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Analysis of Hearing Preservation and Facial Nerve Function for Patients Undergoing Vestibular Schwannoma Surgery: The Middle Cranial Fossa Approach versus the Retrosigmoid Approach – Personal Experience and Literature Review

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Key Words
Facial nerve · Acoustic neuroma · Vestibular schwannoma surgery

Abstract
Objective: To compare hearing preservation and facial nerve function outcomes in patients undergoing vestibular schwannoma surgery performed using either the middle cranial fossa approach (MCFA) or the retrosigmoid approach (RSA). ***Materials and Methods:*** A review of the medical records of patients diagnosed with vestibular schwannoma who underwent surgical tumor removal in a single reference center via the MCFA or the RSA between January 1988 and December 2008 was conducted. ***Results:*** During this period, 90 patients underwent surgery via the MCFA while 86 patients received surgical treatment via the RSA. Of the patients subjected to the MCFA, 80.7% were characterized by a House-Brackmann (HB) grade I or II outcome, whereas 96.5% of patients undergoing the RSA were characterized by a HB grade I or II outcome ($p = 0.001$). This difference appeared only for extrameatal tumors when we compared size-matched tumors (58.3% MCFA vs. 98% RSA; $p = 0.0006$). There was no statistically significant difference in the hearing outcomes upon consideration of hearing preservation as characterized by the modified Sanna classification system involving classes A and B (18.9% MCFA vs. 10.6% RSA; $p = 0.122$). ***Conclusion:*** No statistically significant difference in hearing preservation was identified when comparing tumors operated upon via the MCFA versus the RSA. However, our results indicate that a higher risk of facial nerve function impairment exists if the surgery is performed via the MCFA under circumstances where the tumor extends to the cerebellopontine angle.

Introduction

Vestibular schwannomas account for 6–8% of all intracranial tumors and 80% of all cerebellopontine angle (CPA) tumors [Darwish et al., 2005]. At the beginning of the last century, the mortality rate of patients undergoing vestibular schwannoma surgery for treatment was 80%. However, owing to improvements in surgical techniques, monitoring, and anesthesiology, these mortality rates have remarkably decreased to less than 1% [Sanna et al., 2004a]. The objective of this surgical procedure has subsequently shifted to complete removal of the tumor with the lowest possible morbidity [Sanna et al., 2004b].

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Table 1. Modified Sanna hearing classification

Class	PTA, dB HL	SDS, %
A	0–20	100–80
B	21–30	79–70
C	31–40	69–60
D	41–60	59–50
E	61–80	49–40
F	≥81	39–0

The PTA is obtained by averaging 4 frequencies, i.e. 0.5, 1, 2, and 4 kHz. Hearing is classified based on either PTA or SDS. A better SDS class than PTA designates the category one class higher, e.g. a patient with a 60-dB PTA and 75% SDS is classified into class C.

Table 2. AAO-HNS hearing classification

Class	PTA, dB HL	SDS, %
A	≤30	≥70
B	>30 and ≤50	≥50
C	>50	≥50
D	any level	<50

Table 3. Patient and tumor characteristics in each group

Variable	MCFA (n = 90)	RSA (n = 85)	Statistical analysis
Mean age ± SE years	44.58 ± 1.19	46.68 ± 1.05	Mann-Whitney test, p = 0.231
Sex			
Male, n (%)	39 (43.33)	46 (51.11)	χ^2, p = 0.153
Female, n (%)	51 (56.67)	39 (45.89)	
Preop HL MSC			
A, n (%)	37 (41.11)	32 (37.65)	χ^2, p = 0.879
B, n (%)	24 (26.67)	25 (29.41)	
C, n (%)	29 (32.22)	28 (32.94)	
Preop HL AAO-HNS			
A, n (%)	61 (67.78)	57 (67.05)	Fisher's test, p = 0.256
B, n (%)	29 (32.22)	25 (29.41)	
C, n (%)	0	3 (3.56)	
Mean tumor size ± SE, mm	0.9 ± 0.2	8.0 ± 0.6	Mann-Whitney test, p < 0.0001[a]

Preop HL MSC = Preoperative hearing level according to the modified Sanna classification; Preop HL AAO-HNS = preoperative hearing level according to the AAO-HNS classification.
[a] Significant.

Hearing loss and facial nerve dysfunction compromise the quality of life in patients operated for vestibular schwannoma [Noudel et al., 2009]. The postoperative outcomes for preserving facial nerve function are now higher than 90% [Arts et al., 2006]. Regarding hearing loss outcomes, a thorough comparative analysis has historically been difficult to achieve because success rates depend on an individual's concept of hearing preservation [Khrais and Sanna, 2006].

Hearing preservation in vestibular schwannoma surgery is possible using the middle cranial fossa approach (MCFA) or the retrosigmoid approach (RSA) [Staecker et al., 2000; Sanna et al., 2004b; Noudel et al., 2009; Hillman et al., 2010; Sameshima et al., 2010]. The selection of the approach depends on several factors including the tumor's size, its location, anatomical factors, the patient's age, and the surgeon's level of experience [Sameshima et al., 2010].

The MCFA and the RSA provide different angles to the internal auditory canal. However, there is some controversy about how this affects the postoperative results.

The objective of this study is to compare potential hearing loss and facial nerve function outcomes in patients undergoing surgery for vestibular schwannoma performed using either MCFA or RSA.

Materials and Methods

The study consisted of a medical record review of patients diagnosed with vestibular schwannoma and who underwent tumor removal between January 1988 and December 2008 in a neurotology and lateral skull base reference center. During this period, a total of 1897 vestibular schwannoma surgeries were performed according to the aforementioned criteria. A minimum 1-year follow-up was required for the patients' records to be deemed eligible for this study. Overall, 90 patients underwent surgery via the MCFA and 86 via the RSA.

The House-Brackmann (HB) classification system has been used to evaluate facial nerve function [House and Brackmann, 1985]. Specifically, tumor size has been classified based on the largest extrameatal diameter (mm) into groups including intrameatal (0 mm), small (1–10 mm), medium (11–20 mm), moderately large (21–30 mm), large (31–40 mm), and giant (>40 mm) according to a report by Kanzaki et al. [2003]. Preoperative and postoperative hearing results were also classified into groups according to a modification of the Sanna classification [Kanzaki et al., 2003] (table 1) and the guidelines of the American Academy of Otolaryngology-Head and Neck Surgery Committee on Hearing and Equilibrium [AAO-HNS, 1995] (table 2).

Both groups of patients in this study were compared according to age, gender, preoperative hearing capacity, and tumor size. For the statistical analysis, intrameatal tumors were considered as having a diameter of 0 mm.

Table 4. Postoperative facial nerve function – all tumor sizes

Approach	HB classification						Total
	I	II	III	IV	V	VI	
MCFA, n (%)	43 (48.9)	28 (31.8)	11 (12.5)	3 (3.4)	0	3 (3.4)	88 (100)
RSA, n (%)	73 (85.9)	9 (10.6)	1 (1.2)	0	1 (1.2)	1 (1.2)	85 (100)

At this center, the choice of the surgical approach is based on the size and location of the tumor and the patient's age and preoperative hearing level. Nowadays, patients with poor preoperative hearing (characterized by a modified Sanna classification class C, D, E or F) or with tumor diameters greater than 1.5 cm undergo procedures through the enlarged translabyrinthine approach with or without transapical extension (ETLA ± TA). Patients with tumor diameters in the CPA that are greater than 0.5 cm or who are older than 65 years of age do not undergo surgery via the MCFA (in the last 10 years, only intrameatal tumors have been removed using this approach). The RSA combined with retrolabyrinthine mastoidectomy is used when hearing function preservation is attempted in patients with tumors extending into the CPA. We perform RSA for intracanalicular tumors when the fundus is free of tumor because in this approach the facial nerve is anteriorly and medially located and less exposed. The anatomical location of the facial nerve in the internal auditory canal renders it more prone to surgical manipulation in MCFA.

Grades I and II of the HB grading system are considered to be characterized by good facial nerve function. Adequate hearing preservation was defined as a modified Sanna classification class A or B.

The statistical analysis was performed using GraphPad Prism version 5.00 for Windows (GraphPad Software, San Diego, Calif., USA). The normal distribution of the sample was evaluated using the Kolmogorov-Smirnov test when necessary. Continuous data were expressed as means ± standard error, and subsequent statistical analyses of these data were performed using the Mann-Whitney test. Nominal data were analyzed using the χ^2 test or Fisher's exact test. The level of statistical significance was set at 5% ($p < 0.05$).

Results

One patient who underwent surgery via the RSA was excluded because his follow-up examination was performed in another country, resulting in a sample consisting of 90 patients undergoing the MCFA and 85 undergoing the RSA. Of the latter 85 patients, 28 patients underwent the RSA until 2001. The remaining 57 surgical procedures in this group were performed by combining the RSA and the retrolabyrinthine approaches. In the MCFA group, charts for 2 patients failed to specify the HB classification at least 1 year after the surgery was performed. These two cases were excluded from the analysis of facial nerve function.

There were no statistically significant differences between the two groups regarding the patients' age, gender, and preoperative hearing level. However, the mean tumor size was significantly greater in the group undergoing treatment using the RSA (table 3).

The tumors removed by the MCFA were classified as intrameatal (n = 78) or small (n = 12), while the tumors removed by the RSA were classified as intrameatal (n = 16), small (n = 51), medium (n = 17), or moderately large (n = 1).

The patients who were subjected to the RSA retained good facial nerve function as determined in the postoperative period (HB I and II) in 96.5% of cases. The same analysis performed for patients who underwent surgery via MCFA resulted in significantly lower values, with 80.7% of HB I and II (χ^2, p = 0.001) (table 4). This difference appears only for extrameatal tumors if we compare tumors of the same size classification (table 5). According to modified Sanna classification system classes A and B, the more favorable results were obtained using the MCFA (18.9% for MCFA vs. 10.6% for RSA), but these data did not reveal a statistically significantly difference (χ^2, p = 0.122) (table 6). In addition, no statistically significant difference was observed upon comparison of the hearing results as a function of tumor size classes (table 7). However, according to AAO-HNS classes A and B, a statistically significant difference was achieved for a higher level of hearing preservation among patients who underwent the MCFA (χ^2, p = 0.0008) (47.8% for MCFA vs. 23.5% for RSA) (table 8). This difference was statistically significant only in the context of intrameatal tumors (table 9).

In the RSA group, there were 6 cases of postoperative cerebrospinal fluid leakage (CSF-L), which were solved with reintervention, and 1 case treated with lumbar puncture and rest. In this group, 1 case of pneumococcal meningitis that occurred 5 years following tumor removal was observed. There was also 1 case of cerebellar edema

Table 5. Postoperative facial nerve function for intrameatal and small tumors

Tumor size classification	HB classification				Statistical analysis
	HB I and II		HB III to VI		
	MCFA, n (%)	RSA, n (%)	MCFA, n (%)	RSA, n (%)	
Intrameatal	64 (84.2)	16 (100)	12 (15.8)	0	Fisher's test; p = 0.117
Small	7 (58.3)	50 (98)	5 (41.7)	1 (2)	Fisher's test; p = 0.0006*

* Significant.

Table 6. Hearing results classified according to modified Sanna classification criteria – all tumor sizes

Preoperative classes		Postoperative classes, n						A + B (%)
		A	B	C	D	E	F	
MCFA	n = 90							
A	n = 37	5	6	14	2	0	10	
B	n = 24	0	5	8	2	2	7	18.9
C	n = 29	0	1	11	3	0	14	
RSA	n = 85							
A	n = 32	3	2	4	2	1	20	
B	n = 25	1	3	7	5	0	9	10.6
C	n = 28	0	0	3	5	1	18	

A + B (%) = Percentage of patients with postoperative classes A and B according to the modified Sanna classification.

Table 7. Hearing results for intrameatal and small tumors according to the modified Sanna classification

Tumor size classification	Hearing preservation		No hearing preservation		Statistical analysis
	MCFA, n (%)	RSA, n (%)	MCFA, n (%)	RSA, n (%)	
Intrameatal	15 (19.2)	2 (12.5)	63 (80.8)	14 (85.5)	Fisher's test, p = 0.727
Small	2 (16.7)	6 (11.8)	10 (83.3)	45 (88.2)	Fisher's test, p = 0.641

with intracranial pressure elevation that required shunting. Among the patients who underwent MCFA, 2 cases presented CFS-L which spontaneously resolved in 1 case after 24 h while the second case was treated with a lumbar puncture. In this group there was also 1 case of trigeminal neuralgia. The mortality rate was zero for both groups. In addition, the cochlear nerve was sacrificed in 2 MCFA cases because of tumor infiltration. There was no case of partial tumor removal.

Discussion

The reduction in mortality related to the surgical removal of acoustic schwannoma brought up two significant and persistent challenges involving the maintenance of facial nerve function and hearing preservation [Holsinger et al., 2000; Noudel et al., 2009; Hillman et al., 2010; Sameshima et al., 2010]. These challenges increased in severity as a function of a higher number of small size schwannomas that were observed after the introduction

Table 8. Hearing results classified according to AAO-HNS criteria – all tumor sizes

Preoperative classes		Postoperative classes, n				A + B (%)
		A	B	C	D	
MCFA	n = 90					
A	n = 61	16	19	8	18	
B	n = 29	1	7	7	14	47.8
RSA	n = 85					
A	n = 57	9	8	10	30	
B	n = 25	0	3	5	17	23.5
C	n = 3	0	0	2	1	

A+B (%) = Percentage of patients with postoperative classes A and B according to the AAO-HNS classification.

Table 9. Hearing results for intrameatal and small tumors according to the AAO-HNS hearing classification

Tumor size classification	Hearing preservation		No hearing preservation		Statistical analysis
	MCFA, n (%)	RSA, n (%)	MCFA, n (%)	RSA, n (%)	
Intrameatal	39 (50)	3 (18.8)	39 (50)	13 (81.2)	Fisher's test, $p = 0.027$*
Small	4 (33.3)	15 (29.4)	8 (66.7)	36 (70.6)	Fisher's test, $p = 0.790$

* Significant.

of the magnetic resonance imaging (MRI) [Sanna et al., 1995; Brackmann et al., 2000; Noudel et al., 2009].

The Gruppo Otologico is a quaternary referral center for neurotology and lateral skull base surgery with surgical experience that includes the treatment of more than 2400 cases of vestibular schwannoma. The vast majority of these patients were operated on using the ETLA ± TA [Sanna et al., 2003]. Among those with criteria indicative of hearing preservation, until December 2008, 90 patients had undergone surgery via the MCFA while 86 were treated using the RSA. The two groups did not demonstrate a statistically significant difference regarding gender, age, or preoperative hearing level; however, the mean tumor size was significantly larger in the RSA group. Several publications indicate that the postoperative hearing status and facial nerve outcomes are correlated with the tumor size [Staecker et al., 2000; Sughrue et al., 2010]. Thus, it is necessary to compare postoperative results for size-matched tumors.

Besides the tumor's size, its localization is also important. Intracanalicular tumors approached using the RSA have the fundus free more often than cases managed by

Table 10. Comparative results of postoperative facial nerve function in the MCFA and the RSA

Reference	MCFA n	HB I or II %	RSA n	HB I or II %	Statistical significance
Irving et al., 1998	40	100	49	95.9	no
Holsinger et al., 2000	35	100	12	100	no
Staecker et al., 2000	15	93.3	15	93.3	no
Kumon et al., 2000	36	75	17	88.2	no
Arriaga and Chen, 2001	58	88	48	91	no
Moriyama et al., 2002	10	100	20	95	no
Oghalai et al., 2003	149	93.3	60	95	no
Mangham, 2004[a]	439	81[d]	177[b]	95[d]	yes
Noudel et al., 2009[c]	509	72–100	314	80–100	no
Hillman et al., 2010	88	88	50	90	no
Sameshima et al., 2010	42	100	76	100	no
Current study	88	80.7	85	96.5	yes

[a] Literature review.
[b] Patients from the author's institution and literature review.
[c] Meta-analysis including only intrameatal tumors.
[d] Percentage of patients with HB grade I.

Table 11. Postoperative facial nerve function – literature review

Reference	Approach	Patients n	HB I/II (%)
Holsinger et al., 2000	MCFA	35	100
Kumon et al., 2000	MCFA	36	75
Thomsen et al., 2000	MCFA	23	86.9
Staecker et al., 2000	MCFA	15	93.3
Arriaga and Chen, 2001	MCFA	58	88
Gjuric et al., 2001	MCFA	643	92
Kobayashi et al., 2002	MCFA	45	84.4
Moriyama et al., 2002	MCFA	10	100
Satar et al., 2002	MCFA	153	90.8
Oghalai et al., 2003	MCFA	149	93.3
Satar et al., 2003[c]	MCFA	706	92.5
Mangham, 2004[a]	MCFA	439	81
Baumann et al., 2005	MCFA	30	73.3
Arts et al., 2006	MCFA	72	96
Meyer et al., 2006	MCFA	162	97
House and Shelton, 2008	MCFA	98	89
Shiobara et al., 2008	MCFA	760	83.3
Hillman et al., 2010	MCFA	88	88
Iyer et al., 2010	MCFA	24	92
Sameshima et al., 2010	MCFA	42	100
Current study	MCFA	88	80.7
Holsinger et al., 2000	RS	12	100
Kumon et al., 2000	RS	17	88.2
Staecker et al., 2000	RS	15	93.3
Arriaga and Chen, 2001	RS	48	91
Somers et al., 2001	RS	26	96
Elsmore and Mendoza, 2002	RS	127	43.3
Magnan et al., 2002	RS	119	96
Moriyama et al., 2002	RS	20	95
Lassaletta et al., 2003	RS	65	72
Mamikoglu et al., 2003	RS	17	59
Maw et al., 2003	RS	40	90
Oghalai et al., 2003	RS	60	95
Danner et al., 2004	RS	86	89
Mangham, 2004[a]	RS	177[b]	95
Darwish et al., 2005	RS	94	53.2
Samii et al., 2006	RS	200	81
Yang et al., 2008	RS	110	91
Veronezi et al., 2008	RS	20	65
Hillman et al., 2010	RS	50	90
Sameshima et al., 2010	RS	76	100
Current study	RS	85	96.5

[a] Literature review.
[b] Patients from the author's institution and literature review.
[c] Meta-analysis.

MCFA. It should be kept in mind that comparisons made in this study are more applicable for tumor involvement in the porus.

In this cohort, 96.5% of patients preserved satisfactory facial nerve function after treatment involving the RSA, while 80.7% maintained the same results in the MCFA group 1 year posttreatment. These better outcomes for the RSA are in accordance with previous studies [Mangham, 2004; Sanna et al., 2004b]. On the other hand, some reports indicated a statistically significant difference in facial nerve function that was observed only during the first postoperative months [Irving et al., 1998; Hillman et al., 2010; Sameshima et al., 2010]; other reports failed to show any statistically significant difference [Kumon et al., 2000; Staecker et al., 2000; Arriaga and Chen, 2001; Moriyama et al., 2002; Oghalai et al., 2003; Noudel et al., 2009], while other studies achieved rates of 100% for satisfactory facial nerve function during the postoperative period for both approaches [Holsinger et al., 2000] (table 10). HB grade I and II outcomes were observed in 73.3–100% of the postoperative cases involving MCFA and in 43.3–100% of cases involving RSA as per a review of the literature from 2000 on (table 11). Our facial nerve outcomes are within the range of the largest series reported by Shiobara et al. [2008], whereas some smaller series have 100% facial nerve preservation in MCFA.

Additionally, our series showed that there is no statistically significant difference regarding postoperative facial nerve function for intracanalicular tumors. There is, however, an increased risk for patients undergoing the MCFA, specifically for the treatment of tumors that extend outside the internal auditory canal. Therefore, subsequent to the year 2000, we do not use the MCFA for hearing preservation if the tumor reaches the CPA. Satar et al. [2002] also showed that patients with tumors in the CPA that are larger than 10 mm in diameter present a higher risk of persistent facial nerve dysfunction when the MCFA is performed.

The results can vary due to differences in the experience of the staff at each medical center. However, the tumor is reached via a different angle when comparing the MCFA to the RSA. When the tumor arises from the inferior vestibular nerve, the facial nerve is typically interposed between the tumor and the surgeon if the MCFA is being performed. This condition makes it more difficult to preserve the function of the facial nerve due to the necessity of a higher mobilization of this nerve [Arriaga and Chen, 2001; Sanna et al., 2004b; Hillman et al., 2010]. In our series, the inferior vestibular nerve was the source of

Table 12. Comparative results of hearing preservation in the MCFA and the RSA

References and approaches	AAO-HNS AB %		SS	Modified Sanna AB %		SS
	MCFA	RSA		MCFA	RSA	
Irving et al., 1998; MCFA n = 50, RSA n = 50	52	14	yes	20	6	yes
Briggs et al., 2000; MCFA n = 10, RSA n = 27	80	29.6	yes	30	11.1	no
Holsinger et al., 2000; MCFA n = 35, RSA n = 12	69	33	yes	NA	NA	–
Jaisinghani et al., 2000; MCFA n = 33, RSA n = 45	42.4	8.9	yes	24.2	0	yes
Kumon et al., 2000; MCFA n = 36, RSA n = 17	52.8	47.1	no	25	17.7	no
Staecker et al., 2000; MCFA n = 15, RSA n = 15	53.5	46.7	no	33.3	40	no
Moriyama et al., 2002; MCFA n = 10, RSA n = 20	70	70	no	NA	NA	–
Oghalai et al., 2003; MCFA n = 146, RSA n = 42	47.9	19	yes	NA	NA	–
Jacob et al., 2007; MCFA n = 51, RSA n = 34	37.3	29.4	no	NA	NA	–
Noudel et al., 2009[a]; MCFA n = 529, RSA n = 314	62	58	no	NA	NA	–
Hillman et al., 2010; MCFA n = 59, RSA n = 26	59.3	38.5	yes	32.2	15.4	yes
Sameshima et al., 2010; MCFA n = 43, RSA n = 82	76.7	73.2	no	37.2	25.6	no
Sughrue et al., 2010[a]; MCFA n = 286, RSA n = 702	63	47	yes	NA	NA	–
Current study; MCFA n = 90, RSA n = 85	47.8	23.5	no	18.9	10.6	no

AAO-HNS AB % = Percentage of patients with postoperative classes A and B on the AAO-HNS classification; Modified Sanna AB % = percentage of patients with postoperative classes A and B on the modified Sanna classification; SS = statistical significance.

[a] Meta-analysis.

the tumor in 91% of cases in the group of patients in which it was possible to identify the tumor origin intraoperatively [Khrais et al., 2008]. Notably, the RSA provides the surgeon access to the tumor with an angle that is more likely to maintain facial nerve integrity via an anterior and medial position that is more distant from the tumor dissection plain in the majority of cases [Hillman et al., 2010].

Interestingly, hearing preservation appears to be the most challenging issue. The mechanisms through which hearing loss can occur during tumor dissection include myelin tension, direct trauma to the cochlear nerve, and ischemia caused by internal auditory canal vessel injury [Staecker et al., 2000]. Comparison of our data with other studies was not trivial. This difficulty was due to the variability of the selection criteria of patients undergoing hearing preservation surgery [Brackmann et al., 2000; Yang et al., 2008; Noudel et al., 2009] and the approach used to define hearing preservation, which varies among medical centers [Chee et al., 2003; Noudel et al., 2009]. For example, maintenance of the preoperative hearing level can be considered as hearing preservation. The levels of hearing in the postoperative period can also be categorized as normal [pure-tone threshold averages (PTA) $\leq$30 dB and speech discrimination score (SDS) $\geq$70%], serviceable (PTA $\leq$50 and SDS $\geq$50%), and measurable (any measurable hearing) [Sanna et al., 1995]. Preserved hearing can also be defined as any one of the aforementioned categories. Herein, the modified Sanna hearing classification system was used to characterize hearing preservation [Kanzaki et al., 2003]. Differently from the classification by the AAO-HNS, which used frequencies of 500, 1000, 2000, and 3000 Hz for the calculation of PTA, this classification is based on the frequencies 500, 1000, 2000, and 4000 Hz because this last frequency is crucial for speech intelligibility [Sanna et al., 1995]. Additional advantages of such a system are that this classification divides the postoperative results into 6 separate categories, which facilitates differentiation of the outcomes. Moreover, this system places relatively less importance on PTA in relation to the SDS, which serves as a more accurate predictor of the patients that could benefit from hearing aids [Meyer et al., 2006; Woodson et al., 2010].

The present study, in accordance with several previous studies [Sanna et al., 1987; Irving et al., 1998; Briggs et al., 2000; Holsinger et al., 2000; Jaisinghani et al., 2000; Staecker et al., 2000; Oghalai et al., 2003; Mangham, 2004; Hillman et al., 2010; Sughrue et al., 2010], showed that the overall hearing preservation rate is superior for the MCFA as opposed to the RSA when invok-

Table 13. Hearing preservation – literature review

Reference	Approach	Patients n	AAO-HNS classifications A and B[c], %	Modified Sanna classifications A and B[c], %
Brackmann et al., 2000	MCFA	333	59	33
Briggs et al., 2000	MCFA	10	80	30
Holsinger et al., 2000	MCFA	35	69	NA
Jaisinghani et al., 2000	MCFA	33	42.4	24.2
Kumon et al., 2000	MCFA	36	52.8	25
Staecker et al., 2000	MCFA	15	53.5	33.3
Thomsen et al., 2000	MCFA	23	43.5	8.7
Gjuric et al., 2001[b]	MCFA	423	44.9	27.4
Stidham and Roberson, 2001	MCFA	30	57	NA
Moriyama et al., 2002[b]	MCFA	10	70	NA
Satar et al., 2002	MCFA	135	53.3	22.2
Oghalai et al., 2003[b]	MCFA	146	47.9	NA
Satar et al., 2003[a, b]	MCFA	716	38.4	21.9
Baumann et al., 2005[b]	MCFA	22	45.5	27.3
Arts et al., 2006[b]	MCFA	62	73	33.9
Meyer et al., 2006[b]	MCFA	124	57.3	36.3
Jacob et al., 2007	MCFA	51	37.3	NA
Shiobara et al., 2008[b]	MCFA	270	46.7	NA
Noudel et al., 2009[a]	MCFA	529	62	NA
Goddard et al., 2010	MCFA	101	55.4	26.7
Hillman et al., 2010[b]	MCFA	59	59.3	32.2
Iyer et al., 2010	MCFA	24	58.3	NA
Sughrue et al., 2010[a, b]	MCFA	286	63	NA
Sameshima et al., 2010[b]	MCFA	43	76.7	37.2
Woodson et al., 2010	MCFA	49	59.2	12.2
Current study	MCFA	90	47.8	18.9
Briggs et al., 2000	RS	27	29.6	11.1
Holsinger et al., 2000	RS	12	33	NA
Kumon et al., 2000	RS	17	47.1	17.7
Jaisinghani et al., 2000	RS	45	8.9	0
Staecker et al., 2000	RS	15	46.7	40
Magnan et al., 2002	RS	119	30	14.5
Moriyama et al., 2002[b]	RS	20	70	NA
Chee et al., 2003	RS	126	34.1	NA
Lassaletta et al., 2003[b]	RS	29	17	0
Mamikoglu et al., 2003	RS	17	23	6
Maw et al., 2003	RS	40	37.5	12.5
Oghalai et al., 2003[b]	RS	42	19	NA
Yates et al., 2003[b]	RS	64	6.3	0
Danner et al., 2004[b]	RS	86	27.9	NA
Mohr et al., 2005	RS	128	24.2	NA
Jacob et al., 2007	RS	34	29.4	NA
Cohen, 2008	RS	96	43.8	NA
Yang et al., 2008[b]	RS	99	37.4	14.1
Noudel et al., 2009[a]	RS	314	58	NA
Yamakami et al., 2009	RS	22	63.6	9.1
Hillman et al., 2010[b]	RS	26	38.5	15.4
Sughrue et al., 2010[a, b]	RS	702	47	NA
Sameshima et al., 2010[b]	RS	82	73.2	25.6
Current study	RS	85	23.5	10.6

NA = Not available. [a] Meta-analysis. [b] Only patients with preoperative AAO-HNS classification classes A and B were included. [c] Percentage of postoperative classes A and B in relation to the total number of patients included.

ing the concept of serviceable hearing (SDS $\geq$50% and PTA $\leq$50 dB HL) (table 12). However, this difference is statistically significant only for intrameatal tumors. There is no statistically significant difference in the context of the concept of normal hearing (SDS $\geq$70% and PTA $\leq$30 dB HL; modified Sanna classification classes A and B). We believe that this concept represents the true measurement of hearing preservation. The vast majority of vestibular schwannoma patients are characterized by unilateral hearing loss, with the contralateral hearing possessing normal or better hearing compared to the affected ear. The rationale for hearing preservation should be to preserve the affected ear's ability to participate in binaural hearing, which enables sound localization and suppression of background noise, facilitating speech comprehension in noisy conditions and overcoming the head shadow effect. Moreover, the interaural hearing difference should not exceed 25 dB for functional binaural hearing [Darwish et al., 2005; Khrais and Sanna, 2006].

We compared our results with some representative studies that included the possibility of controlling the results using the AAO-HNS classification system or the modified Sanna classification, a nontrivial process due to the different criteria used for determining which approach to implement under the any given set of circumstances (MCFA or RSA). The results of some published reports are correlated with the total number of patients, regardless of their preoperative hearing level. In other studies, only patients with classes A and B (AAO-HNS) were considered for analysis. The percentage of patients registered includes those in either class A or class B of the modified Sanna classification or of the AAO-HNS classification. The rate of patients subjected to the AAO-HNS classification system (class A or B) in the postoperative period ranged from 37.3 to 80% for the MCFA and from 6.3 to 73.2% for the RSA, respectively. If we specifically take into consideration the modified Sanna classification system (classes A and B), the rate decreased to 8.7 and 37.2% for the MCFA and to 0 and 25.6% for the RSA, respectively (table 13). Our results are within the range reported by other centers regarding hearing preservation. This indicates that while the results regarding facial nerve function are satisfactory for both approaches, the likelihood of preservation of a useful postoperative hearing level is still very low. The advances in instrumentation for hearing monitoring such as the fast auditory brainstem response (ABR) and the cochlear nerve action potential have failed to improve hearing outcomes [Piccirillo et al., 2008].

The incidence of complications for each method should be taken into consideration when choosing the surgical approach for tumor removal. In the present cohort, which has a very low rate of complications, the number of events involving postoperative CFS-L was higher in the RSA group (8.2% for the RSA vs. 2.2% for the MCFA), but the difference was not statistically significant (p = 0.071). Beginning in 2001, we introduced a combination of the RSA and the retrolabyrinthine mastoidectomy (RS-RL). This combined procedure involves a process by which air cells between the facial nerve and the sigmoid sinus are removed by drilling, preserving the dura intact. The incidence of CFS-L following the introduction of the RS-RL was reduced to 1.8% [Falcioni et al., 2008].

Conclusions

Analysis of the hearing outcomes of patients undergoing vestibular schwannoma surgery performed either via the MCFA or the RSA with the aforementioned criteria indicated that the rate of hearing preservation is still not encouraging. Meanwhile, satisfactory facial nerve function is preserved in a high percentage of patients undergoing both treatment approaches.

In our analysis, no statistically significant difference in hearing preservation was identified for tumors operated on via the MCFA or the retrosigmoid/retrolabyrinthine approach. There was a clear tendency for better facial nerve results after RSA compared to MCFA in this study, although this could not be substantiated with statistical analyses for size-matched intrameatal tumors. We emphasize a higher risk of facial nerve function impairment if the surgery is performed using the MCFA if the tumor extends into the CPA.

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Disclosure Statement

We certify that there is no conflict of interest with any financial organization regarding the material discussed in this paper.

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