HEARING PRESERVATION SURGERY IN VESTIBULAR SCHWANNOMA: THE HIDDEN TRUTH

MARIO SANNA, MD
PIACENZA, ITALY

TAREK KHRAIS, FRCS(I), DHSM
IRBID, JORDAN

ALESSANDRA RUSSO, MD
PIACENZA, ITALY

ENRICO PICCIRILLO, MD
PIACENZA, ITALY

ANGELA AUGURIO, MD
PIACENZA, ITALY

To compare the results of hearing preservation surgeries using different approaches — the enlarged middle cranial fossa approach and the retrosigmoid approach — and different classification systems, stressing the importance of preserving "normal hearing," we performed a retrospective case review in a tertiary care medical center. The charts of 107 patients with vestibular schwannoma who underwent tumor resection were reviewed. Hearing preservation was reported according to 2 different classification systems: the modified Sanna classification and the classification of the American Academy of Otolaryngology–Head and Neck Surgery. The facial nerve results were graded according to the House-Brackmann scale. The hearing preservation rates differed markedly depending on the classification used. We conclude that hearing preservation in acoustic neuroma is a more difficult proposition than most surgeons appreciate, especially in terms of serviceable hearing.

KEY WORDS — complication, hearing classification, hearing preservation, normal hearing, vestibular schwannoma.

INTRODUCTION

The history of vestibular schwannoma (VS) surgery has passed through different stages, with different aims during each stage. In the beginning, the main aim was to reduce the mortality rate, and the introduction of microsurgery made it feasible to preserve the function of the facial nerve (FN). With the introduction of contrast magnetic resonance imaging, VSs are being discovered at early stages when hearing is still present, posing a new challenge to surgeons: preservation of hearing. And now, with the development of complex intraoperative hearing monitoring, most surgeons have started seeking the grandeur of success of hearing preservation without considering the usefulness of the hearing levels being preserved. In our opinion, achieving such a critical result should begin by adopting a classification system that reflects more accurately what kind of hearing is being preserved.

In this study, we report and evaluate our data using 2 different classification systems. The first is the modified Sanna classification, which was approved during the Acoustic Neuroma Consensus on Systems for Reporting Results.[1] The second is the commonly used classification of the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS).[2] After reporting the data, we compare the results, stressing the need for a detailed classification that reflects the results in a more accurate manner, and the need for the presence of a cutoff point that signifies the usefulness of preserved hearing.

The two principal hearing preservation approaches are the middle cranial fossa approach (MCFA) and the retrosigmoid approach (RSA). In our study, we present 107 cases of hearing preservation surgery for VS performed by the senior author (M.S.), and then we compare the two approaches regarding hearing preservation, FN function, and complications.

MATERIALS AND METHODS

Patients. Of the 793 VS operations performed at our center (Gruppo Otologico Piacenza-Rome) in the period from July 1987 to July 2002, there were 107 hearing preservation procedures (Table 1). Of these, there were 5 procedures performed in 4 cases of neurofibromatosis type 2 (NF2). Fifty-nine of the 107 procedures were by the MCFA, 43 were by the RSA, and 5 were by the retrolabyrinthine approach. Because of the similarities of results and approaches, we pre-

TABLE 1. AGE AND SEX DISTRIBUTION OF PATIENTS

	Age Range (y)	*Sex*	*No.*
Total	15-64	M	59
		F	48
MCFA (59 patients)	15-61	M	31
		F	28
RSA (48 patients)	23-64	M	28
		F	20

MCFA — middle cranial fossa approach, RSA — retrosigmoid approach.

CORRESPONDENCE — Mario Sanna, MD, Gruppo Otologico Piacenza-Rome, Via Emmanueli 42, 29100 Piacenza, Italy.

TABLE 2. SANNA CLASSIFICATION

Class	*PTA (dB)*	*SDS (%)*
A	0-20	100-80
B	21-40	79-60
C	41-60	59-40
D	61-80	39-20
E	81-100	19-0
F	>100	

PTA — pure tone average, SDS — speech discrimination score.

sent the retrolabyrinthine and retrosigmoid cases as one group. The age range of the patients was from 15 to 64 years, with an average of 44.6 years. Fifty-seven of the patients were male, and 45 were female. All of the procedures were carried out by the senior surgeon (M.S.).

Preoperative Workup. All of the cases in our series were diagnosed by either high-resolution computed tomography with contrast administration or gadolinium-enhanced magnetic resonance imaging, and all underwent preoperative hearing assessment by pure tone audiometry with average thresholds at 0.5, 1, 2, and 4 kHz, speech discrimination score (SDS), and auditory brain stem response (ABR) audiometry.

Selection Criteria. Earlier in our practice, we used a classification system proposed by Sanna et al (Table 2) in which cases were considered for hearing preservation surgery when they were either class A or B. During the past 2 years, we started applying the modified Sanna classification (Table 3), considering patients for hearing preservation surgery only if the hearing is better than 30 dB and the SDS is more than 70%. In cases of an only hearing ear or NF2 and in some cases in which the patient's occupation requires binaural hearing, these criteria can be loosened and patients in higher classes can be considered for hearing preservation surgery. We prefer the age of the patient to be less than 65 years.

Tumor size was determined as the largest extrameatal diameter of the tumor; the intrameatal tumor was designated size 0.[3] Those patients with tumors that reached the fundus of the internal auditory canal and were less than 0.5 cm extrameatal were operated on by the MCFA, whereas the RSA was reserved for tumors that did not reach the fundus. Regarding the size limit of the tumors operated on by the latter approach, we used to include tumors as large as 2 cm extrameatal, but we found that the results were unsatisfactory and we tightened the limits. Now, we only operate on tumors ranging from 0.5 to 1.5 cm.

TABLE 3. MODIFIED SANNA CLASSIFICATION

Class	*PTA (dB)*	*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

TABLE 4. AMERICAN ACADEMY CLASSIFICATION

Class	*PTA*		*SDS (%)*
A	≤30 dB	and	≥70
B	>30 dB, ≤50 dB	and	≥50
C	>50 dB	and	≥50
D	Any level		<50

Another factor that we evaluate before hearing preservation surgery is the preoperative ABR audiometry results. The criteria we consider are the presence or absence of waves I, III, and V, in addition to interaural latencies for both wave V and the I-V interval, of which we consider the upper limits to be 0.2 ms and 0.3 ms, respectively. Although we evaluate these criteria in every patient, we consider them to be only adjuvant factors in deciding whether to carry out a hearing preservation operation.

Intraoperative Monitoring. Facial nerve monitoring was carried out for all of our patients who underwent VS surgery. The monitoring system we use now in our center is the electromyographic (NIM 2 Xomed Treace, Jacksonville, Florida) system.

We started the use of hearing function monitoring in February 1998, and for that purpose we use a real-time ABR monitor, which enables us to obtain the results within 5 seconds instead of the usual 2 to 3 minutes. We also monitor the cochlear nerve action potential via a monopolar electrode made of silver woven threads with a terminal cottonoid at the contact point with the cochlear nerve. The monitoring machine we use is the MK 12 (Amplaid, Milan, Italy).

RESULTS

Fifty-nine patients in our series were operated on

TABLE 5. RESULTS ACCORDING TO MODIFIED SANNA CLASSIFICATION

	MCFA				*RSA*			
	Preop		*Postop*		*Preop*		*Postop*	
Class	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
A	22	37.3	0	0.0	22	45.8	1	2.1
B	13	22.0	4	6.8	13	27.1	7	14.6
C	16	27.0	17	28.8	4	8.3	10	20.9
D	8	13.7	7	11.9	8	16.7	1	2.1
E	0	0.0	5	8.5	1	2.1	3	6.2
F	0	0.0	26	44.0	0	0.0	26	54.1
	59		59		48		48	

TABLE 6. RESULTS ACCORDING TO AMERICAN ACADEMY CLASSIFICATION

	MCFA				*RSA*			
	Preop		*Postop*		*Preop*		*Postop*	
Class	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
A	35	59.0	4	6.8	35	69.7	8	16.7
B	23	39.0	15	25.4	9	18.7	7	14.6
C	1	1.7	10	16.9	4	8.3	4	8.3
D	0		8	13.5	0		7	14.6
Dead ears			22	37.3			22	45.8

by the MCFA, and 48 by the RSA. The hearing results were reported by 2 different hearing classification systems. The first is the system we use at our center for selection of patients for hearing preservation surgery: the modified Sanna classification (Table 3). The second is the classification of the AAO-HNS (Table 4). The results obtained with each classification are shown in Tables 5 and 6. Postoperative class A or B was obtained in 32.2% of the MCFA patients and in 31.3% of the RSA patients when the AAO-HNS grading scheme was used. These figures dropped to 6.8% and 16.7%, respectively, when the modified Sanna system was applied. Tables 7 and 8 show the details of all of our patients in whom any hearing was preserved.

The FN grade according to the House-Brackmann classification was recorded at discharge and at 3 months for all of the patients. The FN follow-up at 1 year was missing for 10 patients, 8 of whom had not completed the postoperative year at the time of this

TABLE 7. HEARING RESULTS FOR MIDDLE CRANIAL FOSSA PATIENTS FOR WHOM ANY MEASURABLE HEARING WAS PRESERVED

No.	*Date*	*Age (y)*	*Sex*	*Tumor Size (cm)*	*Preop PTA (dB)*	*Preop SDS (%)*	*Postop PTA (dB)*	*Postop SDS (%)*
1	Sep 26, 2000	43	F	0.5	15	100	23	100
2	Jul 25, 2001	52	F	IC	15	100	25	100
3	Apr 27, 1998	43	M	IC	22	100	26	100
4	Jul 9, 1988	37	M	0.7	21	100	27	100
5	Jul 9, 2001	61	M	0.5	17	100	32	100
6	Jan 18, 2001	33	M	IC	15	100	32	100
7	Dec 5, 2001	51	M	0.4	22	100	32	100
8	Feb 3, 1997	26	M	IC	12	100	32	100
9	Jun 6, 2001	38	M	IC	15	100	33	100
10	Jun 7, 2001	43	M	0.3	15	100	36	100
11	Nov 11, 1998	50	F	IC	37	100	37	100
12	Jun 18, 2002	49	F	IC	25	100	37	100
13	Sep 19, 2001	53	M	IC	40	100	40	100
14	Mar 14, 1994	48	F	IC	20	100	41	100
15	Apr 1, 1996	36	F	IC	35	90	44	100
16	May 20, 1996	57	F	IC	26	100	48	70
17	Jul 9, 1996	56	F	IC	36	80	50	70
18	Sep 13, 2000	46	M	IC	15	100	50	100
19	Apr 16, 1997	28	M	0.2	12	100	50	80
20	Nov 16, 2000	50	M	1	15	100	55	50
21	Jun 20, 2001	43	M	IC	20	100	57	100
22	Nov 19, 1997	58	M	0.7	32	100	60	90
23	Nov 27, 1989	48	F	0.1	37	60	60	90
24*	Feb 22, 1997	15	M	IC	27	100	61	90
25	Feb 22, 1999	25	M	IC	10	100	61	100
26	Feb 14, 2002	43	M	IC	41	100	64	100
27	Oct 14, 1991	24	F	0.6	31	100	67	100
28	Mar 23, 1998	49	M	IC	42	100	69	90
29	Jul 19, 1993	41	F	IC	10	100	71	0
30	Sep 30, 1998	47	F	IC	20	100	72	40
31	Jul 7, 1993	51	F	0.3	21	100	76	0
32	Jul 23, 1998	46	M	IC	25	100	77	40
33	Jul 6, 1992	55	M	IC	55	70	81	70
34	Jul 24, 2002	53	M	IC	31	100	89	30
35	Jun 19, 1997	40	M	IC	46	100	102	0
36	Apr 9, 2001	37	M	IC	22	100	105	40
37	Sep 4, 1995	31	M	IC	39	100	116	0

IC — intracanalicular.
*Neurofibromatosis type 2.

TABLE 8. HEARING RESULTS FOR PATIENTS WITH RETROSIGMOID APPROACH

No.	*Date*	*Age (y)*	*Sex*	*Tumor Size (cm)*	*Preop PTA (dB)*	*Preop SDS (%)*	*Postop PTA (dB)*	*Postop SDS (%)*
1	May 11, 1999	34	F	IC	15	100	16	100
2	Dec 13, 2001	52	F	0.5	20	100	22	100
3	May 30, 1994	50	M	IC	15	100	24	100
4	Jan 9, 1995	24	M	0.8	21	100	25	100
5	May 22, 2002	54	F	1	20	100	25	100
6	Jun 29, 1992	48	M	1	15	100	26	80
7	Sep 29, 1999	35	F	IC	15	100	30	100
8	Dec 16, 1999	40	M	0.8	20	100	30	100
9	Nov 28, 2001	51	M	0.5	21	100	34	100
10	Feb 15, 2001	52	F	1.4	26	100	37	100
11	Apr 21, 1997	23	F	1.5	11	100	40	90
12	May 15, 2001	49	F	0.5	23	100	45	100
13	Oct 25, 2001	43	M	1	25	100	45	100
14	Jun 8, 1992	51	F	0.8	51	100	49	70
15	Mar 22, 2001	43	F	0.5	15	100	50	100
16	Feb 22, 1993	57	M	0	35	90	53	90
17	Apr 20, 1998	45	M	0.8	41	100	55	80
18	Oct 10, 1994	26	M	0.8	26	100	57	70
19	Jan 24, 2001	63	F	1.4	46	90	63	70
20	Jun 11, 2001	61	M	IC	35	100	66	15
21	Feb 22, 1989	41	M	0.5	51	20	67	20
22	Jan 11, 2001	47	M	2	65	80	80	10
23	May 30, 2002	63	F	0.5	30	100	86	10
24	Feb 6, 2002	48	M	1	20	100	90	0
25	Feb 26, 1990	50	M	0.9	56	80	94	0
26	Jun 1, 1992	57	M	0.8	47	100	115	0

study. The remaining 2 patients were lost to follow-up.

Except for 1 patient who was operated on by the MCFA and had an FN grade of 4, all of the patients available for follow-up had grade 3 or better after 1 postoperative year. When comparing the available results of the 2 groups, the RSA patients had better FN results: 83% of them (34 cases) had grade I results, 12% (5 cases) grade II, only 5% (2 cases) grade III, and none had grade IV or more. On the other hand, the rates for the MCFA patients were 39.2% (22 cases) with grade I results, 12.5% (7 cases) grade II, 46.5% (26 cases) grade III, and 1.8% (1 patient) grade IV; there were none with grade V or VI results (Table 9).

TABLE 9. FACIAL NERVE RESULTS FOR 97 PATIENTS

Grade	*MCFA* *No.*	*MCFA* *%*	*RSA* *No.*	*RSA* *%*
1	22	39.2	34	83
2	7	12.5	5	12
3	26	46.5	2	5
4	1	1.8	0	0
5	0	0	0	0
6	0	0	0	0
Total	56		41	

Total was 107 patients, but 8 had not completed 1-year follow-up and 2 were missing to follow-up.

The complication rate was low overall. The most common complication was a cerebrospinal fluid (CSF) leak, which occurred in 9 patients: 8 RSA patients and 1 MCFA patient. Of the 9 CSF leaks we had in our series, none occurred in patients in whom hearing was preserved — a fortunate outcome, because it left all options of treatment open. Medical management in the form of lumbar drainage stopped the leak in the MCFA case and in 1 of the RSA cases. The remaining 7 cases required surgical management. Five cases were treated by obliteration of the middle ear space with a free fat graft and closure of the eustachian tube. In 1 case, the tract of the leak was identified and closed. In the last case, a defect in the dura was identified as the route of the leak, and it was closed.

Other complications included a case of meningitis that preceded a CSF leak in 1 of the RSA cases and a case of cerebellar edema after an RSA that led to a rise in intracranial pressure and required a shunting procedure. In 2 MCFA cases, the cochlear nerve was sacrificed because of tumor infiltration. In this series, we had 1 residual tumor after an MCFA. This was a case of NF2, and the residual tumor was left on the cochlear nerve on purpose to preserve the hearing because the ABR and cochlear nerve action potential were present at the end of the operation and the pa-

TABLE 10. POSTOPERATIVE HEARING PRESERVATION RATES ACCORDING TO AMERICAN ACADEMY AND MODIFIED SANNA CLASSIFICATION SYSTEMS

			American Academy				Modified Sanna			
			Class A		Class B		Class A		Class B	
Authors	No.	Approach	No.	%	No.	%	No.	%	No.	%
Post et al[7]	56	RSA	2	3.6	13	23.2	0	0.0	2	3.6
Moffat et al[13]	50	RSA	1	2.0	3	6.0	1	2.0	0	0.0
Mazzoni et al[12]	150	RSA	9	6.0	22	14.7	3	2.0	6	4.0
Arriaga et al[14]	34	MCFA	15	44.1	8	23.5	9	26.5	6	17.6
	26	RSA	7	26.9	7	26.9	3	11.5	4	15.4
Cohen et al[15]	152	RSA	9	5.9	20	13.2	8	5.2	3	2.0
Brackmann et al[16]	24	MCFA	8	33.3	7	29.1	3	12.5	5	20.8
Goel et al[17]	42	RSA	10	23.8	2	4.7	5	11.9	5	11.9
Current study	48	RSA	8	16.7	7	14.6	1	2.1	7	14.6
	59	MCFA	4	6.8	15	25.4	0	0.0	4	6.8

tient had bilateral VSs. Now the patient is under follow-up. Another patient operated upon by the MCFA presented with a recurrence 5 years after the operation. This patient is also being followed up.

DISCUSSION

Until recently, we classified the hearing of VS patients undergoing hearing preservation surgery by using Sanna's classification (Table 2). The reason we used this classification and not the commonly used AAO-HNS classification is that the latter uses only 4 rough categories for hearing, in which class A requires 30 dB and a 70% SDS and the second-best category, class B, requires 50 dB and a 50% SDS. Thus, it fails to separate normal hearing and subnormal but socially serviceable hearing, increasing the chance of reporting a significant hearing deterioration as "not changed" or "preserved." This classification frequently results in a false sense of success in hearing preservation when in fact, in most interventions near the cochlear nerve, the patient is left with at least a slight decrease that might shift hearing into the nonfunctional levels. This problem is especially apparent with a disorder such as VS, in which most patients present to medical care with a unilateral hearing loss and contralateral hearing that is normal or at least significantly better than the affected side.

This opinion is strongly supported by our results (Tables 5 and 6), as well as by the results of other authors if this particular aspect is focused upon. Nadol et al[4] reported 85% of patients to have a deterioration in hearing level of at least 15 dB, and Samii and Matthies[5] reported that 75% to 85% of patients, depending on the preoperative hearing level, were downgraded after operation by at least 1 grade, which stands for a 30-dB deterioration according to their classification. In a comparative analysis among different centers, Mangham and Skalabrin[6] stated that overall, 74% of patients had their hearing preserved; they defined hearing preservation as a decrease or increase of 20 dB in the preoperative hearing level, without providing the exact percentage of patients in whom a postoperative deterioration of hearing took place. These results signify that the contribution of such an already-impaired ear to hearing in the presence of a better-functioning ear will most likely be further decreased by the intervention.

The modified Sanna classification[1] (Table 3) constricts class B to include only patients with a hearing level in the range of 21 to 30 dB and an SDS in the range of 79% to 70%, thereby limiting the number of candidates for such surgery and refining the boundaries of success.

In studying our results with the AAO-HNS and modified Sanna hearing classifications (Tables 5 and 6), we can see that applying the AAO-HNS system, and considering any measurable hearing level as a successful result as some authors do, we have hearing preservation rates of 62.7% in MCFA and 54.2% in RSA, which are comparable to other results in the literature.[7-12] Another commonly used criterion is the so-called 50-50 rule, which includes both class A and class B of the AAO-HNS and which is supposed to define the level of useful hearing. Using this definition, we have a rate of 32.2% in MCFA and 31.3% in RSA. On the other hand, using the modified Sanna hearing classification system, in which success is taken to be either class A or B, we found a 0% class A rate and a 6.8% class B rate in the MCFA group. The figures are 2.1% and 14.6% for classes A and B, respectively, in the RSA group. In spite of the fact that the patients of this group are strictly selected on the basis of a good preoperative hearing level, we can see that the likelihood of preservation of a useful postoperative hearing level is still very low — a fact that reflects the difficulty of actual hearing preservation and deserves serious consideration by other clinicians.

TABLE 11. HEARING PRESERVATION AND COMPLICATION RATES FOR RETROSIGMOID APPROACH

Authors	*No. of Patients*	*Hearing Preservation Rate (%)**	*CSF Leak (%)*	*Facial Nerve Grade 1 or 2 (%)*	*Residual Tumor (%)*	*Other Complications (%)*
Post et al[7]	56	48.2	18	96	7	Foot drop 1.8 Transient diplopia 1.8 Transient swallowing difficulties 1.8
Harner et al[18]	335	16.5 (out of 273)	11.9	58	2.4	Meningitis 4.8 Aspiration 2.4 Hemorrhage 1.8 Vocal cord paralysis 1.5 Death 0.6
Samii and Matthies[5]	1,000	39.5 (out of 732)	9.2	59	2.1	Headache 9 Swallowing difficulties 4.5 Meningitis 3 Hemorrhage 2.2 Death 1.1
Moffat et al[13]	50	18	NM	86	2.3	NM
Mazzoni et al[12]	150	45.3	10	85.3	3.3	Cerebellar malacia 15.2 Death 1.3
Holsinger et al[11]	12	33	16.6	100	16.6	NM
Irving et al[10]	50	34	NM	95.9	NM	NM
Fischer et al[19]	102	28.4	2.9	63.7	6.7	Death 2.9 Thrombophlebitis 1
Shelton et al[20]	15	57	13	100	NM	Meningitis 7
Cohen and Ransohoff[21]	20	40	15	95	5	Meningitis 15 Hemorrhage 5
Magnan et al[22]	119	48.7	NM	96.6	NM	Headache 1.7 Cranial nerve VI palsy 0.8
Current study	48	54.2	16.7	95	0	Cerebellar edema 2 Meningitis 2 No other complications

Some figures have been extrapolated from reported results.
CSF — cerebrospinal fluid, NM — not mentioned in paper or rate given is not detailed enough to be used for population mentioned.
*Criterion used is any measurable hearing.

In order to make sure that the results obtained with the application of the modified Sanna classification to our series are not caused by an unnoticed confounding variable, we analyzed the results of some other authors who have reported the preoperative and postoperative hearing details of their patients. We submitted their data to a comparison of classes A and B of the AAO-HNS to those of the modified Sanna hearing classification (Table 10[7,12-17]), and the results were similar to ours, namely, a marked reduction of the achieved preservation of useful hearing.

In light of the above discussion, we perceive that any attempt at preservation of such hearing should be measured against the added risk of morbidity of the hearing preservation operation. In order to explore this point, we reviewed a number of publications that addressed the topic of hearing preservation, and formulated Tables 11[5,7,10-13,18-22] and 12,[9-11,16,23-28] which include the hearing preservation rate in the form of any measurable hearing, as that was the most commonly presented criterion. We include in these Tables the rates and types of complications, if given. Examining these Tables, one can appreciate the high rate of CSF leaks, residual tumors, and other neurologic complications. Our data show that although the rate of complications in our patients who underwent hearing preservation surgery was similar to the rates presented in Tables 11 and 12, in our hands the non–hearing preservation approach, namely, the translabyrinthine approach (TLA), offers a much better chance of avoiding complications. Instead of a CSF leak rate of 16.7% as in RSA, we had a CSF leak rate of 0% in our last study,[29] which included 200 consecutive TLA operations and an overall CSF leak rate of 1.4% (unpublished data) with the TLA. In an attempt to reduce this high rate of CSF leaks in RSA, we devised a combination, the retrosigmoid-retrolabyrinthine ap-

TABLE 12. HEARING PRESERVATION AND COMPLICATION RATES FOR MIDDLE CRANIAL FOSSA APPROACH

Authors	No. of Patients	Hearing Preservation Rate (%)*	CSF Leak (%)	Facial Nerve Grade 1 or 2 (%)	Residual Tumor (%)	Other Complications (%)
Weber and Gantz[9]	49	68.8	6.2	93.9	NM	Headache 4
Holsinger et al[11]	35	69	11.4	100	5.7	Subdural hematoma
Irving et al[10]	50	64	NM	100	NM	Single seizure 2
Satar et al[23]	153	47*	NM	90.8	6.5	NM
Gjuric et al[24]	735	26.5*	2.2	92	2.9	Temporary neural deficit 5.7 Meningitis 1.2 Death 0.4 Cerebellopontine angle hemorrhage 0.3 Temporal contusion 0.3 Seizure 0.1
Slattery et al[25]	151	68	7	95	NM	Meningitis 2
Brackmann et al[26]	333	80	NM	NM	NM	NM
Wade and House[27]	20	35	NM	95	NM	NM
Brackmann et al[16]	24	84	0	91.6	0	Epidural hematoma 4.1
Russo et al[28]	27	54	3.7	63	0	0
Current study	59	62.7	1.7	51.7	3.4	0

Some figures have been extrapolated from reported results.

*Criterion used is any measurable hearing except in reports of Satar et al[23] and Gjuric et al,[24] in which value written is that of classes A and B according to classification of American Academy.

proach. In this combination, besides the usual RSA, we add the drilling of all of the air cells between the FN and the sigmoid sinus, keeping the dura in that area intact. The preliminary results show a marked reduction: only 1 case of CSF leak in the last 16 operations using this combination, as compared to 7 cases in the rest of the group. This reduction did not reach statistical significance because of an insufficient number of operated cases, and so this trial is still under assessment.

For the MCFA, the rate of CSF leak was 1.7% (1 of 59 cases). The difference between the two approaches, MCFA and RSA, could be explained by the increased likelihood of missing some open air cells in the area of the internal auditory meatus and the retrosigmoid area after retrosigmoid surgery.

Another major source of morbidity in hearing preservation surgery is the high rate of FN dysfunction after MCFA operations; we had a rate of only 50% when grades 1 and 2 were considered in the long term. That is in contrast to 95% in RSA and, for tumors of similar sizes, 82.6% in TLA. This difference of FN preservation rates between the TLA and MCFA approaches can be explained by the fact that in MCFA, the FN lies between the surgeon and the tumor, which in most instances arises from the inferior vestibular nerve[30,31] and thus is at an increased risk during surgery. At this point, we would like to stress that the assessment of the FN grade should be done by an experienced surgeon on the operating team, preferably not the same surgeon who has done the surgery, to eliminate bias — and of course, never by the patient, in whom the lack of experience could lead to misclassification, especially between successive classes such as 2 and 3, in which a slight difference could affect the grade. In addition, we introduced photographic documentation of the FN function that includes 4 photographs of the face: at rest, closing the eyes forcefully, opening the mouth to show teeth, and wrinkling the nose. Those 4 views are documented at every visit in order to facilitate realistic follow-up of the patient and avoid interobserver misjudgment.

Another serious complication that we faced was 1 case of cerebellar edema resulting from cerebellar retraction following an RSA operation; it led to raised intracranial pressure that required shunting.

Other complications included 2 cases of sacrifice of cochlear nerves that were found to be infiltrated by tumor during surgery. There was 1 case of residual tumor that was intentionally left over the cochlear nerve to preserve the hearing in a patient with NF2 who had bilateral tumors. There was another case of recurrence that manifested 5 years after operation. Both of these latter cases occurred after an MCFA.

CONCLUSIONS

Hearing preservation, although a laudable aim of

VS surgery, takes second place to the recognized goal of safe and total tumor excision, especially in light of the frequency and usefulness of the preservation of hearing. We have introduced a new system of classifying hearing in such endeavours that attempts to optimize hearing preservation in these patients. We believe this new classification addresses this issue in a practical and accurate manner.

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