Eur Arch Otorhinolaryngol (2007) 264:115–120
DOI 10.1007/s00405-006-0168-x

OTOLOGY

Petrous bone cholesteatoma: clinical longitudinal study

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Received: 6 February 2006 / Accepted: 3 August 2006 / Published online: 3 November 2006

Abstract The object of this retrospective study was to describe a series of patients with petrous bone cholesteatomas, paying particular attention to classification, diagnosis, surgical strategy, results, complications and recurrences. Furthermore, the study was designed to evaluate the impact of imaging techniques on an early diagnosis. Topographically, the petrous bone cholesteatomas of the present series were grouped using Sanna's classification and different surgical approaches were used. High resolution CT and/or MRI were used to follow-up the patients. The case notes of 52 patients with petrous bone cholesteatomas who were referred to our hospital for surgery between 1987 and 2003 were reviewed postoperatively. There were 45 primary cases and 7 recurrences. The facial nerve had been infiltrated and compressed by the cholesteatoma in 18 patients. Fourteen were managed with cable grafts using sural nerve or great auricular nerves. About 26 patients with preoperative grade I confirmed their normal facial function in 23 cases. In the other ten patients, the preoperative facial paralysis was due to compression by the cholesteatoma and its removal provided partial recovery of facial function in four patients. Our study compared two observation periods (1987–1996 and 1997–2003) when the diffusion and the availability of imaging techniques in our national health system had considerably increased. Two important factors emerged: firstly, the number of less extensive surgical approaches was higher in the more recent observation period, proving that cholesteatomas smaller in size had been diagnosed. Secondly, preoperative facial paralysis was less frequent in the same period—falling to 25% of cases of total facial paralysis from the 45.8% of the earlier period—practically half as much. The partial paralyses instead increased slightly, demonstrating that otologists have become more sensitive to and pay more attention to this symptom.

Keywords Petrous bone cholesteatoma · Facial paralysis · Hearing loss · Skull base

Introduction

Petrous bone cholesteatoma is not a common pathology that may cause severe functional damage and may negatively affect the quality of life of the patients [1–12]. It is known to frequently invade the labyrinth and Falloppian canal causing facial nerve paralysis and permanent hearing loss. It may also involve all the anatomical structures within the temporal bone with the risk of damaging structures vital for life (internal carotid artery, jugular vein, sigmoid sinus, dura).

The object of this study was to describe a series of patients with petrous bone cholesteatomas, paying particular attention to classification, diagnosis, surgical strategy, results, complications and recurrences.

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Furthermore, the study was designed to evaluate the impact of imaging techniques on an early diagnosis.

Materials and methods

The case notes of 52 patients with petrous bone cholesteatomas who were referred to our hospital for surgery between 1987 and 2003 were reviewed postoperatively. There were 45 primary cases and 7 recurrences. The group consisted of 31 men and 21 women. Their mean age was 43.7 years ranging from 18 to 72 years. About 35 patients were referred to our department from other hospitals.

Preoperatively, 35 patients had chronic discharge of the ear. Otoscopic examination revealed 13 normal tympanic membranes, 11 epitympanic perforations and 12 subtotal or total perforations. The other patients had a history of previous otologic surgery (radical mastoidectomy, open tympanoplasty or closed tympanoplasty).

Hearing impairment was distributed among 18 cases of dead ears, 21 of mixed hearing loss in different degrees, 5 of conductive hearing loss and 1 sensorineural hearing loss. Seven had normal hearing.

The major symptom was facial nerve paralysis in 28 patients, 18 of which had a preoperative grade V and VI paralysis according to the House–Brackmann system [13]. In the remaining patients facial function showed the following distribution: 1 grade II, 5 grade III and 4 grade IV paralysis.

Topographically, the petrous bone cholesteatomas of the present series were grouped using Sanna's classification [6] and different surgical approaches were used [14–18] (Table 1; Figs. 1, 2).

High resolution CT and/or MRI were used to follow-up the patients [19]. Each patient had had regular imaging (at least every year after surgery) to monitor the risk of recurrence. The follow-up was on average 7.8 years ranging from 14 months to 16 years.

Table 1 Petrous bone cholesteatoma classification (sanna) and surgical approaches

Petrous bone cholesteatomas	A	B	C	D	E
Supralabyrinthine	5	11	3	–	–
Infralabyrinthine	–	12	3	–	–
Massive labyrinthine	–	–	10	2	–
Infralabyrinthine–apical	–	1	2	–	1
Apical	–	–	–	–	2

A Transtemporal supralabyrinthine approach, *B* subtotal petrosectomy, *C* transotic approach/translabyrinthine, *D* transcochlear approach, *E* infratemporal type B or A/B

Data were statistically evaluated using multiple chi-squared tests. A value of $P < 0.05$ was considered to be significant.

Results

In all patients the petrous bone cholesteatoma was totally removed. Recurrences were identified in four patients (two within 2 years, one after 5 years and the last one after 8 years). One had been operated via a middle fossa/transmastoid approach, two via a subtotal petrosectomy without blind sac closure of the external auditory canal and obliteration of the eustachian tube and one via a transcochlear approach.

Postoperative hearing with pure-tone averages in the frequency range of 250–800 Hz showed an increase in the patients with total deafness and a marked reduction in the patients with normal hearing (Table 2).

The facial nerve had been infiltrated and compressed by the cholesteatoma in 18 patients (ten patients observed and treated in the first decade; eight patients managed during the observation period 1997–2003). Fourteen were managed with cable grafts using sural nerve or great auricolar nerves. Of these, two patients were treated using a facial–hypoglossal anastomosis due to failure of the previous graft or due to the long-standing paralysis (Table 3).

In the remaining patients a so called "baby sitter" [20], two-stage procedure was preferred: first stage, 30% of the hypoglossal cranial nerve anastomized with facial nerve at the stilomastoid foramen in order to obtain adequate bulk of the facial muscles plus cross facial interposition sural nerve grafts for coaption of the selected branches of the normal facial nerve between the normal and deteriorated sides; second stage, the peripheral branches of the paralysed facial nerve usually coupled with the cross facial grafts (after 9 months).

In the other ten patients, the preoperative facial paralysis was due to compression by the cholesteatoma and its removal provided partial recovery of facial function in four patients (one from grade II to I, two from grade III to II and one from grade IV to III). The others did not improve (Table 4).

Finally, the 26 patients with preoperative grade I confirmed their normal facial function in 23 cases. The final facial results of the remaining cases showed grade III facial palsy in two cases and grade IV in one case (Table 5).

Intraoperatively, nine patients had involvement of the vertical and/or horizontal segment of the carotid artery. Cholesteatoma was removed with no anatomic or functional lesions.

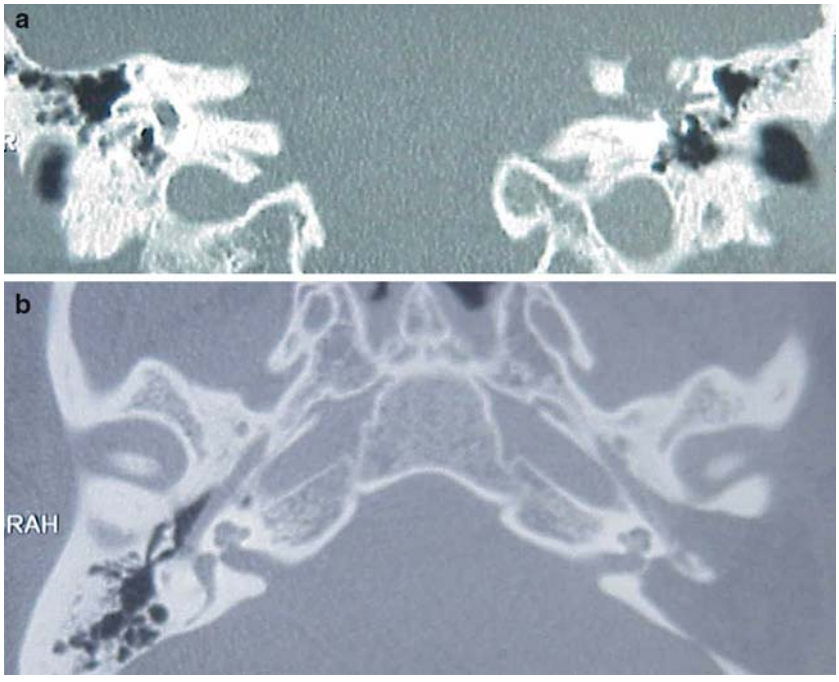

Fig. 1 CT scan. Preoperative (**a**) supralabyrinthine petrous bone cholesteatoma. Postoperative (**b**) translabyrinthine approach

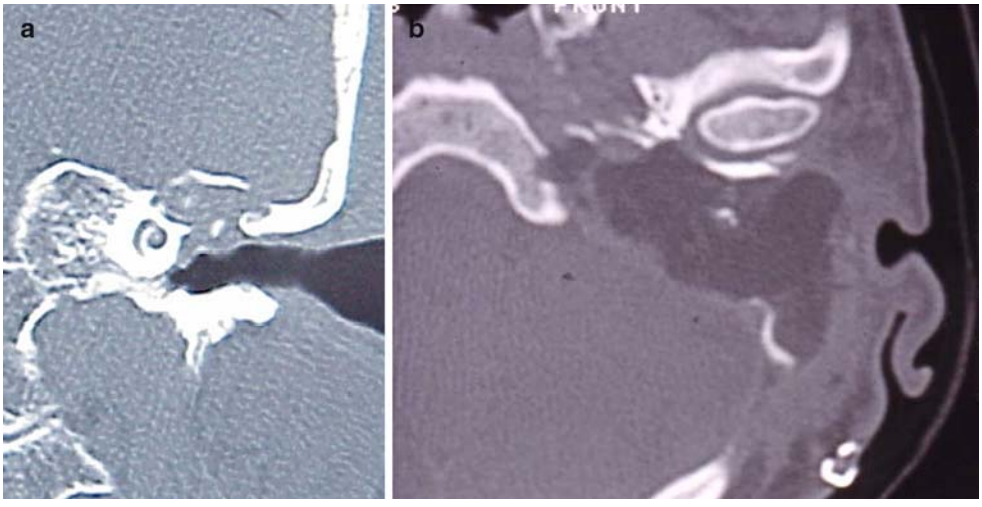

Fig. 2 CT scan. Preoperative (**a**) massive petrous bone cholesteatoma. Postoperative (**b**) transcochlear approach

Table 2 Preoperative and postoperative hearing with pure air-tone averages

	Preoperative	Postoperative
Normal	4	2
Conductive hearing loss	12	9
Mixed hearing loss	24	21
Sensorineural hearing loss	1	1
Dead ear	11	19

The sigmoid sinus and jugular bulb were ligated and removed to eradicate adherent and undetachable cholesteatoma in four patients.

Table 3 Preoperative total facial paralysis (18 patients) and postoperative facial function

House–Brackmann	Sural nerve grafts	VII–XII anastomosis	Baby sitter
Grades I–II	–	–	–
Grades III–IV	8	2	1
Grades V–VI	6	–	1

CSF leakage following removal of the cholesteatoma from the dura with bipolar cautery occurred in three patients and it was managed conservatively.

The clinical findings of the petrous cholesteatomas regarding the site, the surgical approach and the pre- and

Table 4 Preoperative partial paralysis (ten patients)

House–Brackmann	Preoperative	Postoperative
Grade I	–	1
Grade II	1	2
Grade III	5	4
Grade IV	4	3
Grade V	–	–
Grade VI	–	–

Table 5 Preoperative normal facial function (26 patients)

House–Brackmann	Preoperative	Postoperative
Grade I	26	23
Grade II	–	–
Grade III	–	2
Grade IV	–	1
Grade V	–	–
Grade VI	–	–

postoperative hearing and facial function in the first and second decades were compared in order to evaluate the eventual impact of the diffusion of imaging techniques (CT or MRI) on an earlier diagnosis.

In Tables 6 and 7, the distributions of the site and the surgical approaches in the first decade and in the following years are summarized. It is interesting to note that in the first decade the cholesteatomas were more extensive requiring wider approaches. Chi-squared test was statistically significant compared with the second decade ($P < 0.1$). In the following years the number of subtotal petrosectomies increased. It should be stressed that five of these were combined with partial labyrinthectomy (three patients had hearing preservation).

Clinically, this is confirmed by the preoperative symptoms with a reduction of the incidence of facial paralysis in the period 1997–2003 (Table 8) ($P < 0.5$).

In contrast, the incidence of hearing impairments (Table 9) remained stable and no difference ($P < 0.4$) was seen.

Table 6 Classification and type of surgical approach (decade 1987–1996)

Petrous bone cholesteatomas	A	B	C	D	E
Supralabyrinthine	2	3	2	–	–
Infralabyrinthine	–	4	2	–	–
Massive labyrinthine	–	–	5	1	–
Infralabyrinthine–apical	–	–	1	–	1
Apical	–	–	–	–	2

A Transtemporal supralabyrinthine approach, *B* subtotal petrosectomy, *C* transotic approach/translabyrinthine, *D* transcochlear approach, *E* infratemporal type B or A/B

Table 7 Classification and type of surgical approaches (decade 1997–2003)

Petrous bone cholesteatomas	A	B	C	D	E
Supralabyrinthine	3	8	1	–	–
Infralabyrinthine	–	8	1	–	–
Massive labyrinthine	–	–	5	1	–
Infralabyrinthine–apical	–	1	1	–	–
Apical	–	–	–	–	–

A Transtemporal supralabyrinthine approach, *B* subtotal petrosectomy, *C* transotic approach/translabyrinthine, *D* transcochlear approach, *E* infratemporal type B or A/B

Table 8 Preoperative facial paralysis

	Total paralysis (grades V–VI)	Partial paralysis (grades II–IV)
1987–1996	11 (45.8%)	4 (16.7%)
1997–2003	7 (25%)	6 (21.4%)

Discussion

Cholesteatoma of the petrous bone represents a complex challenge for the otologist both from a diagnostic and a therapeutic angle [1–12]. Its slow silent growth, in particular in the congenital form, may cause in many cases a delay in its diagnosis, which is only clear when the damage is considerable and clinically involves structures important for quality of life (facial nerve, acoustic nerve).

The advent of CT and MRI has strongly influenced the diagnostic procedure of this pathology, ensuring the information essential for its proper identification, evaluating its spread and to what extent the various anatomical structures in the temporal bone are involved and also allowing the surgical strategy to be planned [19]. From a careful review of the literature, however, it is not clear whether imaging techniques actually do allow for an early diagnosis that would reduce substantially the frequency of complications and at the same time ensure less complicated, less extensive and therefore less risky surgical approaches to be made. To evaluate this particular aspect, our study compared two observation periods (1987–1996 and 1997–2003) when the diffusion and the availability of imaging techniques in our national health system considerably increased.

Two important factors emerged: firstly, the number of less extensive surgical approaches was higher in the more recent observation period, proving that cholesteatomas smaller in size had been diagnosed. Secondly, preoperative facial paralysis was less frequent in the

Table 9 Preoperative and postoperative hearing with pure air-tone averages

Petrous bone cholesteatomas	Preoperative		Postoperative	
	1987–1996	1997–2003	1987–1996	1997–2003
Normal	2	2	1	1
Conductive hearing loss	5	7	4	5
Mixed hearing loss	11	13	9	12
Sensorineural hearing loss	–	1	–	1
Dead ear	6	5	10	9

same period falling to 25% of cases of total facial paralysis from the 45.8% of the earlier period, practically half as much. The partial paralyses instead slightly increased.

It is interesting to note that in one of our previous studies on a group of petrous bone cholesteatoma patients treated by 1995, the frequency of preoperative total paralyses was 62.5% of the whole survey, whereas currently this percentage has dropped to 33%, just below the 37% reported by Bartels [5] and the 42.5% by Sanna et al. [6].

An early diagnosis with preservation of the facial nerve is the best way to maintain optimal facial function. Once damage to the nerve has developed, the recovery, even with grafting techniques, hypoglossal facial anastomosis or the "baby sitter" procedure (in spite of the latter ensuring better synchronism of the facial movements with less synkinesis and more natural smile), can never provide a normal or a near-normal facial function [20]. It is important to emphasize that in the first decade 43% of the patients underwent facial nerve grafting with various techniques. In contrast, only 27% of the patients of the second decade need facial nerve reconstruction. This statistically significant datum ($P > 0.1$) should be interpreted as a further favourable impact of the early diagnosis with a less incidence of severe injury of the facial nerve.

The analysis of the preoperative hearing damage did not confirm this trend, since there was no significant difference between the two observation periods. This could be accounted for by the characteristics of this type of cholesteatoma's growth that may give signs of its presence only when the damage to hearing is irreversible. About 40% of our cases had preoperative dead ears. To further confirm this, it should be pointed out that preserving postoperative hearing capacity is even more difficult. The cholesteatoma may already have widely invaded the membranous labyrinth, thus requiring a surgical approach that sacrifices the hearing to reduce the risk of recurrence. There is general agreement favouring radical removal of the petrous bone cholesteatoma using surgical techniques with sacrifice of the otic capsule and obliteration of the cavity.

The introduction of techniques that partially destroy the labyrinth but preserve the hearing capacity has only slightly modified this trend [21, 22]. Selective ablation of the labyrinth is only indicated when the vestibule is not involved but is ideal when the otic capsule fistula affects the superior and posterior semicircular canals, sparing or only partially damaging the lateral semicircular canal. This technique was adopted in five patients operated on during the second decade with encouraging, even if not definitive, outcomes.

When the cholesteatoma affects the only hearing ear, no alternative to exteriorization of the temporal bone cavity proposed by Glasscock et al. [4], Fisch [23] and Sanna et al. [6] has yet been found.

Conclusion

From the comparison of our personal experiences in treating petrous bone cholesteatomas in two different periods (1987–1996 and 1997–2003) the following conclusions have been drawn:

1. The number of less extensive surgical approaches was higher in the more recent observation period, proving that cholesteatomas smaller in size had been diagnosed.
2. Preoperative facial paralysis was less frequent in the same period—falling to 25% of cases of total facial paralysis from the 45.8% of the earlier period.
3. In the first decade, 43% of the patients underwent facial nerve grafting with various techniques.
4. In contrast, only 27% of the patients of the second decade need facial nerve reconstruction. This can be explained as a further factor of the importance of the early diagnosis afforded by the diffusion of the imaging techniques.

There was no significant difference between the two observation periods analysing the preoperative and postoperative hearing loss. About 40% of our cases had preoperative dead ears. However, it should be stressed that in three patients operated on through a subtotal petrosectomy approach combined with partial

labyrinthectomy hearing was preserved. This is an encouraging finding that, if confirmed in larger series, may have an interesting impact on the strategy of hearing preservation in petrous bone cholesteatomas.

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