

OTOLOGY

Hearing preservation surgery in acoustic neuroma: long-term results

Risultati a lungo termine nella chirurgia di preservazione dell'udito nel neurinoma dell'acustico

A. MAZZONI¹, E. ZANOLETTI², V. CALABRESE³

¹ Neurosurgery Dept. Ospedali Riuniti, Bergamo, Italy; ENT Dept. Humanitas Milano-Rozzano, Italy; ENT-Otochirurgia Dept., University of Padova, Italy; ² ENT-Otochirurgia Dept., University of Padua, Italy; ³ ENT Dept. Ospedale degli Infermi, Rimini, Italy

SUMMARY

Long-term hearing was examined in 200 patients operated on during 1976-2000 with removal of acoustic neuroma with a retrosigmoid approach and hearing preservation technique. Ninety-four cases preserved hearing, and 91 cases were followed-up for at least 6 years (range 6 to 21 years). Hearing was measured with the PTA 0.5 KHz to 4 KHz and the SDS, and followed the guidelines of the American Academy of Otolaryngology and Head Neck Surgery (AAOHNS classification). Change (or stability) of the short to long-term class was the main outcome measure. Postoperative hearing of class A and B was preserved at long-term and within class B in 87% of cases. A total of 13% presented a decrease of class to C or D. Small size and good preoperative good correlated with good short- and long-term hearing.

KEY WORDS: Hearing preservation surgery • Surgery for acoustic schwannoma • Long-term hearing results

RIASSUNTO

Oggetto dello studio è stata la valutazione dell'udito a lungo termine dopo rimozione di neurinoma del nervo stato-acustico con approccio retro sigmoideo con tecnica di preservazione della funzione uditiva, in riferimento a 200 casi operati negli anni 1976-2000. Sono stati studiati 91 dei 94 casi con udito conservato e la durata del controllo è stata non inferiore a 6 anni (da 6 a 21 anni). Quali indicatori di funzionalità uditiva sono stati utilizzati la media tonale da 0,5 a 4 KHz (PTA) e la discriminazione vocale (SDS), riunite in classi secondo le indicazioni dell'American Academy of Otolaryngology and Head Neck Surgery Guidelines (AAOHNS). Il cambio o il mantenimento della classe a lungo rispetto a quella a breve termine è stato il principale indicatore di risultato, con particolare riferimento alla classe A-B. L'udito postoperatorio in classe A-B è rimasto entro i limiti della classe B a lungo termine nell'87% dei casi. Il 13% ha avuto un decadimento di classe a C o D. Una buona preservazione della funzione uditiva a breve e lungo termine è stata confermata in caso di piccole dimensioni del tumore e buon udito preoperatorio.

PAROLE CHIAVE: *Chirurgia di preservazione dell'udito • Chirurgia del neurinoma dell'acustico • Risultati uditivi a lungo termine*

Acta Otorhinolaryngol Ital 2012;32:98-102

Introduction

Surgery of small acoustic neuroma aims at minimal brain and facial nerve morbidity. The attempt to preserve hearing has become the next step in all the modalities of treatment, including surgery, radiotherapy or observation. Hearing preservation surgery (HPS) has made important progresses with an increase of good preserved hearing and minor chance of total loss of hearing. Nonetheless, the long-term stability preserved hearing is still unclear. The several reports on the stability of preserved hearing with widely divergent rates. Shelton et al.¹ significant long-term decline of hearing after middle cranial fossa approach in 56% of patients. In a later publication², no decline of preserved hearing was reported in 23 cases after 5 years of follow-up. Woodson et al.³ reported minimal

decline of hearing after a follow-up of at least two years. Divergent outcomes were reported with a retrosigmoid approach⁴⁻⁸, with declines ranging from 40%⁷ to 17.6%⁶. No correlation was found^{4,5,8} between the loss of hearing quality and patient's age and symptoms, tumour size or preoperative hearing. Several theories for hearing decline have been proposed including microscopic tumour recurrence or disorder of blood supply to labyrinth or internal auditory canal. Fibrosis and scarring of the meotomy area are a common finding at MRI, and may cause vascular insult. It is possible that the scarring is more pronounced as a consequence of fat or muscle graft packing of the internal auditory canal^{1,6,7} acting either through a mechanical or a vascular insult. Endolymphatic hydrops secondary to damage of the endolymphatic duct has also been mentioned as a possible cause⁹.

Materials and methods

Case material

Our experience with HPS involves 322 cases of sporadic acoustic neuroma which underwent intervention in the same institution (ENT Department Ospedali Riuniti Bergamo) by the same surgeon (A.M.). Table I summarizes the cases from 1976 to 2009 as well as the three phases of HPS, each one characterized by increasingly restrictive criteria to select patients for hearing preservation. A study on long-term hearing outcome was carried out in 2006 on the first series of 200 cases, which was the object of a previous article¹¹ with shorter follow-up on the first 150 cases. Seven cases of intrameatal tumour operated upon with the middle cranial fossa approach were excluded due to their small number. The follow-up is 6 to 21 years as the first cases with preserved hearing date to 1985. There were 194 class A or B cases, 4 class C and 2 class D. Size of tumour was expressed in mm of the largest diameter in cerebello-pontine angle at contrast MRI and with the separate group of intrameatal tumours (Table II). The C class cases had a size of 1.5, 5 and 6 mm. The D class cases had sizes of 10 and 11 mm. The procedure used was a retrosigmoid approach with retrolabyrinthine meatotomy¹⁰ as described earlier. Follow-up data are reported in Table III.

Table I. Hearing preservation surgery (1976-2009) in 322 cases. Guidelines for inclusion were size of tumour and hearing.

Series	Inclusion criteria Ø, PTA/SDS	No. of cases	Short-term preserved hearing (A-B class)
I (1976-2000)	≤ 20 mm, 50/50	207	27%
II (2000-2002)	≤ 15 mm, 30/70	51	32%
III (2002-2009)	≤ 10 mm, 30/70	64	50%

Table II. Average size in mm of intrameatal and cerebellopontine angle tumour.

	i.m.	0-10	11-15	16-20	> 20 (21-32)
No. of cases	25	92	48	17	18

Table III. Follow-up data.

I series (1976-2000) 200 cases	
Follow-up 1985-2006 cases*	6-21 years
Mean/ median	14/9 years
No. cases with preserved hearing	94
No. cases with long-term follow-up	91 (97%)

* First cases with preserved hearing date to 1985.

Outcome measure and reporting

Hearing outcome measurements were done using the pure tone average (PTA) from 500 to 4000 Hz and the speech discrimination score (SDS) obtained at an intensity of 40 db over detection or less¹¹. The cases were grouped in 4 classes according to the guidelines of the American Academy of Otolaryngology and Head Neck Surgery (AAOHN)¹¹, where class A refers to a PTA of 30 db or less and SDS of 70 or better, class B at least 50 PTA/50 SDS, class C any PTA and at least 50 SDS, class D any level of PTA and less than 50 SDS. Long-term outcome was expressed by PTA, SDS and the change of hearing class. The outcome data are reported as follows:

- number and rate of the cases with measurable postoperative hearing;
- the postoperative spreading to equal or different class for every preoperative class, both in the short- and long-term;
- the rate of a postoperative class for every preoperative class, e.g. postoperative A/preoperative A and, as the A/B classes were considered good/useful hearing, the outcome of class A was expressed with the cumulative datum of postop A+B/preoperative A;
- the loss of hearing involving a decrease in class was also expressed as a change to the next lower class, i.e. the change of class A to B and class B to C. This event was reported as the rate of A+B/B and rate B+C/B;
- the outcome in relation to size of tumour;
- the change to new class for each short-term class.

Results

Ninety-four of 200 cases (47%) preserved measurable postoperative hearing, and 91 underwent long-term follow-up (97%). Table IV reports the short- and long-term global hearing outcomes. Each preoperative class either remained in the class or dropped to a lower class with a different rate depending on the previous level, i.e. a better class shows a trend to a lesser loss. The rate of class preservation was similar for class A or B, but if the change to the next lower class was considered, the trend to a loss of hearing was different. The A class cases stayed in A or B in 39 of 89 of cases (44%) in the short-term, and in 46 of 89 (40%) in the long-term. The class B cases stayed in class B or C in 25 of 100 patients (25%) in the short-term, and in 22 of 100 patients (22%) in the long-term. If the change of class was considered, class A cases stayed in A in 92% of patients (12 of 13), and class B cases remained in same class in 73% of patients (11 of 15). Altogether, cases in classes A-B remained in classes A or B in 87% (47 of 54) of cases.

Table V reports the outcome in relation to size of tumour in the group with measurable postoperative hearing and in the group of A or B cases in the short- and long-term. The 107 cases with a 10 mm tumour and class A or B

Table IV. Global postoperative outcome according to AAOHNS classification.

Hearing class (N)	Short-term					Long-term					Lost	Tot.
	A	B	C	D	(Anacusis in D)	A	B	C	D	(Anacusis in D)		
A (89)	13	26	5	45	(36)	12	24	6	45	(38)	–	87
B (100)	1	14	10	75	(65)	–	11	11	78	(70)	1	101
C (7)	–	–	2	5	(2)	–	–	1	6	(2)	–	7
D (4)	–	–	–	4	(3)	–	–	–	3	(3)	2	5
Total (200)	14	40	17	129	(106)	12	35	18	132	(113)	3	200

Table V. Outcome of hearing in relation to size in 94 patients with measurable postoperative hearing, in the short- and long-term (cases with class AB).

	No. of cases	Size of tumour				
		i.m. 25	1-10 92	11-15 48	16-20 17	> 20 (21-32) 18
Measurable hearing	94	11	54	16	8	5
Short-term	53	7	32	7	6	1
Long-term	47	8	24	8	6	2

hearing remained in class A or B in 49 cases (33%) in the short-term and in 42 cases (27%) in the long-term. The patients with a small tumour preserved hearing class in about 1 in 3 cases, while hearing was preserved in patients with a large tumour in one over 6, 8 and 18 cases at the size limit of 15, 20 and 32 mm respectively. Change of class at short- to long-term follow-up occurred in 18 cases (19%) (Table VI), with three cases lost to follow-up (one was class B and two were class D at short-term, 23%). The change of class change was less in the A-B classes (8/54, 15%) or 9/54 (17%) if the lost case is included. The short-term A-B cases remained in class A or B (i.e. within the 50 PTA and 50% SDS) in 47 of 54 cases (87%), with a loss of useful hearing occurring in 13% of cases. The

cases without a drop of class were 74 of 91 (81%) or 74 of 94 (79%) if the three cases lost to long-term follow-up were included.

Discussion

We assessed the stability of the preserved hearing, as it is linked to the impact of the lesion, surgical trauma and age. One interesting question is whether any operative event, such as physical insult, reduction of blood supply to the cochlea and nerves, post-surgical scars, change in chemical balance of the internal auditory canal, contribute to the physiological, age-related worsening of hearing.

This also relates to the current dilemma on the optimal therapy of small acoustic schwannoma, which nowadays represents the majority of cases¹². It is also of interest to better understand how to transfer the advantages of early diagnosis of small acoustic schwannoma into less morbidity. Surgical morbidity in acoustic schwannoma is represented by impairment of the facial nerve and hearing. The realistic evaluation of the so-called “conservative” therapies, i.e. observation^{13 14} and radiotherapy^{15 16}, has shown that they cannot be properly considered conservative, if the final result also includes treatment failures. The surgical treatment of a tumour that shows growth during the wait and see period, or after being treated by radiation, involves postoperative hearing loss and a higher risk for the facial nerve^{17 18}. This does not allow considering such therapies as truly “conservative” which, in case of failure, are not associated with a rate of functional suc-

Table VI. Change of class (19 cases, 3 lost to follow-up) in the short- to long-term.

Short-term class	Change to class	No. of cases/ short-term cases
A	B	1/13
B	C	3/40
B	D	3/40
C	D	2/17
D	Anacusis	7/23
C	D	1/17
D	C	1/40
B	Lost	1/40
D	Lost	2/23

cess that they claim to have. The morbidity of observation and radiotherapy, as conceived during the entire course of treatment, seems to be superior to the surgical morbidity of a tumour operated on after early diagnosis¹⁹.

This stresses the role of HPS and the importance of long-term outcome of preserved hearing. In our series (1976-2000), there is hearing stability in 87% of class A+B cases, with a worsening between the short- and long-term assessment in 13% of patients, and a global outcome of class A or B in 47 of 189 cases (25%). This rate compares unfavourably with our later experience¹⁹, and reflects the different selection criteria which included cases with worse hearing, together with less skilled surgery and lack of monitoring.

The favourable effect of the small tumour size on hearing preservation is evident in Table V. The preservation of class in A or B class was 44% in the short-term and 40% in the long-term. The A+B classes remained in A or B in 29% of cases in the short-term and in 25% in the long-term. The lesser decline of hearing at long-term in patients with larger tumours does not allow any definite conclusions due to the small number of cases.

Bechten et al.⁸ stated that the postoperative hearing occurs in an idiosyncratic fashion, and that preoperative and short-term postoperative hearing may predict a late loss, but not always. In our experience, similar to that reported by others³, a positive trend was found between the quality of short-term postoperative hearing and its long-term stability. Smaller tumour size and good preoperative hearing correlated with better short-term postoperative hearing in our experience (Table V). It would appear that a cochlear nerve in good anatomic-functional condition, as it relates with a small size of tumour and favourable audiological tests, allows better short- and long-term hearing. A small tumour size means less involvement of the tumour with the nerve as well as less insult at dissection. The experience of the surgeon may also have a favorable influence.

The rate of long-term hearing can support a role of HPS if it is better than obtained with observation or radiotherapy. Our results show a rate of classes A and B in 29% (54/189) of cases with preserved short-term hearing, which declines to 25% (47/189) in the long-term. Classes A and B together remain stable in the long-term in the B class in 87% (47/54) of cases. The class A dropped to class B in 14% (2/14) of cases, while class B dropped to C or D in 12.5% (5/40) of patients.

Despite this limited decline, the long-term outcome in this first series was not better than with observation or radiotherapy, and it appears to be related more to the limited rate of short-term preservation than to the slight temporal decline. However, during follow-up of the present series, the rate of HPS improved in the second and third series in patients with smaller tumours and good hearing (Table I)¹⁹. The global rate of short-term AB class cases changed from 27%, to 32% and then 50%. The change was more evident for the cases ≤ 10 mm which had a short-term AB rate of

83% when the preoperative PTA was 20 db, and 66% with a preoperative PTA of 30 db. A follow-up of at least 4 years was available in 23 cases, and showed a decrease of hearing class in only one case. The trend towards a smaller temporal decline than the first series needs further study, but, even with the rate of decline of the present series, the long-term outcome should make current HPS a good, and perhaps the first, treatment option with the least morbidity.

Conclusions

The long-term changes in preserved hearing was assessed in a series of 94 cases with 6 to 21 years of follow-up. At the short-term, good or useful hearing was preserved at a rate of 29% to 44% depending on the preoperative hearing, and decreased to 25-40% in the long-term. It appears that preservation/loss were related more to surgery, as shown at the short-term, rather than to time itself, as shown in the long-term. This led to the further stage of hearing preservation surgery with success rates of 66-83% for ≤ 10 mm and 20-30 PTA tumors. Further study can determine whether an expected long-term loss similar to the series we reported will occur and corroborate the role of hearing preservation surgery among conservative treatments.

Experience has taught that hearing preservation surgery involves a loss of hearing in both the short- and long-term, but within the limits of a convenient choice of treatment. Stable preservation of the anatomic-functional condition of the cochlear nerve is the goal of surgery that can be pursued both before and during surgery. At the preoperative stage, patients with small tumours and good hearing as determined with tone and speech audiometry and auditory brainstem responses should be selected, while during surgery, skilled dissection through experience and real-time monitoring is advocated.

References

- Shelton C, Hitselberger WE, House WF, et al. *Hearing preservation after acoustic neuroma removal: long term results*. *Laryngoscope* 1990;10:115-9.
- Friedmann RA, Kesser B, Brackmann DE, et al. *Long term hearing preservation after middle fossa removal of vestibular schwannoma*. *Otolaryngol Head Neck Surg* 2003;129:660-5.
- Woodson AE, Dempewolf RD, Gubbels SM, et al. *Long-term hearing preservation at the microsurgical excision of vestibular schwannoma*. *Otol Neurotol* 2010;31:1144-52.
- McKenna MJ, Halpin C, Djemann RG, et al. *Long term hearing results in patients after surgical removal of acoustic tumors with hearing preservation*. *Am J Otol* 1992;13:134-6.
- Tucci D, Telian SA, Kilenny PR, et al. *Stability of hearing preservation following acoustic neuroma surgery*. *Am J Otol* 1994;15:183-8.
- Umezumi H, Aiba T, Tsuchida S, et al. *Early and late postoperative hearing preservation in patients with acoustic neuromas*. *Neurosurgery* 1996;39:267-72.

- ⁷ Chee GH, Nedzelski JM, Rowed D. *Acoustic neuroma surgery: the results of long-term hearing preservation*. Otol Neurotol 2003;24:672-6.
- ⁸ Bechten SA, Walsh J, Post KD. *Long-term hearing preservation after surgery for vestibular schwannoma*. J Neurosurg 2005;102:6-9.
- ⁹ Atlas MD, Harvey C, Fagan PA. *Hearing preservation in acoustic neuroma surgery: a continuing study*. Laryngoscope 1992;102:779-83.
- ¹⁰ Mazzoni A, Calabrese V, Danesi G. *A modified retrosigmoid approach for direct exposure of the fundus of the internal auditory canal for hearing preservation in acoustic neuroma*. Am J Otol 2000;11:98-109.
- ¹¹ American Academy of Otolaryngology-Head and Neck Surgery. *Committee on hearing and equilibrium guidelines for the evaluation of hearing preservation in acoustic neuroma (vestibular schwannoma)*. Otolaryngol Head Neck Surg 1995;113:179-80.
- ¹² Stangerup SU, Tos M, Thomsen J, et al. *True incidence of vestibular schwannoma?* Neurosurgery 2010;67:1335-40.
- ¹³ Graamans K, Van Dijk JE, Jansen LW. *Hearing deterioration in patients with a non-growing vestibular schwannoma*. Acta Otolaryngol 2003;123:51-4.
- ¹⁴ Stangerup SE, Thomsen J, Tos M, et al. *Long-term hearing preservation in vestibular schwannoma*. Otol Neurotol 2010;31:271-5.
- ¹⁵ Lin VYW, Stewart C, Grebenyuk J, et al. *Unilateral acoustic neuroma: long term hearing results in patients managed with fractionated stereotactic radiotherapy, hearing preservation surgery and expectancy*. Laryngoscope 2005;115:292-6.
- ¹⁶ Yang I, Sughrue ME, Seunggu JH, et al. *A comprehensive analysis of hearing preservation after radiosurgery for vestibular schwannoma*. J Neurosurg 2010;112:851-9.
- ¹⁷ Slattery WH, Brackmann DE. *Results of surgery following stereotactic irradiation for acoustic neuromas*. Am J Otol 1995;16:315-21.
- ¹⁸ Friedmann RA, Cullen RD, Hitselberger WE, et al. *Surgical salvage after failed irradiation for vestibular schwannoma*. Laryngoscope 2005;115:1827-32.
- ¹⁹ Mazzoni A, Biroli F, Foresti C, et al. *Hearing preservation surgery in acoustic neuroma: slow progress and new strategies*. Acta Otolaryngol Ital 2011;31:76-84.

Received: March 3, 2012 - Accepted: March 21, 2012