Vestibular schwannoma case series

A cohort study of adults (≥18 years old) with sporadic vestibular schwannoma who underwent salvage microsurgery following failed primary Stereotactic radiosurgery/Fractionated stereotactic radiotherapy in 7 vestibular schwannoma treatment centers across the US and Norway. Data collection was performed between July 2022 and January 2023, with data analysis performed between January and July 2023.

Main outcomes and measures: Composite outcome of undergoing less than gross total resection (GTR) or experiencing long-term facial paresis.

Results: Among 126 patients, the median (IQR) age at the time of salvage microsurgery was 62 (53-70) years, 69 (55%) were female, and 113 of 117 (97%) had tumors that extended into the cerebellopontine angle at the time of salvage. Of 125 patients, 96 (76%) underwent primary gamma knife SRS, while 24 (19%) underwent linear accelerator-based SRS; the remaining patients underwent FSRT using other modalities. Postoperative cerebrospinal fluid leak was seen in 15 of 126 patients (12%), hydrocephalus in 8 (6%), symptomatic stroke in 7 (6%), and meningitis in 2 (2%). Each 1-mm increase in cerebellopontine angle tumor size was associated with a 13% increased likelihood of foregoing GTR (64 of 102 patients [63%]) or long-term postoperative House-Brackmann grade higher than I (48 of 102 patients [47%]) (odds ratio, 1.13; 95% CI, 1.04-1.23). Following salvage microsurgery, tumor growth-free survival rates at 1, 3, and 5 years were 97% (95% CI, 94%-100%), 93% (95% CI, 87%-99%), and 91% (95% CI, 84%-98%), respectively.

Conclusions: In this cohort study, more than half of patients who received salvage microsurgery following primary SRS/FSRT underwent less than GTR or experienced some degree of facial paresis long-term. These data suggest that the cumulative risk of developing facial paresis following primary SRS/FSRT by the end of the patient's journey with treatment approximates 2.5% to 7.5% when using published primary SRS/FSRT long-term tumor control rates [1)].

2023

Hosmann et al. retrospectively analysed 24 consecutive patients who underwent microsurgical intervention for recurrent vestibular schwannoma post-radiosurgery.

Tumour recurrence post-radiosurgery occurred as solid growth in 19 patients (79%), while 5 patients (21%) developed large brainstem-compressing cysts. The median time interval for tumour recurrence post-radiosurgery was similar between cystic and non-cystic recurrent VS (30 vs. 25 months; p=0.08). Cystic recurrences occurred in primarily cystic VS in 3 patients, and new cysts developed in 2 patients with primarily solid VS. Intra-operatively, tumours were firm in 18 cases (75%) and strongly adhered to surrounding structures in 14 cases (58%). All cystic cases underwent cyst decompression, while complete resection of solid tumour components was avoided due to neurovascular adherence. At a mean follow-up of 42±39 months, 12 patients (50%) showed contrast-enhancing tumour residuals in follow-up imaging, including all cystic recurrent cases. Tumour residuals remained stable without requiring further intervention, except for one patient revealing malignant tumour transformation. House-Brackmann grade I/II was preserved in 15 patients (62%). Three patients (13%) developed new facial palsy, and two patients (8%) improved to House-Brackmann grade II. Cystic recurrences had a significantly higher frequency of tumour residuals compared to solid recurrences (100% vs. 37%; p=0.01) but similar rates of facial palsy (60% vs. 32%; p=0.24). Cyst development in VS post-

radiosurgery is more common in primary cystic lesions but can also occur in rare cases of primary solid VS. Symptomatic cysts require microsurgical decompression. However, complete resection of the solid tumour component is not crucial for long-term tumour control and should be avoided if it risks neurological function in this delicate area [2)]

An institutional review board-approved retrospective review of patients from a prospectively maintained vestibular schwannoma registry imaged in 2003-2017. Signal-intensity ratios of the ipsilateral labyrinth were obtained using T1, T2-FLAIR, and postgadolinium T1 sequences. Signal-intensity ratios were compared with tumor volume and audiometric hearing threshold data including pure tone average, word recognition score, and American Academy of Otolaryngology-Head and Neck Surgery hearing class.

One hundred ninety-five patients were analyzed. Ipsilateral labyrinthine signal intensity including postgadolinium T1 images was positively correlated with tumor volume (correlation coefficient = 0.17, P = .02). Among signal-intensity ratios, postgadolinium T1 was significantly positively associated with pure tone average (correlation coefficient = 0.28, P < .001) and negatively associated with the word recognition score (correlation coefficient = -0.21, P = .003). Overall, this result correlated with impaired American Academy of Otolaryngology-Head and Neck Surgery hearing class (P = .04). Multivariable analysis suggested persistent associations independent of tumor volume with pure tone average (correlation coefficient = 0.25, P < .001) and the word recognition score (correlation coefficient = -0.17, P = .02) but not hearing class (P = .14). No consistent significant associations were noted between noncontrast T1 and T2-FLAIR signal intensities and audiometric testing.

Increased ipsilateral labyrinthine postgadolinium signal intensity is associated with hearing loss in patients with vestibular schwannoma [3)].

MarketScan database were queried using the ICD-9/10 and CPT 4th edition, 2000-2020. We included patients ≥ 18 years of age with the diagnosis of VS who underwent clinical observation, surgery, or Stereotactic Radiosurgery (SRS) with at-least 1-year follow-up. We looked at health care outcomes and MHD at 3-month, 6-month, and 1-year follow-ups.

Results: A cohort of 23376 patients was identified from the database. Of these, 94.2% (n=22041) were managed conservatively with clinical observation at the initial diagnosis, and 2% (n=466) underwent surgery. The surgery cohort had the highest incidence of new-onset MHD followed by SRS and clinical observation at 3 months (Surgery 17%, SRS 12% and clinical observation 7%), 6 months (Surgery 20%, SRS 16% and clinical observation 10%) and 12 months (Surgery 27%, SRS 23% and clinical observation 16%), p<0.0001. The median difference in combined payments between patients with and without MHD was highest in the surgery cohort followed by SRS and clinical observation at all time points, [(12 months: Surgery $14469, SRS $10557, clinical observation $6439), p=0.0002].

Compared to clinical observation only, patients who underwent surgery for VS were twice more likely and those who underwent SRS were 1.5 times more likely to develop MHD with a corresponding increase in health care utilization at one-year follow-up [4)]

Retrospective case series from 2018 to 2021 in a tertiary academic medical center. Patients who

underwent surgical resection with ILA facial nerve dissection of VS (>2.0 cm measured parallel to the petrous ridge) had at least a 3-month follow-up.

Cisternal facial nerve dissection during retrosigmoid or translabyrinthine approach using standardized ILA technique developed by author R.N.

Main outcome measures: Immediate postoperative and last follow-up facial nerve function with House-Brackmann scores of I to II defined as “good” facial nerve function and House-Brackmann scores III to VI defined as “poor” function. The extent of resection was also assessed.

Results: A total of 48 patients underwent large VS resection with ILA dissection of tumor off of the facial nerve from 2018 to 2021. The mean (standard deviation) tumor size was 3.11 (0.76) cm. The mean (standard deviation) follow-up was 9.2 (9.0) months. Gross-total resection or near-total resection was achieved in 75% (radiographic estimate) to 83% (surgeon estimate) of cases. End-of-case facial nerve stimulation at 0.05 mAmp with a response of at least 240 mV was achieved in 80.4% of patients. Good facial nerve function was observed in 72% immediately postoperatively, 70% 1-month postoperatively, and 82% of patients at the last follow-up.

The ILA technique is now the method of choice of the senior surgeon (R.N.) when performing microsurgical dissection of the cisternal facial nerve, with which he has achieved high rates of total or near-total resection with excellent facial nerve preservation [5)]

Immunohistochemical analysis of expression of progesterone (PR) and estrogen receptors (ER) after biopsy was performed in 240 patients with VS between 2018 and 2021. ER/PR expression was assessed in men (n=120) and women (n=120) in 3 age subgroups: young age (18-44 years), middle age (45-59 years) and old age (60-79 years). Each subgroup included 40 patients. Statistical analysis was performed using the Mann-Whitney test and MedCalc software.

ER expression is not typical for VS (men - 1 (0.01%), women - 3 (2.5%)). At the same time, PR expression was found in 29 (24.2%) men and 21 (17.5%) women. We found no significant difference in expression of ER and PR between men and women. However, variability in PR expression was revealed, i.e. predominance of this indicator in young women (p=0.0463) and middle-aged men (p=0.0110). Expression of PR was similar in elderly patients (p=0.2382).

The established incidence of PR expression may be one of the probable causes affecting development and duration of VS pseudoprogression after radiosurgery without clear relationship between sex and age. Further prospective research is needed to predict the risks of pseudoprogression [6)]

Ninety-two patients had VS confined to the internal auditory canal (IAC) with 236 MRIs analyzed, and 108 patients had VS involving the cerebellopontine angle (CPA) with 193 MRIs analyzed. The Spearman rank correlation coefficients between changes in diameter and volume for IAC and CPA tumors were 0.43 ($p < .001$) and 0.65 ($p < .001$), respectively. Linear diameter increases of 1 to <2 mm corresponded to a median volume change of 32% (interquartile range [IQR]: 6%-86%) for IAC tumors, compared to 23% (IQR: 13%-40%) for CPA tumors. Linear diameter increases of 2 to <3 mm (ie, the minimum linear diameter change classically considered “true growth”) corresponded to a median volume change of 42% (IQR: 23%-100%) and 47% (IQR: 26%-69%) for IAC and CPA tumors, respectively.

Changes in linear diameter significantly correlated with changes in volume for IAC and CPA tumors, although diameter changes that did not meet the definition of linear growth (<2 mm) had corresponding median volume changes in excess of 20% for both IAC and CPA tumors [7].

2022

One-hundred consecutive patients diagnosed with vestibular schwannoma were surgically treated between December 2018 and August 2019 in Xuanwu Hospital, Capital Medical University. The clinical classification, surgical position, gross total removal rate, the anatomical and functional preservation rates of the facial nerve, and the postoperative complications were retrospectively analyzed.

Results: All 100 patients including 34 males and 66 females were operated on via a retro-sigmoid approach. According to Koos's vestibular schwannoma grading system, 18 cases were grade 2, 34 cases were grade 3, and 48 cases were grade 4. According to Hannover vestibular schwannoma grading system, 5 cases were T2, 6 cases were T3a, 8 cases were T3b, 30 cases were T4a, and 51 cases were T4b. Seventy-three surgeries were performed under a lateral position, and 27 cases were operated under a semi-sitting position. The gross total removal rate was 90.0%; the anatomic reservation rate of the facial nerve was 96.0%. According to the House-Brackman system, the facial nerve function was grades 1-2 in 78.0% of cases, grade 3 in 7.0% of cases, and grades 4-5 in 15% of cases. For patients with effective hearing before the operation, the hearing reservation rate was 19.0%. Two patients (2.0%) developed intracranial hematoma after the operation.

Most vestibular schwannoma could be completely removed with good postoperative facial nerve function. If total removal of tumor is difficult, we should give priority to the functional preservation of the nerve function [8].

The effects of tumor shape irregularity (TSI) on GK dose-plan quality and treatment outcomes were analyzed in 234 vestibular schwannomas. TSI was quantified using seven different metrics including a volumetric index of sphericity (VioS). GK treatment plans were created on a single GK-Perfexion/ICON platform. The plan quality was measured using the selectivity index (SI), gradient index (GI), Paddick's conformity index (PCI), and efficiency index (EI). Correlation and linear regression analyses were conducted between shape irregularity features and dose plan indices. Machine learning was employed to identify the shape feature that predicted dose plan quality most effectively. The treatment outcome analysis including tumor growth control and serviceable hearing preservation at 2 years, was conducted using Cox regression analyses. All TSI features correlated significantly with the dose plan indices ($P < 0.0012$). With increasing tumor volume, vestibular schwannomas became more spherical ($P < 0.05$) and the dose plan indices varied significantly between tumor volume subgroups ($P < 0.001$ and $P < 0.01$). VioS was the most effective predictor of GK indices ($P < 0.001$) and we obtained 89.36% accuracy (79.17% sensitivity and 100% specificity) for predicting PCI. The results indicated that TSI had significant effects on the plan quality but did not adversely affect treatment outcomes [9].

In a study, 51 planning scenarios of 17 patients with VS were planned for GKSRS using forward plan (FP), inverse plan (IP), and hybrid plan (HP) in Leksell GammaPlan (LGP10.1) using the TMR10 algorithm. The planning images were obtained using the following MRI (GE, USA) scan parameters: T1W images-MPRAGE sequence, FOV-256mmx256mm, matrix size-512mmx512mm, and the slice

thickness 1 mm. The total dose was prescribed 12Gy and normalized at 50% isodose level.

The plan parameters were compared dosimetrically by maintaining FP as a base plan. The statistical analysis, including one-factor, repeated measures ANOVA and Bonferroni correction tests, were performed. The p-value for planning parameters such as brainstem dose, beam ON time, and gradient index significantly favored HP.

Overall, results show that HP is an efficient method for GKSRS of VS. The p-value was less than 0.001 and statistically significant for various plan indices [10)]

2021

Landry et al. retrospectively reviewed charts of patients who underwent primary surgery for Vestibular schwannoma between 2005 and 2020 at a quaternary referral center in Toronto, Canada. Mined data includes patient demographics, clinical presentation, radiological features, and treatment details. Regression modelling was used to identify predictors of tumour control, postoperative morbidity, and correlates of progression free survival (PFS).

Two hundred and five tumours with sufficient data were included in the study. Syndromic NF2, large tumours (>3cm), subtotal resection (vs gross total resection), presence of edema on preoperative MRI, and preoperative trigeminal symptoms were all predictors of postoperative progression/need for further treatment; the latter four were also associated with shorter progression free survival. Extent of resection (EOR), tumour size, and Koos grade were independently predictive of postoperative progression/secondary intervention in multivariate models; however, only EOR was independently predictive of progression-free survival. EOR, tumour size, and patient age are each independently predictive of facial nerve outcome.

They comprehensively explore the clinical landscape of surgically treated vestibular schwannoma and highlight important outcome predictors and disease subgroups. This may have important implications in risk stratifying these challenging cases [11)]

Of 383 patients with VS who had undergone SRS at The University of Tokyo Hospital between 1990 and 2017, Kawashima et al. retrospectively compared younger and older patients' tumor control and radiation-induced complication rates using case-control propensity score (PS) matching.

The mean follow-up was 83 and 92 months in older and younger patients, respectively. Compared with older patients, younger patients were more likely to have a history of resection (20% vs. 39%, p = 0.006) and be treated with higher marginal doses (median, 12 Gy vs. 14 Gy; p = 0.014). Cumulative 5- and 10-year tumor control rates were higher in older patients (97.7% and 93.9%, respectively) than in younger patients (90.2% and 85.4%, respectively, p = 0.024). After PS matching, younger patients' cumulative tumor control rates (93.6%, 85.4%, and 85.4% at 5, 10, and 15 years, respectively) were similar to those of older patients (p = 0.411). No significant between-cohort differences in hearing preservation rates or other cranial nerve complications were observed. Two younger patients had malignant tumors several years post-SRS, with one patient having confirmed histological transformation.

Vestibular schwannoma radiosurgery is equally effective for younger and older patients. Complications other than hearing deterioration are uncommon. However, malignant transformation is

possible, and long-term post-SRS surveillance MRI is important. These data are useful for decision-making involving young adults with VSs [12].

A cross-sectional study aimed to track cortical structural changes by surface-based morphometry in 46 VS patients with sustained (i.e. centralized) or ceased (i.e. peripheral) tinnitus after surgery. A volumetric analysis of cortical and subcortical gray matter (GM) anatomy was performed on preoperative high-resolution MRI and related to the presence of hearing impairment, pre-and/or postoperative tinnitus. Patients with sustained (i.e. chronic) tinnitus showed an increased GM volume of the bilateral caudate nucleus, the contralateral superior colliculus, the middle frontal and middle temporal gyrus, the fusiform gyrus as well as the ipsilateral pars orbitalis when compared to those patients in whom tinnitus ceased postoperatively. Chronic tinnitus in VS patients is associated with characteristic structural changes in frontal, temporal, and subcortical areas. Notably, a significant GM change of the caudate nucleus was detected providing further support for the striatal gaiting model of tinnitus [13].

2019

In Bergen, patients with vestibular schwannoma undergoing wait-and-scan management were included-specifically, those who did not require treatment during a minimum radiologic follow-up of 1 year. Baseline data and follow-up included magnetic resonance imaging, posturography, bithermal caloric tests, and a dizziness questionnaire. Main outcomes were prevalence of moderate to severe dizziness, canal paresis, and postural instability at baseline and follow-up, as compared with McNemar's test.

Out of 433 consecutive patients with vestibular schwannoma, 114 did not require treatment during follow-up and were included. Median radiologic follow-up was 10.2 years (interquartile range, 4.5 years). Age ranged from 31 to 78 years (mean, 59 years; SD, 10 years; 62% women). Median tumor volume at baseline was 139 mm3 (interquartile range, 314 mm3). This did not change during follow-up (P = .446). Moderate to severe dizziness was present in 27% at baseline and 19% at follow-up (P = .077). Postural unsteadiness was present in 17% at baseline and 21% at follow-up (P = .424). Canal paresis was present in 51% at baseline and 56% at follow-up (P = .664).

There was no significant change in the prevalence of dizziness, postural sway, or canal paresis during conservative management of vestibular schwannoma, while tumor volume remained unchanged. This indicates a favorable prognosis in these patients with regard to vestibular symptoms [14].

2018

One hundred fifty-two patients with unilateral vestibular schwannoma (VS) were investigated using multiple auditory-vestibular function tests such as audiometry, sensory organization test (SOT), caloric testing, cervical vestibular evoked myogenic potential (cVEMP) test, and ocular vestibular evoked myogenic potential VEMP (oVEMP) test.

In this study, 89% of patients with unilateral VS had mild to severe hearing loss on the involved side. All patients showed higher threshold values or no response in the cVEMP and oVEMP tests, which both

exhibited a lower response rate on the affected side than on the unaffected side. Patients with a tumor size ≥ 30 mm had significantly lower equilibrium scores for condition 5 and condition 6 of the SOT, which were associated with vestibular dysfunction, higher rates of canal paresis in the caloric test, and lower response rates in the cVEMP and oVEMP tests on the affected sides, compared with the results of patients with a tumor size ≤ 14 mm and patients with a tumor size of 15-29 mm.

A diameter > 30 mm may be the critical threshold at which vestibular function is affected and vestibular compensation is interfered with by a VS tumor. Functional performance of the vestibular system can help clinicians predict the size of a tumor and provide a basis for the development of treatment protocols [15)].

Charts of 192 consecutive VS patients over 18 years of age were reviewed to identify 65 patients who underwent middle cranial fossa (MCF) approach to VS resection between 2006 and 2017. A combination of Ultrasonic Bone Aspirator UBA and high-speed drill (HSD) was used to decompress the internal auditory canal (IAC) in 25 patients and HSD alone was used in the other 40 patients.

There were no significant differences in postoperative facial nerve function, in rate of GTR of tumor, or in rate of Cerebrospinal fluid fistula. In the UBA group 24/25 (96%) had postoperative HB grade I-II compared with 36/40 (90%) in the HSD group (p-value = 0.66). GTR was achieved in 25/25 (100%) in the UBA group compared with 38/40 (95%) in the HSD group (p-value = 1). In the UBA group, there were 0/25 (0%) cases of Cerebrospinal fluid fistula compared with 1/40 (2.5%) in the HSD group (p-value = 1).

UBA use is a safe and effective alternative or adjunct to HSD during MCF approach to expose the IAC contents. This surgical tool allows for bone removal with low risk of injury to adjacent structures [16)].

A consecutive series of 47 patients were treated between July 2010 and January 2018. The mean follow-up after surgery was 37.5 months (median: 36, range: 0.5-96). Mean presurgical tumor volume was 11.8 mL (1.47-34.9). Postoperative status showed normal facial nerve function (House Brackmann score I) in all patients. In a subgroup of 28 patients, with serviceable hearing before surgery and in which cochlear nerve preservation was attempted at surgery, 26 (92.8%) retained serviceable hearing. Nineteen had good or excellent hearing (Gardner Robertson Scale 1) before surgery, and 16 (84.2%) retained it after surgery. Mean duration between surgery and GKS was 6 months (median: 5, range: 3-13.9). Mean residual volume as compared with the preoperative one at GKS was 31%. Mean marginal dose was 12 Gy (11-12). Mean follow-up after GKS was 34.4 months (6-84). Conclusion

Data show excellent results in Large Vestibular Schwannoma management with a combined approach of microsurgical subtotal resection and GKS on the residual tumor, with regard to the functional outcome and tumor control. Longer term follow-up is necessary to fully evaluate this approach, especially regarding tumor control [17)].

In total, 576 patients with sporadic unilateral VS who were managed with wait-and-scan were reviewed retrospectively. Of these, a subset of 154 patients with 5-yr follow-up was separately analyzed. The tumor characteristics including patterns of growth, rate of growth, hearing outcomes, and likely factors affecting the above parameters were analyzed.

The mean period of follow-up was 36.9 ± 30.2 mo. The mean age was 59.2 ± 11.6 yr. Thirteen different patterns of tumor growth were observed. Eighty-four (54.5%) of 154 tumors with 5-yr follow-up showed no growth throughout 5 yr. Fifty-six (36.4%) tumors showed mixed growth rates. Only 57 (37%) patients had serviceable hearing at the start of follow-up, but 32 (56.1%) maintained it at the end of follow-up. One hundred fifty (26%) of the 576 patients who failed wait-and-scan had to be taken up for surgery.

While there may be no price to pay in wait-and-scan as far as hearing is concerned, this may not be the case for facial nerve outcomes, wherein the results may be better if the patients are taken earlier for surgery [18].

There were 579 tumors (576 patients) treated with SRS. Eighty-two percent (473) of tumors had ≥1 yr and 59% (344 ≥3 yr follow-up. In the 244 tumor ears, with measurable hearing before SRS who were followed ≥1 yr, 14% (31) had improved hearing, 13% (29) unchanged hearing, and 74% (158) had worsened hearing. In 175 patients with ≥3 yr follow-up and who had measurable hearing pretreatment, 6% (11 ears) improved hearing, 31% (54 ears) unchanged hearing, and 63% (110 ears) had worsened hearing. Patients with tumors with larger target volumes (P = 0.040) and with neurofibromatosis type 2 (NF2; P = 0.017) were associated with poorer hearing (P = 0.040). Patients with word recognition scores (WRS) of 50% or poorer had tumors with a larger volume (P = 0.0002), larger linear size (P = 0.032), and NF2 (P = 0.045). Traditionally reported hearing outcomes using the Gardner Robertson maintenance of PTA ≤50 db or WRS ≥50% were 48% at 3 yr, which overestimates hearing outcomes compared to the above reporting standards.

Hearing declines over time in VS treated with SRS in a high proportion of cases. The frequency and magnitude of long-term hearing decline following SRS argues against prophylactic radiation for small tumors in hearing ears with undetermined growth behavior [19].

Panigrahi et al., from the Department of Neurosurgery, Krishna Institute of Medical Sciences, Secunderabad, Telangana, evaluated the association of cell proliferative markers like MIB with recurrence in Vestibular schwannoma (VS).

Retrospective data of 144 consecutive patients who underwent surgical excision for sporadic VS between January 2010 and July 2015 was collected. Comparison between groups based on recurrence of VS was done.

The average age of the study population was 43.95 ± 12.86 years with 77 (53.5%) men. The average maximal diameter of VS was 40.25 ± 7.23 mm. Gross total resection was done in 52 (36.1%) patients. While near total resection was performed in 81 (56.3%) patients, the remaining 11 (7.6%) patients underwent a sub total resection. The mean follow-up period was 37.99 ± 10.09 months (24 - 60). Recurrence of VS was observed in 18 (12.5%) patients. There was no difference between the groups for diameter of the tumor (42.22 ± 8.04 vs 39.64 ± 7.00 mm; p=0.191). The average MIB index value was higher in patients with recurrence of tumor at follow-up (4.78 ± 5.77 vs 1.89 ± 1.48 mm; p<0.001). There was no difference between the groups for extent of resection or post-operative complications. MIB was the only significant predictor for recurrence (β=1.355 (1.07-1.78;CI 95%); p=0.031). On receiver operating characteristic curves, a cut-off value of 3.5% for MIB showed a specificity of 84.1%.

MIB index ≥ 3.5% are associated with recurrence in VS. Maximal diameter of the tumor and extent of resection are perhaps not associated with recurrence of VS [20].

Six patients affected by vestibular schwannoma (VS) involving the fundus of the IAC (Koos grading scale I-II) were included in a study from the Section of Otolaryngology and the Section of Neurosurgery, University of Verona, Italy. The patients already demonstrated symptoms of IAC involvement by the neuroma, with severe to profound hearing loss.

Transcanal microscopic, endoscopic assisted, approach was chosen for total resection of the tumor. Preoperative and intraoperative electrophysiological monitoring was performed using electrically evoked auditory brainstem responses (EABR) to evaluate preservation of cochlear function.

A retrospective evaluation of electrophysiological data collected during surgeries has been conducted; clinical outcomes, surgical complications, and postoperative radiological evaluations were also considered.

Total tumor removal was achieved in all patients with no major complications. One patient showed temporary facial palsy (HB stage II). We were able to preserve cochlear function in five out of six patients. In those patients intraoperative monitoring with EABR was performed after tumor removal with good responses.

Transcanal retrocochlear approach for VS removal allows preservation of cochlea and cochlear nerve function. This is the first step towards developing an effective surgical technique for VS removal and hearing rehabilitation with CI [21].

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168 patients underwent surgical treatment (2007-2013) for VS at the Division of Neurosurgery and Otolaryngology, Head and Neck Surgery, Department of Surgery, Montreal University Hospital Center (CHUM), Montreal, Canada. There were no exclusion criteria. Patients were separated into two groups according to the surgical approach: translabyrinthine (TL) group and retrosigmoid (RS) group. Signs and symptoms including ataxia, headache, tinnitus, vertigo and cranial nerve injuries were recorded pre- and postoperatively. Surgical complications were analyzed. Perioperative facial nerve function was measured according to House-Brackmann grading system.

Tumor resection was similar in both groups. Facial paresis was significantly greater in RS group patients preoperatively, in the immediate postoperative period and at one year follow-up ($p<0.05$). A constant difference was found between both groups at all three periods ($p=0.016$). The evolution of proportion was not found to be different between both groups ($p=0.942$), revealing a similar rate of surgically related facial paresis. Higher rate of ataxic gait ($p=0.019$), tinnitus ($p=0.039$) and cranial nerve injuries ($p=0.016$) was found in RS group patients. The incidence of headache, vertigo, vascular complications, Cerebrospinal fluid fistula and meningitis was similar in both groups. No reported mortality in this series.

Both approaches seem similar in terms of resection efficacy. However, according to our analysis, the TL approach is less morbid. Thus, for VS in which hearing preservation is not considered, TL approach is preferable [22].

The goal of microsurgical removal of a vestibular schwannoma is to completely remove the tumor, to provide long-term durable cure. In many cases, less than gross total resection (GTR) is performed to preserve neurological, and especially facial nerve function.

To analyze the long-term quality of life (QoL) in a cohort of patients who received either GTR or less than GTR.

Patients who operated for vestibular schwannoma less than 3.0 cm in posterior fossa diameter at 1 of 2 international tertiary care centers were surveyed using generic and disease-specific QoL instruments.

A total of 143 patients were analyzed. GTR was performed in 122, and 21 underwent less than GTR. QoL was assessed at a mean of 7.7 yr after surgery (interquartile range: 5.7-9.6). Patients who underwent GTR had smaller tumors; otherwise, there were no baseline differences between groups. Patients who underwent GTR, after multivariable adjustment for baseline features and facial nerve and hearing outcomes, reported statistically significantly better Short Form Health Survey-36 (SF-36) physical and mental scores, Patient-Reported Outcomes Measurement Information System (PROMIS-10) physical and mental scores, and Penn Acoustic Neuroma Quality of Life (PANQOL) facial, energy, general health, and total scores compared to patients receiving less than GTR.

GTR is associated with better QoL using the general QoL measures SF-36 and PROMIS-10 and the disease-specific PANQOL, even after controlling for baseline and outcome differences. This is especially significant in the assessment of mental health, indicating there may indeed be a psychological advantage to the patient that translates to overall well-being to have the entire tumor removed if microsurgical resection is undertaken [23)].

2017

A retrospective study included 100 patients who underwent low-dose SRS (12- to 13-Gy marginal dose) for vestibular schwannomas between January 2004 and January 2014. Clinical factors and hearing outcomes following radiosurgery were reviewed.

All patients had serviceable hearing at diagnosis and prior to SRS. The median follow-up period was 6.5years (range, 3-10years). The hearing preservation rate in the first, third, and fifth year after radiosurgery was 89%, 68%, and 63%, respectively. A mean cochlear dose lower than 4Gy was a favorable predictor of hearing outcome. Maximal cochlear dose, patient age, pre-treatment pure-tone average, and imaging characteristics were not associated with post-treatment hearing preservation. Our study showed an accelerated rate of deterioration of serial pure-tone average in the first 3years, followed by a more gradual decline after radiosurgery.

The results suggest that cochlear dose constraint is the most crucial factor for hearing preservation. This study provides insight into the rate of hearing preservation and the pattern of hearing deterioration following radiosurgery and can help clinicians advise patients of hearing outcomes following SRS [24)].

2016

The records of 399 VS patients who were cared for by 2 neurosurgeons and 1 neurotologist between

2001 and 2014 were evaluated. From this data set, 3 retrospective matched cohorts were created to compare hearing preservation (21 matched pairs), facial nerve preservation (83 matched pairs), intervention-free survival, and complication rates (85 matched pairs) between cases managed with SRS and patients managed with MS. Cases were matched for age at surgery (± 10 years) and lesion size (± 0.1 cm). To compare hearing outcomes, cases were additionally matched for preoperative Class A hearing according to the American Academy of Otolaryngology-Head and Neck Surgery guidelines. To compare facial nerve (i.e., cranial nerve [CN] VII) outcomes, cases were additionally matched for preoperative House-Brackmann (HB) score. Investigators who were not involved with patient care reviewed the clinical and imaging records. The reported outcomes were as assessed at the time of the last follow-up, unless otherwise stated. RESULTS The preservation of preoperative Class A hearing status was achieved in 14.3% of MS cases compared with 42.9% of SRS cases (OR 4.5; $p < 0.05$) after an average follow-up interval of 43.7 months and 30.3 months, respectively. Serviceable hearing was preserved in 42.8% of MS cases compared with 85.7% of SRS cases (OR 8.0; $p < 0.01$). The rates of postoperative CN VII dysfunction were low for both groups, although significantly higher in the MS group (HB III-IV 11% vs 0% for SRS; OR 21.3; $p < 0.01$) at a median follow-up interval of 35.7 and 19.0 months for MS and SRS, respectively. There was no difference in the need for subsequent intervention (2 MS patients and 2 SRS patients). CONCLUSIONS At this high-volume center, VS resection or radiosurgery for tumors ≤ 2.8 cm in diameter was associated with low overall morbidity. The need for subsequent intervention was the same in both groups. SRS was associated with improved hearing and facial preservation rates and reduced morbidity, but with a shorter average follow-up period. Facial function was excellent in both groups. Since patients were not randomly selected for surgery, different clinical outcomes may be of different value to individual patients. Both anticipated medical outcomes and patient goals remain the drivers of treatment decisions [25].

The series consists of 100 patients who underwent VS microsurgery during a 5-year period in whom the position and course of the FN could be confirmed by direct stimulation. The course of the FN was classified into 4 patterns according to its position: anterior (ventral) surface of the tumor (A), anterior-superior (AS), anterior-inferior (AI), and dorsal (D).

The distribution of patterns was as follows: AS in 48 cases, A in 31, AI in 21, and D in zero. For tumors <1.5 cm, the AS pattern was most common (68.4%). For tumors ≥1.5 cm, the proportion of A and AI positions increased (31.4% and 25.5%). Significant differences were observed between position and course patterns of the FN and postoperative nerve results. Patients with AS and AI patterns had better House-Brackmann FN function compared with patients with the A pattern ($P < 0.05$). Moreover, in tumors >3.0 cm, the FN tended to adhere strongly to the tumor capsule, and postoperative facial deficits were more frequent ($P < 0.05$).

The AS pattern was most common for smaller VSs. The A position and course and adhesion of the FN to the tumor capsule were the 2 factors most strongly associated with worse postoperative FN result [26].

Case-control study of 37 patients who underwent surgical resection of sporadic VS following prior SRS at two tertiary academic referral centers between 2003 and 2015. A cohort of nonirradiated control subjects, matched according to tumor size, age, and treatment center, were used as comparison.

Thirty-seven patients were included. The median time from radiation to surgical salvage was 36

months (range 9.6-153 months). Following tumor progression after SRS, 18 (49%) patients underwent gross total resection, 10 (27%) underwent near-total resection, and nine (24%) underwent subtotal resection. Postoperative complications following salvage surgery included one (3%) case of stroke, four (11%) cases of Cerebrospinal fluid fistula, and two (5%) cases of meningitis. Twenty-seven (73%) patients had good postoperative facial nerve outcome (House-Brackmann Score I-II) at long-term follow-up. There were no cases of tumor recurrence or regrowth after a median length of 26 months following microsurgical salvage (range 3-114 months). The rate of satisfactory postoperative facial nerve function was not different between study and control subjects (73% vs. 76%; P = 0.8); however, less-than-complete resection was utilized more frequently among previously radiated patients (P = 0.01).

Microsurgical salvage of VS following primary radiation therapy is challenging. Less-than-complete resection is required in a greater percentage of patients to preserve facial nerve integrity and prevent neurological complications. Long-term follow-up is needed to determine the risk of delayed progression following incomplete tumor removal [27)].

A total of 106 patients with unilateral VS were enrolled in this study prospectively. Each patient received a caloric reflex test, vestibular evoked myogenic potential (VEMP) test, and cochlear nerve function test (hearing) before the operation and 1 week, 3, and 6 months, postoperatively. All patients underwent surgical removal of the VS using the suboccipital approach. During the operation, the nerve of tumor origin (SVN or IVN) was identified by the surgeon. Tumor size was measured by preoperative magnetic resonance imaging.

The nerve of tumor origin could not be unequivocally identified in 38 patients (38/106, 35.80%). These patients were not subsequently evaluated. In 26 patients (nine females, seventeen males), tumors arose from the SVN and in 42 patients (18 females, 24 males), tumors arose from the IVN. Comparing with the nerve of origins (SVN and IVN) of tumors, the results of the caloric tests and VEMP tests were significantly different in tumors originating from the SVN and the IVN in our study. Hearing was preserved in 16 of 26 patients (61.54%) with SVN-originating tumors, whereas hearing was preserved in only seven of 42 patients (16.67%) with IVN-originating tumors.

The data suggest that caloric and VEMP tests might help to identify whether VS tumors originate from the SVN or IVN. These tests could also be used to evaluate the residual function of the nerves after surgery. Using this information, we might better predict the preservation of hearing for patients [28)].

2015

Patients were categorized according to management (microsurgery, n = 47; gamma knife radiosurgery, n = 27; and observation, n = 34).

Tumor control rates were 94.0% in the microsurgery group and 96.2% in the radiosurgery group. The most annoying symptoms were hearing loss in the microsurgery group, dizziness in the radiosurgery group, and tinnitus in the observation group. Quality-of-life scores did not differ significantly among the three groups in four of the eight domains of the questionnaire. The microsurgery group had a significantly higher score in the general health perception domain than the other groups (p = 0.003).

Quality of life is higher after microsurgery than after radiosurgery. One specific management strategy

cannot always guarantee the better quality of life. The functional status and personality traits of the patient should be considered, as well as tumor size and location when choosing a management option [29].

Zhang et al. reviewed a series of 221 cases of VS resected via a retrosigmoid approach from October 2008 to April 2014 and determined the incidence of postoperative facial and cochlear deficits.

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.

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 fistula occurred in 6 patients (2.7%), lower cranial nerve palsies in 9 patients (4.1%), and intracranial hematomas 3 cases (1.4%).

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 [30].

A retrospective cohort study of 489 patients who underwent vestibular schwannoma resection at the Department of Neurologic Surgery, Mayo Clinic, Rochester, Minnesota between 2000 and 2014. Delayed facial palsy was defined as deterioration in facial function of at least 2 House-Brackmann (HB) grades between postoperative days 5 to 30. Only patients with a HB grade of I to III by postoperative day 5 were eligible for study inclusion.

One hundred twenty-one patients with HB grade IV to VI facial weakness at postoperative day 5 were excluded from analysis. Of the remaining 368, 60 (16%) patients developed DFP (mean 12 days postoperatively, range: 5-25 days). All patients recovered function to HB grade I to II by a mean of 33 days (range: 7-86 days). Patients that developed DFP had higher rates of gross total resections (83% vs 71%, P = .05) and retrosigmoid approaches (72% vs 52%, P < .01). There was no difference in recovery time between patients who received treatment with steroids, steroids with antivirals, or no treatment at all (P = .530).

Patients with a gross total tumor resection or undergoing a retrosigmoid approach may be at higher risk of DFP. The prognosis is favorable, with patients likely recovering to normal or near-normal facial function within 1 month of onset [31].

2014

2368 patients who underwent surgery for VS, 111 patients who had incomplete excisions of VSs were included in the study. Of these patients, 73 (65.77%) had undergone near total resection (NTR) and

38 (34.23%) had undergone subtotal resection (STR). Of the VSs, 62 (55.86%) were cystic and 44 (70.97%) of these cystic VSs underwent NTR. The residual tumor was left behind on the facial nerve alone in 62 patients (55.86%), on the facial nerve and vessels in 2 patients (1.80%), on the facial nerve and brainstem in 15 patients (13.51%), and on the brainstem alone in 25 patients (22.52%). In the 105 patients with normal preoperative facial nerve function, postoperative facial nerve function was House-Brackmann (HB) Grades I and II in 51 patients (48.57%), HB Grade III in 34 patients (32.38%), and HB Grades IV-VI in 20 patients (19.05%). Seven patients (6.3%) showed evidence of tumor regrowth on follow-up MRI. All 7 patients (100%) who showed evidence of tumor regrowth had undergone STR. No patient in the NTR group exhibited regrowth. The Kaplan-Meier plot demonstrated a 5-year tumor regrowth-free survival of 92%, with a mean disease-free interval of 140 months (95% CI 127-151 months). The follow-up period ranged from 12 to 156 months (mean 45.4 months).

The authors' report and review of the literature show that there is undoubtedly merit for NTR and STR for preservation of the facial nerve. On the basis of this they propose an algorithm for the management of incomplete VS excisions. Patients who undergo incomplete excisions must be subjected to follow-up MRI for a period of at least 7-10 years. When compared with STR, NTR via an enlarged translabyrinthine approach has shown to have a lower rate of regrowth of residual tumor, while having almost the same result in terms of facial nerve function [32)]

Iwao Yamakami et al., report the long-term outcomes and preservation of function after retrosigmoid approach removal and clarify the management paradigm for small tumors.

A total of 44 consecutively enrolled patients with small tumor and preserved hearing underwent retrosigmoid tumor removal in an attempt to preserve hearing and facial function by use of intraoperative auditory monitoring of auditory brainstem responses (ABRs) and cochlear nerve compound action potentials (CNAPs). All patients were younger than 70 years of age, had a small AN (purely intracanalicular/cerebellopontine angle tumor ≤ 15 mm), and had serviceable hearing preoperatively.

According to the American Academy of Otolaryngology Head and Neck Surgery hearing preservation reporting guidelines of the 44 patients were as follows: Class A, 19 patients; Class B, 17; and Class C, 8. The surgical technique for curative tumor removal with preservation of hearing and facial function included sharp dissection and debulking of the tumor, reconstruction of the internal auditory canal, and wide removal of internal auditory canal dura.

For all patients, tumors were totally removed without incidence of facial palsy, death, or other complications. Total tumor removal was confirmed by the first postoperative Gadolinium enhanced MRI performed 12 months after surgery. Postoperative hearing levels were Class A, 5 patients; Class B, 21; Class C, 11; and Class D, 7. Postoperatively, serviceable (Class A, B, or C) and useful (Class A or B) levels of hearing were preserved for 84% and 72% of patients, respectively. Better preoperative hearing resulted in higher rates of postoperative hearing preservation ($p = 0.01$); preservation rates were 95% among patients with preoperative Class A hearing, 88% among Class B, and 50% among Class C. Reliable monitoring was more frequently provided by CNAPs than by ABRs (66% vs 32%, $p < 0.01$), and consistently reliable auditory monitoring was significantly associated with better rates of preservation of useful hearing. Long-term follow-up by MRI with Gd administration (81 ± 43 months [range 5-181 months]; median 7 years) showed no tumor recurrence, and although the preserved hearing declined minimally over the long-term postoperative follow-up period (from 39 ± 15 dB to 45 ± 11 dB in 5.1 ± 3.1 years), 80% of useful hearing and 100% of serviceable hearing remained at the same level.

As a result of a surgical technique that involved sharp dissection and internal auditory canal reconstruction with intraoperative auditory monitoring, retrosigmoid removal of small ANs can lead to successful curative tumor removal without long-term recurrence and with excellent functional outcome. Thus, Yamakami et al., suggest that tumor removal should be the first-line management strategy for younger patients with small tumor and preserved hearing [33].

A retrospective study was performed in 333 patients with unilateral vestibular schwannoma indicated for surgical treatment between January 1997 and December 2012. Postoperative complications were assessed immediately after VS surgery as well as during outpatient followup.

In all 333 patients microsurgical vestibular schwannoma (Koos grading scale 1: 12, grade 2: 34, grade 3: 62, and grade 4: 225) removal was performed. The main neurological complication was facial nerve dysfunction. The intermediate and poor function (HB III-VI) was observed in 124 cases (45%) immediately after surgery and in 104 cases (33%) on the last followup. We encountered disordered vestibular compensation in 13%, permanent trigeminal nerve dysfunction in 1%, and transient lower cranial nerves (IX-XI) deficit in 6%. Nonneurological complications included CSF leakage in 63% (lateral/medial variant: 99/1%), headache in 9%, and intracerebral hemorrhage in 5%. We did not encounter any case of meningitis.

The study demonstrates that despite the benefits of advanced high-tech equipment, refined microsurgical instruments, and highly developed neuroimaging technologies, there are still various and significant complications associated with vestibular schwannomas microsurgery [34].

2013

In a total of 72 patients with large (≥ 3 cm) vestibular schwannomas,age of the patient and presenting symptoms such as headache, ataxia, or preoperative facial nerve dysfunction correlated with poorer facial nerve outcome ($p < 0.05$). Patients with larger tumor volumes and extrameatal growth experienced a worse outcome ($p < 0.05$). Anterior and caudal extension ($p = 0.001$) correlated with poorer outcome, as well. Intrameatal extension and bony changes of the internal acoustic meatus did not correlate with the outcome ($p > 0.05$). Of the various examined factors, preoperative facial nerve function independently predicted postoperative facial nerve outcome. Conclusion Our study suggests that young patients with small tumor volume and normal facial nerve function at presentation are more likely to experience a good postoperative facial nerve outcome. These clinical and radiological parameters can be used to predict facial nerve outcome prior to surgery [35].

A retrospective review was undertaken of 24 cases of vestibular schwannoma jointly operated upon by a team of neurosurgeons and otologists at the Suez Canal University Hospital, with assessment of VIIth and VIIIth cranial nerve function, tumour size, and extent of growth. All surgery utilised a retromastoid, suboccipital approach.

Complete tumour removal was achieved in 19 patients. Anatomical preservation of the facial nerve was possible in 66.6 per cent of patients. Pre-operative, useful hearing was present in four patients, and preserved in 80 per cent. Cerebrospinal fluid fistula was diagnosed in two (8.3 per cent) patients,

who responded to conservative therapy.

The retromastoid, suboccipital surgical approach to the skull base can be safely and successfully achieved using a microsurgical technique, with minimal or no damage to neurovascular structures, even for large tumours [36].

Thirty-two patients diagnosed with acoustic neuroma received contrast-enhanced magnetic resonance imaging of brain were recruited. The volume was calculated by the ABC/2 equation and planimetry method (defined as exact volume) at the same time. The 32 patients were divided into three groups by tumor volume to avoid volume-dependent overestimation (<3 ml, 3-6 ml and >6 ml).

The tumor volume by ABC/2 method was highly correlated to that calculated by planimetry method using linear regression analysis (R2=0.985). Pearson's correlation coefficient (r=0.993, p<0.001) demonstrates nearly perfect association between two methods.

The ABC/2 formula is an easy method in estimating the tumor volume of acoustic neuromas that is not inferior to planimetry method [37].

2012

Three hundred eighty-one patients with sporadic unilateral vestibular schwannomas and 2 or more magnetic resonance scans were included. Linear measurements were used to assess tumor size. The point of growth and pattern of growth progression were assessed. Factors influencing growth were investigated.

Approximately 33% of tumors demonstrated significant growth. Mean size at presentation was 9.9 mm (standard deviation [SD]. 4.8). For growing tumors, mean size at final review was 13.7 mm (SD, 4.8). This was a statistically significant increase in size ($p < 0.0001$). Mean annual change in size for growing tumors was 2.3 mm (SD, 2.3). 52.4% of growing tumors showed radiologically demonstrable first growth within 18 months of presentation. Approximately 7.2% of tumors showed radiologically demonstrable first growth after 5 years of follow-up. There were no demographic or morphologic predictors of growth.

Tumor growth is usually slow and is most likely to occur within the first 3 years of observation. Growth may occur after five years of follow-up. A protocol for the scanning of patients is suggested based on the findings of the study [38].

2011

Thirty-eight VS patients were split in three groups according to caloric vestibular test results before surgery; nine had a symmetrical vestibular response (vestibular normoreflexy), 19 with a decreased response of more than 20% of the affected side (vestibular hyporeflexy) and 10 with an absent caloric response on the side of the affected labyrinth (vestibular areflexy). They underwent pendular rotary vestibular testing (RVT), allowing to evaluate gain and directional preponderance of the vestibulo-ocular reflex, and a sensory organisation test (SOT), evaluating balance control in six conditions (C1

to C6). These tests were performed shortly before, and 8 and 90 days after surgery. Directional preponderance performances of patients with vestibular normoreflexy or hyporeflexy followed a classical time-course with a huge asymmetry just after surgery and a recovery to pre-operative performances at 90 days; patients with vestibular areflexy were relatively stable in time. Variation in SOT performances of patients with vestibular normoreflexy, especially in the more complex C4 to C6, followed a classical time-course with an important postural degradation just after surgery and a recovery to pre-operative performances at 90 days. Patients with vestibular areflexy showed no balance degradation just after surgery and a marked increase in performances at 90 days after surgery, especially in C5 and C6. Performances of patients with vestibular hyporeflexy were intermediate, close to performances of patients with vestibular normoreflexy before surgery and close to performances of patients with vestibular areflexy at 8 and 90 days after surgery. Pre-operative vestibular function alteration triggers an adaptive process, characterized by a restoration of the symmetry of the vestibular nuclei activity and by sensory substitution and new behavioural strategies, allowing the anticipation of unilateral vestibular deafferentation effects [39].

2009

A total of 70 vestibular schwannoma patients who were initially included in the wait and scan protocol between January 2002 and December 2003 were followed with a mean observation time of 43 months. All patients had small- or medium-sized tumors when they were included in the protocol. QOL was measured at diagnosis and at the end of follow-up in those patients who were still conservatively treated using the Short Form 36 Health Survey (SF-36). The study group was characterized by nongrowing small tumors and relatively stable symptoms over time.

MAIN OUTCOME MEASURES: Clinical, audiometric, radiologic, and QOL results.

RESULTS: In 44 patients (63%), growth of the tumor was not observed, and 25 (36%) tumors did grow. Of the 70 included patients, 27 patients (39%) required treatment. Forty-one patients (59%) were still conservatively treated at the end of follow-up (mean 47 +/- 16 mo). Hearing was preserved in 16 (57%) of the 28 patients with useful hearing at diagnosis. At the end of follow-up, SF-36 scores were only slightly deteriorated for almost all subscales when compared with scores at diagnosis; however, differences were statistically not significant ($p > 0.05$). There was no significant correlation between the presence of cochleovestibular symptoms and QOL scores ($p > 0.05$).

CONCLUSION: Conservative observation of small vestibular schwannomas may be regarded as a reasonable management option because most of these tumors do not grow during an initial period of observation. Conservative treatment of this subset of patients with small, nongrowing tumors does not significantly affect life functioning, as reflected in SF-36 survey data. However, hearing loss did progress in this population. Thus, patients should be counseled regarding this risk and generic QOL measures such as the SF-36 should be used with caution in future assessments. This study emphasizes the importance of combining generic and disease-specific QOL measures in future studies of protocols of vestibular schwannoma management [40].

From 1990 to 2005, 386 patients underwent conservative management for VS because of the following: age > 60 years, poor health/medical risks, risk of deterioration of good hearing, small tumor size, minimal or no incapacitating symptoms, and/or patient preference. Tumor size was measured by MR imaging according to the guidelines of the Committee on Hearing and Equilibrium. The first MR imaging study was performed 1 year after diagnosis, and subsequent imaging was performed yearly

or every 2 years depending on the appearance of new symptoms, tumor growth, or both.

RESULTS: Sixty-one patients were lost to follow-up the first year after presentation. Of the 325 patients for whom 1-year follow-up data were available, 39 showed tumor growth > or = 3 mm. Conservative management was discontinued for these 39 patients. The patients who returned for follow-up were evaluated at 1- or 2-year intervals depending on tumor growth. The authors extrapolated to obtain data for 2-year intervals, yielding data for 160, 56, 21, and 8 patients at 3, 5, 7, and 9 years after initial presentation, respectively. The overall mean tumor growth rate (+/-standard deviation) was 1.15 +/- 2.4 mm/year. This rate was estimated by pooling all values of tumor growth that had been determined for all patients and dividing by the total number of “events,” with each assessment constituting an event. In 58.6% of patients, the annual tumor growth rate was < 1 mm/year; in 29.2%, 1-3 mm/year; and in 12.2%, > or = 3 mm/ year. The growth rates of intrameatal (1.02 +/- 1.8 mm/year) and extrameatal (1.40 +/- 3.1 mm/year) tumors did not differ significantly. No significant association was found between tumor growth rate and sex, age, initial hearing status, or initial tumor grade. Delay in diagnosis was the only significant factor associated with tumor growth rate. During follow-up, conservative management was discontinued for 77 (23.7%) of the 325 patients for whom at least 12-month follow-up data were available; surgery was performed in 60 (77.9%) and radiation therapy in 17 (22.1%).

CONCLUSIONS: The results of this study support the role of a conservative “wait-and-scan” policy of management for small-sized VSs because most have a slow growth rate. Long-term neuroimaging follow-up is needed even with non-growing tumors [41)].

2000

158 operations via the retrosigmoid-transmeatal (RS-TM) approach with the aid of intraoperative auditory monitoring. Several auditory monitoring methods are described. Of these, the bipolar cochlear nerve action potential (CNAP) was found to be the most helpful in preserving hearing. Of 106 patients with useful hearing preoperatively, more than 50% had useful hearing after surgery. Electrical auditory brainstem responses were useful in the placement of an auditory brain stem implant (ABI) in 4 patients with neurofibromatosis type 2 (NF2). All 4 reported speech perception benefit and use their ABIs regularly in their lives. It is the firm belief that intraoperative auditory monitoring has a pivotal role in the preservation and restoration of hearing in surgery [42)].

1987

The present series deals with 176 operations performed sub-occipitally in 159 patients from 1970 up to 1985. Twelve patients were operated upon 29 times. According to the W.T. Koos classification, there were 16 type II, 39 type III and 121 type IV neuromas. Ten patients died postoperatively. In seven of these, death was related to surgery, in two it was caused by respiratory failure. In the last patient unexplained sudden death occurred. 169 patients had no facial weakness preoperatively, in 158 of these the facial nerve was anatomically preserved (93.5%). Facial nerve function was judged by evaluation of function of face at least 12 months after operation. Up to 36 months after surgery, a good facial result may be expected in cases where the facial nerve was macroscopically spared at completion of removal. Functional results have been reviewed in 151 patients according to the J.W. House's International Evaluation System, with an excellent or good result in 66 (44%), fair in 65 (43%), bad or poor in 20 (13%). The anatomical preservation of the cochlear nerve could be achieved

in 80 patients of the group of 169 in whom the auditory function had not been damaged by a previous operation. In fact, the auditory function preservation could be reasonably attempted in 79 patients: showing a hearing loss below 70 dB on tone audiometry, whatever may be the result of speech discrimination score. 59 patients (75%) of this later group had their auditory nerve preserved, 14 (18%) showed preserved hearing function postoperatively, 10 of these with a speech discrimination score over 50%. Two of these showed an improvement of preoperative hearing, two others showed a total recovery of hearing function after removal [43)].

1981

Seventy-six patients underwent the primary removal of an acoustic neurinoma at the Mayo Clinic from 1978 through 1980. Hearing loss was present in 97% of the patients, and tinnitus and dysequilibrium occurred in 70% of the patients. The most common signs were a decreased corneal reflex, nystagmus, and facial hypesthesia. In these patients, pure tone and speech audiometry are used to define the hearing loss. When hearing is still present, the speech discrimination is often disproportionately low. Acoustic reflex testing and brain stem evoked response are used to determine whether the hearing loss is cochlear or retrocochlear. When these tests could be performed in this series of patients, they were accurate in 85 to 95%. The vestibular response to caloric testing is expected to be decreased or absent in about 90% of patients, and this was so in 86% of our patients. Radiographic studies are the most important tests currently used for the diagnosis of acoustic neurinoma. Tomography of the internal auditory canal shows abnormalities in 80% of patients. Computed tomography with contrast enhancement demonstrates abnormalities in 90% of patients. The computed tomographic (CT) scan may reveal the location, the size, and often the consistency of the tumor. In cases still questionable after CT scanning, positive contrast rhombencephalography is used for clarification. In this series, no single symptom, sign, abnormal audiometric test result, or abnormal radiographic finding was present in all patients; therefore, the most important factor in diagnosis is an alert physician [44)].

1979

126 tumors have been operated by Sterkers from 1966 to 1978. The surgery was done either by the middle fossa, or the translabyrinthine, or the retrosigmoid approach. The perservation of the Facial nerve is obtained in 93%, the facial function is normal in 70%. The hearing is preserved after removal of the tumor in 50% of the intracanalar neuromas, and in 35% after removal of tumors expanded in the angle [45)].

Unclassified

Case series

2016

A retrospective study of 24 consecutive patients who underwent retrosigmoid transmeatal resection, who underwent a method of fat graft-assisted internal auditory canal (IAC) closure. They assessed

rates of postoperative Cerebrospinal fluid fistula (incisional leak, rhinorrhea, or otorrhea), pseudomeningocele formation, and occurrence of meningitis. Twenty-four patients (10 males, 14 females) with a mean age of 47years (range 18-84) underwent fat graft-assisted IAC closure. No lumbar drainages were used postoperatively. There were no instances of postoperative Cerebrospinal fluid fistula (incisional leak, rhinorrhea, or otorrhea), pseudomeningocele formation, or occurrence of meningitis. There were no graft site complications. The results demonstrate that autologous fat grafts provide a safe and effective method of IAC defect closure to prevent postoperative Cerebrospinal fluid fistula after vestibular schwannoma removal via a retrosigmoid transmittal approach [46].

2015

In 89 consecutive patients with unilateral vestibular schwannoma indicated for microsurgery. Patient and tumor related parameters, pre- and postoperative hearing level, intraoperative findings, and hearing and tinnitus handicap inventory scores were analyzed.

Cochlear nerve integrity was achieved in 44% corresponding to preservation of preoperatively serviceable hearing in 47% and useful hearing in 21%. Main prognostic factors of hearing preservation were grade/size of tumor, preoperative hearing level, intraoperative neuromonitoring, tumor consistency, and adhesion to neurovascular structures. Microsurgery led to elimination of tinnitus in 66% but also new-onset of the symptom in 14% of cases. Preservation of useful hearing and neurectomy of the eighth cranial nerve were main prognostic factors of tinnitus elimination. Preservation of cochlear nerve but loss of preoperative hearing emerged as the main factor for tinnitus persistence and new onset tinnitus. Decrease of THI scores was observed postoperatively.

The results underscore the importance of proper pre- and intraoperative decision making about attempt at hearing preservation versus potential for tinnitus elimination/risk of new onset of tinnitus.

The aim of this study was to analyze the effect of vestibular schwannoma microsurgery via the retrosigmoid-transmeatal approach with special reference to the postoperative tinnitus outcome. [47].

2010

89 patients with retrosigmoid transmeatal approach using the intraoperative electrophysiological monitoring.

Gross total resection was performed in 38 (42.7%) of the 89 patients, near total resection in 35 (39.3%), and subtotal resection in 16 (18.0%). The facial nerve was anatomically intact at the end of surgery in 83 (93.3%) patients. At 1 year after surgery, 48 (53.9%) patients had good facial nerve function (House-Brackmann (HB) Grades I-II), 23 (25.8%) patients had regular facial nerve function (HB Grades III-IV), and 18 (20.2%) patients had poor facial nerve function (HB Grades V-VI).

For large acoustic neuromas, the goal of complete tumor resection and preservation of acceptable facial nerve function can be attained via the retrosigmoid transmeatal approach, using the intraoperative facial nerve monitoring. The surgical strategy of near total resection is indicated for the large acoustic neuromas with severe adherence or inclusion in order to preserve facial nerve function [48].

2009

103 consecutive patients who had undergone VS resection were included in this study. Medical records, operation summaries, follow-up data, and neuroradiological findings were analyzed. The relationship between tumor size, location, and topography relative to the facial nerve bundles was studied for a mean duration of 16 months (range: 3-39 months).

Complete tumor resection in combination with anatomic preservation of the facial nerve was achieved in 101 (98.1%) cases. The facial nerve was fully preserved in 100% of cases with small or medium tumors and in 37/39 patients with large tumors. Overall, 83.5% of patients had normal or near-normal facial nerve function 3-12 months post-surgically. The mortality rate was 0%.

Even in large VS, preservation of facial nerve function (H-B Grade I or II) should be prioritized over total resection. For tumors >3cm, the goal of low morbidity and maintenance of normal facial nerve function can be attained with the retrosigmoid transmeatal approach, refined microsurgical technique, and intraoperative facial nerve monitoring [49].

2007

15 patients (8 females, 7 males; mean age, 37.8 years) with residual or recurrent vestibular schwannomas operated on between 1987 and 2005. These 15 patients were part of a larger series of 252 consecutive vestibular schwannoma excisions. Tumors were classified as large (10) when their diameter exceeded 3.5 cm and giant (5) when their diameter exceeded 4.5 cm. All patients had previously undergone surgery. Hearing was lost in all cases, 8 had complete facial nerve palsy, 6 had trigeminal nerve deficits, 5 had cranial nerve IX and X palsy, and 10 had ataxic gait. Twelve patients had hydrocephalus. The tumors were reoperated through the retrosigmoid-transmeatal approach. The mean postoperative follow-up was 4.9 years. Complete resection was achieved in all patients. The facial nerve was preserved in 6 of the 7 patients with preoperative facial function. Transient worsening of bulbar cranial nerves palsy occurred in 2 cases. Cerebrospinal fluid fistula occurred in 3 patients. There were no deaths, and the tumors were histologically benign. Surgical removal is the only treatment for these lesions. Total resection associated with a low morbidity rate is possible. Preservation of the facial nerve is difficult due to severe scar tissue [50].

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