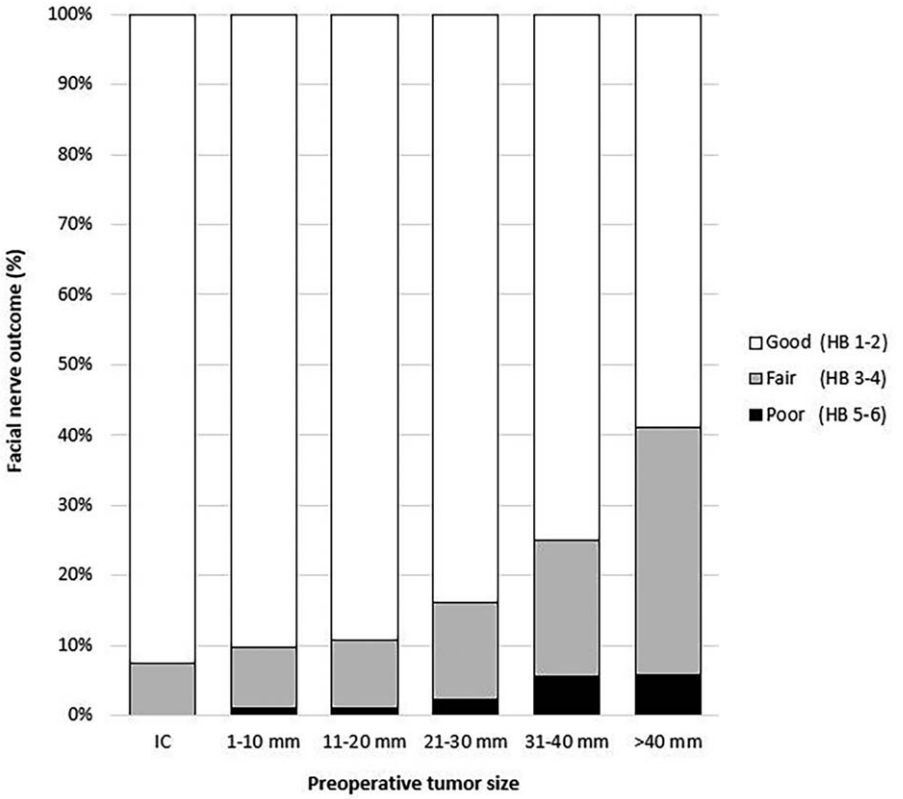

FIG. 3. Facial nerve outcome related to preoperative tumor size.

TABLE 3. *Facial nerve function at 1 year in relation to the facial nerve function at hospital discharge*

		House-Brackmann (HB) Grade at Hospital Discharge							
		HB 1	HB 2	HB 3	HB 4	HB 5	HB 6	No Data	Total
House–Brackmann grade 1 year postoperative	HB 1	255 (98.5)	104 (82.5)	38 (63.3)	19 (30.2)	5 (11.4)	1 (2.6)	5 (83.3)	427
	HB 2	4 (1.5)	21 (16.7)	15 (25.0)	22 (34.9)	14 (31.8)	5 (13.2)	1 (16.7)	82
	HB 3	0 (0.0)	1 (0.8)	6 (10.0)	18 (28.6)	10 (22.7)	23 (60.5)	0 (0.0)	58
	HB 4	0 (0.0)	0 (0.0)	1 (1.7)	3 (4.8)	8 (18.2)	5 (13.2)	0 (0.0)	17
	HB 5	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (6.8)	1 (2.6)	0 (0.0)	4
	HB 6	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.6)	4 (9.1)	3 (7.9)	0 (0.0)	8
Total		259 (100)	126 (100)	60 (100)	63 (100)	44 (100)	38 (100)	6 (100)	596

facial nerve outcome; in total resections 86% had a good facial nerve outcome, compared with 86 and 84% in near-total and subtotal resections, respectively.

Compared with the facial nerve function at discharge, the facial nerve function was unchanged (n = 291; 49%) or improved (n = 288; 49%) at 12 months after surgery. Only 11 patients (2%) experienced a decreasing facial nerve function after hospital discharge, in five patients eventually resulting in a poor facial nerve function (HB 5–6) (Table 3). Of those with poor facial nerve function at discharge (n = 82), 72 patients (88%) improved over time, and 25 patients (30%) had a good facial nerve function (HB 1–2) at 12 months after surgery (Table 3).

Other Postoperative Complications

Major complications related to the translabyrinthine surgical approach, i.e., cerebellopontine angle hematoma (n = 7), meningitis (n = 25), cerebrospinal fluid leak (n = 47), wound infection (n = 2), and subcutaneous abdominal hematoma (n = 8) necessitating intervention, occurred in 89 (15%) patients. Other complications were minor (n = 106), e.g., ulnar neuropathy (n = 11), cerebral venous sinus thrombosis (n = 7), aspiration pneumonia (n = 2), deep venous thrombosis (n = 2), and atrial fibrillation (n = 5). Cerebrospinal fluid leak was the most frequent complication, accounting for 24% of all complications. Of these patients, 29 were treated with an external lumbar drain and 18 underwent revision surgery. The risk of cerebrospinal fluid leak increased with tumor size, from 5% in intracanalicular tumors up to 12% in giant vestibular schwannoma ($p = 0.039$, OR = 1.327). No mortality occurred.

DISCUSSION

Tumor Control

The primary aim of treatment of patients with a vestibular schwannoma is long-term recurrence free survival with integrity of the facial nerve and low additional morbidity. Tumor control after translabyrinthine surgery in this series was high (94.5%), with a mean follow-up of 50.3 months. We could only identify three studies in recent literature with a sufficient long-term follow-up after translabyrinthine surgery, reporting 91 to 98% tumor control (8–10). Most other reports do not focus on tumor control, but on postoperative facial nerve outcome (11–25) and frequently include a mix of surgical approaches (16,19,20,22–32). After a retrosigmoid approach the reported tumor control is often more variable (76–99%) (31,33–36).

The high rate of tumor control in the current study was achieved despite a comparatively low rate of total tumor removal (32% versus 81–99% in other reported series) (9–13,29,32,37). Even so, the extent of tumor resection as assessed at the end of surgery was significantly associated with recurrence risk in our cohort. Most patients in the current study had a near-total resection (58%), indicating a more than 98% tumor removal in these patients. A study by El-Kashan et al. (38) found no evidence of regrowth in patients with a more than 98% tumor removal. The inverse relation between recurrence risk and extent of resection is in agreement with other studies, reporting a recurrence rate of 2 to 16% after near-total resections and 10 to 32% after subtotal resections (8–10,27). The difference in recurrence free survival was statistically significant and resulted in hazard ratios of 4.1 for near-total and 10.7 for subtotal resections. Thus, the estimated extent of tumor resection at the end of surgery is a clinically relevant predictor of recurrence, at least for our team. As definitions of near-total and subtotal resections vary, this predictor may not be universally applicable (5,9,26,27,32).

A second predictor of recurrence is the presence of tumor progression before surgery, with a hazard ratio of 2.3 for tumors with MRI documented preoperative tumor growth. The third significant factor is a young patient age at the time of surgery. We hypothesize that the young age at which the tumor became manifest is a reflection of a more aggressive tumor type or host-related factors facilitating tumor growth. Alternatively, it could simply be due to the fact that younger patients have more time to develop a recurrence within their lifespan. Indeed, in this cohort we found a recurrent vestibular schwannoma after 131 months of follow-up. It demonstrates that long follow-up for residual and recurrent tumors are warranted, especially after incomplete resections.

We did not find other significant predictors of recurrence after vestibular schwannoma surgery. Paldor et al. (39) suggested cystic degeneration to be associated with tumor progression preoperatively, and Freeman et al. (26)

suggested sex to be a potential predictor, but using our larger dataset, we could not confirm these associations.

Facial Nerve Outcome

In the current cohort, the facial nerve was anatomically and electrophysiologically intact at the end of surgery in 91% of patients. A good facial nerve function (HB 1–2) at 12 months postoperatively was achieved in 85%, comparable with other large cohorts reporting on the translabyrinthine approach (70–88%) (11,12,17,18,29). The reported facial nerve outcome after retrosigmoid approaches varies, but a good postoperative facial nerve function is generally achieved in a lower percentage of patients (56–97%) (31,33–35,40). Ho et al. (41) described a 7.2 times increased risk of a poor facial nerve function immediately after surgery for retrosigmoid approaches when compared with translabyrinthine approaches.

A good facial nerve function immediately after translabyrinthine surgery is a good predictor of long-term good facial nerve function (19,20). An unfavorable facial nerve function (HB 5 or 6) immediately after surgery however does not always imply an unfavorable facial nerve outcome at 1 year after surgery, as the facial nerve function will recover to a fair to good outcome (HB 3 or better) in the majority of patients (Table 3).

Surgical resection of a large vestibular schwannoma is associated with a significantly higher risk of a less favorable facial nerve outcome. This is in line with previous reports (17,19–22,27). We did not find an association with other evaluated factors, such as age, sex, histologic composition, or for the extent of resection. This latter observation may be somewhat surprising, as residual tumor is usually left in situ by the surgeons because of adherence of the tumor to the facial nerve, a factor that is reported to be associated with postoperative facial paresis (23). The observation that the facial nerve function is equally good after total, near-total, or subtotal resections is in contrast with the findings of Gurgel et al. (40) in their review of studies on large vestibular schwannomas. It is probably a reflection of the judicious decision made intraoperatively by the surgeons on the extent of tumor resection in relation to the risk of facial nerve injury.

Other Postoperative Complications

Postoperative complications occurred in 164 patients, and most complications were minor. A cerebrospinal fluid leak was found in 47 patients (8%). This rate is in line with the rates reported in a review of Selesnick et al. (42) of several large series on translabyrinthine surgery (10%, range, 0–21%). Our data indicate a direct relation between tumor size and the incidence of cerebrospinal fluid leak that reached statistical significance. Several other studies report a higher incidence of cerebrospinal fluid leak in large tumors (≥3 cm) (13,43,44). In this study, no mortality due to translabyrinthine surgery or related complications occurred. The mortality of surgery reported in other studies is less than or equal to 1% (11,12,24,25,29,37). Usually the cause of death is associated with severe neurovascular complications. In our cohort seven neurovascular complications occurred (1%), comparable with other series (12,37). In general the rate of major complications remains relatively low and the translabyrinthine approach provides a safe and effective method for vestibular schwannoma surgery.

Limitations

The main limitation of this study is the retrospective study design. Second, although the mean follow-up in our study population is approximately 5 years, a proportion of patients had a shorter follow-up, potentially resulting in an underestimation of tumor recurrence. Last, the comparability of our results is somewhat limited because of the existing variability in the literature of reported definitions for tumor control and extent of tumor resection.

CONCLUSION

This study shows that the translabyrinthine approach is a safe and effective technique for vestibular schwannoma surgery, with a tumor control rate of 94.5%, a good facial nerve outcome (HB 1–2) in 85%, and no mortality. Prognostic factors for recurrence after translabyrinthine approach in vestibular schwannoma surgery are the extent of tumor resection, a younger patient age, and a progressive tumor preoperatively. The only preoperative predictor for postoperative facial paresis is preoperative tumor size.

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