Does Endoscopic Surgery Reduce Recurrence of the Petrous Apex Cholesteatoma?

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Abstract The aim of this study is to present the clinical symptoms, complications and treatments of the petrous apex cholesteatoma and is to describe the current role of oto-endoscopy. This was a retrospective non-randomized study of 14 petrous apex cholesteatoma surgeries performed between 1994 and 2012. Petrosectomy was performed according to the location of the cholesteatoma, hearing level of the patients and facial nerve function. Oto-endoscopy was used in the petrous apex and the cerebellopontine angle for residual cholesteatoma. 14 patients, seven were men and seven women were included in this study between 1994–2012. The most common symptom was hearing loss (85.7 %) and tinnitus (50 %) at the presentation. During the surgeries, it was observed that cholesteatoma involved most frequently facial nerve, dura and labyrinthines. Labyrinthectomy, middle cranial fossa approach and petromastoidectomy was performed to these patients. Four of six patients operated without the endoscope assistance between 1994–2006 had recurrences after the operation. These patients were re-operated and in the follow up, there was no recurrence. In the endoscopy assisted surgery, there was no recurrence observed (significance level $p = 0.014$). The most common complication after the surgery was hearing loss (42.8 %) but it was not significant after surgery ($p > 0.05$). The petrous apex and mastoid cavity was obliterated with fat tissue in eight patients while six patients were exteriorized to follow the recurrence and it was insignificant in recurrences

($p > 0.05$) Conclusion: Endoscope-assisted surgery allows to remove residual the cholesteatoma around the carotid artery, dura and facial nerve in the petrous apex resulting in less invasive surgery and less recurrence in blind spots.

Keywords Petrous apex · Cholesteatoma · Oto-endoscopy · Mastoidectomy

Introduction

Petrous apex (PA) cholesteatomas constitute 4–9 % of the PA lesions. PA cholesteatomas are growing lesion of the squamous epithelium in the petrous part of the temporal bone [1].

Petrous apex is one of the less accessible regions of the skull. They usually give late onset of symptoms. Approach to PA creates difficulty in diagnosis and treatment. Cholesteatoma may be congenital (primary) or acquired (secondary) [2].

Cholesteatoma develops from the epithelium trapped in the mastoid and petrous bone during the embryological development of the middle ear. It may invade the auditory canal or grow into the cerebellopontine angle [3].

The tympanic membrane should be intact with congenital cholesteatoma. A history of ear discharge, tympanic membrane perforation, parastentesis, surgical intervention such as ventilation tube insertion and temporal bone trauma does not exist [4].

Improvements in skull base surgery and recent advances in radiological imaging allow refining the management of petrous bone cholesteatoma. Surgical approaches to the PA are divided into extralabyrinthine and translabyrinthine routes [5].

Petrous apex cholesteatoma varies according to patients. According to Fisch [6], PA cholesteatomas were classified as supralabyrinthine, infralabyrinthine and apical while

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Sanna et al. [7] classified them as supralabyrinthine, infralabyrinthine, massive labyrinthine, infralabyrinthine-apical and apical.

Petrous apex cholesteatoma usually presents with hearing loss and facial paralysis. The most affected part of the facial nerve in the PA lesions is the ganglion geniculi. Tinnitus, vertigo, otorrhea, headache, otalgia are also common [8].

Recent progresses in endoscopic surgery, using image guided system, allow removal of the PA cholesteatoma by endoscopically.

The aim of this study is to present the clinical symptoms, complications and treatments of the PA cholesteatoma and is to describe the current role of endoscopy.

Materials and Methods

The study was conducted at a tertiary referral center. This retrospective non-randomized study included 14 patients performed between 1994 and 2012 to treat PA cholesteatomas.

All patients were diagnosed with otoscopic examination, otomicroscopy and radiologically. Coronal and axial computed tomography and temporal magnetic resonance imaging were performed for each patient. Selection of the surgical approach was based on the location and extent of the lesion in petrous bone, anatomic position of the internal carotid artery and the jugular bulb, as well as hearing on the affected side and the facial nerve function.

Petro-mastoidectomy, the middle cranial fossa approach, labyrinthectomy or transotic approaches were applied according to the location of the cholesteatoma. Six patients were operated without endoscope assistance. Eight patients

were evaluated by using endoscopy in the PA and the cerebellopontine angle for the location of residual cholesteatoma during the surgery. 2.7 mm Hopkins rod endoscopes with 0°, 30° and 70° were used for these patients.

Post-operative facial function, hearing loss, recurrent cholesteatoma, and petrous cavity in relation to preoperative signs, intraoperative findings, and surgical techniques were measured.

The hearing loss, recurrences according to obliteration and endoscope assistance were analysed using MedCal 13.0 Statistical Software.

Results

The study included cholesteatoma surgery performed between 1994 and 2012 to treat PA cholesteatoma. The age of the patients ranged from 4 to 67 years; seven were men and seven were women. The arithmetic mean and the standard deviation of the patient ages were 36.7 ± 18.55 (Pearson test $p = 0.66$).

The most common symptoms were hearing loss (85.7 %) and tinnitus (50 %) (Table 1).

Pre-operative and post-operative hearing thresholds were evaluated with the results of pure tone audiogram (Table 2). In the study group, nine patients had total hearing loss in the cholesteatoma ears before surgery. Labyrinthectomy and transotic surgery was performed to these patients. Four patients had a moderate sensorineural hearing loss and petromastoidectomy was performed. Middle fossa approach was applied to a patient with normal hearing thresholds. There was no statistically significant hearing loss after the surgery ($p = 0.063$).

Table 1 The patient symptoms when the operation was decided

Symptoms	Hearing loss	Tinnitus	Facial paralysis	Otorrhea	Vertigo	Headache	Meningitis
N (cases)	12	7	6	5	5	4	3
%	85.7	50	42	35.7	35.7	28.5	21.3

Table 2 Pre-operative and post-operative hearing levels of the patients in cholesteatoma ears

Number of cases (N)	Mean pre-operative hearing loss dB (sound pressure level)		Mean post-operative hearing loss dB (sound pressure level)		Surgical method
	Mean air conduction	Mean bone conduction	Mean air conduction	Mean bone conduction	
1 Patient	20	8.3	21.6	15	Middle cranial fossa approach
4 Patients	51.6	19.6	44.1	25.7	Petro-mastoidectomy
9 Patients	Total hearing loss		Total hearing loss		Labyrinthectomy and transotic approach

Wilcoxon test (paired samples) two-tailed probability $p = 0.063$

Six patients were operated between 1994–2006. Four of them had recurrences after the operation without the endoscopic assisted surgery. These patients were re-operated and in the follow up, there was no recurrence. Eight patients were operated between 2007–2012 with the endoscopic assisted surgery and there was no recurrence in the follow up. The recurrences occurred significantly less in the endoscopic assisted surgery ($p < 0.05$) (Table 3).

There was no difference in the recurrence of the cholesteatoma between the hearing preserving surgery and destructive surgery (Table 4). During the surgery, it was observed that cholesteatoma involved most frequently facial nerve, dura and labyrinthine (Table 5). The most common complication after the surgery was hearing loss (42.9 %). Other complications such as facial paralysis and vertigo disappeared in follow-up. Interposition graft was performed in three, rerouting and end to end anastomosis was performed in two of six patients with preoperative facial paralysis while two patients had no intervention. The PA and mastoid cavity was obliterated with fat tissue in

Table 3 The effect of the endoscopic surgery on the cholesteatoma recurrences

Endoscopy assisted	Recurrence (+)	Recurrence (–)	Number of cases (N)
Surgery with endoscopic assisted	0 (100 %)	8 (100 %)	8 (100 %)
Surgery without endoscopic assisted	4 (66.3 %)	2 (33.3 %)	6 (100 %)
Total	4 (28.6 %)	10 (71.4 %)	14 (100 %)

Significance level $p = 0.015$ (Fisher's exact test)

Table 4 The cholesteatoma recurrence after the surgical intervention

Surgical method	Recurrence (+)	Recurrence (–)	Number of cases (N)
Labyrinthectomy	3 (33.3 %)	6 (66.6 %)	9 (100 %)
Without labyrinthectomy	1 (25 %)	4 (75 %)	5 (100 %)
Total	4 (28.6 %)	10 (71.4 %)	14 (100 %)

Fisher's exact test $p = 0.055$

Table 5 Post-operative complications

Complications	N	%
Hearing loss	6	42.9
Without complication	5	35.7
Vertigo	2	14.3
Facial paresis	1	7.1
Total	14	100

eight patients while six patient were exteriorized to follow the recurrence. There was no significant difference in recurrences between obliteration and exteriorization ($p > 0.05$) (Table 6).

Discussion

According to Schuknecht and Gao [9], the area between the vertical plane medial to modiolus of the cochlea and the vertical plane passing through the superior semicircular canal was named perilyabyrinthine area to determine the location of the perilyabyrinthine cholesteatoma. Perilyabyrinthine region can be subdivided into an infralabyrinthine area and a supralabyrinthine area.

The supralabyrinthine cholesteatoma is located superior to the inner ear while infralabyrinthine area located inferior to the acoustic meatus. Supralabyrinthine cholesteatoma may spread along to the internal carotid artery and dura. Therefore, angle telescopes may benefit the removal of the residual cholesteatoma by increasing the vision for supralabyrinthine area.

In most cases middle ear cholesteatoma are diagnosed at an early age because of conductive hearing loss. However, PA cholesteatomas are diagnosed late with sensorineural hearing loss and facial paralysis. In this study, PA cholesteatoma presented most commonly with hearing loss (85.7 %) and tinnitus (50.0 %). These findings are seen in most patients admitted to our outpatient clinics. For this reason surgeon should be very careful at diagnosis.

In both cases, radiology helps us to demonstrate the expansion of the lesion and the affected structure in the terms of treatment planning. PA cholesteatoma are seen as low-density smooth edge lesions in the computed tomography (Figs. 1, 2). Especially in recent times, on diffusion-weighted magnetic resonance imaging give specific findings in the differential diagnosis of cholesteatoma. In T1 and T2 weighted MR imaging, cerebrospinal fluid and arachnoid cyst have similar views with the cholesteatoma. However, the fluid attenuated inversion recovery (FLAIR) and on diffusion-weighted images occurs as hyperintense [10] (Fig. 3).

Table 6 The surgical procedure applied for petrous apex and mastoid cavity after drilling the temporal bone

Cavity procedure after surgery	Recurrence (+)	Recurrence (–)	Number of cases (N)
Obliteration	4 (50 %)	4 (50 %)	8 (100 %)
Exteriorization	0 (0 %)	6 (100 %)	6 (100 %)
Total (N)	4 (28.6 %)	10 (71.4 %)	14 (100 %)

Significance level $p = 0.085$ (Fisher's exact test)

Fig. 1 **a** In the axial temporal bone computed tomography scan; the *left* ossicular chain deformed by the cholesteatoma. At the level of the petrous apex, hypodense lytic areas were surrounded by sclerosis. **b** In the axial temporal bone computed tomography scan; in the bone window image, heterogeneous post-operative hypodense region was observed after the obliteration of the mastoid cavity with fat tissue

Fig. 2 **a** *Left* axial computed tomography scan of the temporal bone: At the apex of the *left* petrous bone structure, wide range of distinctive character of a destructive expansile lytic area has been observed. The first cervical vertebra destruction in the *left* lateral arc has also been observed. **b** Coronal computed tomography of the *left* petrous apex cholesteatoma and extension of the destruction to the first vertebra on the same case

Fig. 3 **a** Large cholesteatoma markedly hyperintense lobulated contoured extending to the brain stem in T2-weighted MRI coronal section. **b** Apparent diffusion limitation suggesting *left* petrous apex cholesteatoma in diffusion-weighted magnetic resonance imaging

Previously in our cases, coronal and axial temporal bone CT and cranial MRI has been used as the radiologic technique but in recent years diffusion-weighted images has also been started to be used. This is very useful in both the localization and diagnosis of the disease as well as in the follow-up of the recurrences (Fig. 3b).

Atticotomy, antrotomy, intact canal or canal wall down procedures through transcanal, endaural or post-auricular approaches can be applied in the middle ear cholesteatoma. Selection of the surgical approach depends on the location and extent of the lesion in petrous bone, anatomic position of the internal carotid artery and the jugular bulb, as well as

hearing on the affected side and the facial nerve function. The middle fossa, translabyrinthine, infratemporal fossa type A, transcochlear or transotic approaches are applied for PA cholesteatoma [11].

The middle cranial fossa approach is the best approach for patient having good preoperative hearing and facial nerve function in combination with mastoidectomy. However, application of this approach is limited for patients having relatively small petrous cholesteatomas [12].

In poor hearing patients, the translabyrinthine approach with or without the transcochlear approach allows adequate removal of the lesion [13]. The classical translabyrinthine maintains good facial function and allows a wide pathway for complete tumor removal. In our study, we applied labyrinthectomy and transotic approach to nine patients while four patients had petromastoidectomy. Also middle cranial approach was applied to one patient which the hearing was preserved. There was no difference in the recurrence of the cholesteatoma between the hearing preserving surgery and destructive surgery ($p = 0.055$) (Tables 2, 4).

Furthermore, these approaches to PA may not be possible when there is poor pneumatization of the temporal bone [10].

It is also difficult to identify the extent of the cholesteatoma in the pneumatic mastoid during surgery. Therefore, endoscopes can be used as an adjunctive tool for inspection/endoscope-assisted removal of remnants when the lesion extends around the cochlea, the labyrinth and the internal auditory canal.

Endoscopic assisted surgery is beneficial especially in cholesteatomas between medial aspect of the internal carotid artery and tip of the PA. Also it can be used in the medial superior semicircular canal, dura and the angle between the internal acoustic canal and facial nerve named supralabyrinthine space. Otherwise middle cranial fossa approach might be applied which is more invasive procedure.

The cholesteatoma inferior to the cochlea and the region around the internal carotid artery could be well visualized by the use of 2.7 mm otoendoscopes with 30° and 70° optics. This allows manipulation of lesion located in the blind spot of traditional microscopic surgery. We have achieved better results with using oto-endoscopes.

Furthermore, endoscope shows the localization and extent of the PA cholesteatoma resulting in less drilling and less invasive surgery.

Recent progresses in endoscopic surgery, using image guidance system, allow removal of the PA cholesteatoma by an endoscopic transsphenoidal approach with minimal morbidity [13, 14].

It has been reported that the cholesteatoma matrix adherent to dura and internal carotid artery might be removed by bipolar coagulation or 90 % ethyl alcohol [11]. This is

effective in destroying squamous epithelium. It is extremely important to follow-up these patients for recurrences.

Eight cases in our study were evaluated by using endoscopy in the cerebellopontine angle and PA during the surgery. We have found that 5 of 8 patient had residual cholesteatoma inferior to cochlea and around the internal carotid artery with endoscopic assisted surgery during the surgery.

This also shows us the importance of endoscopic assisted surgery in demonstrating the blind spots. But manipulation of instruments using a 70 rigid endoscope is difficult due to limited operating field and the surgeon must be careful around the life-threatening structure. There still exists a possibility of future recurrence. So careful follow-up is needed.

If there isn't infection and residual cholesteatoma, the large cavity formed by this process is obliterated with fat tissue. However, if infection or matrix exists in the cavity, it is best to leave it open called exteriorization [15].

The PA and mastoid cavity was obliterated with fat tissue in eight patients while six patients were exteriorized to follow the recurrence. There is no significant difference in recurrences between obliteration and exteriorization ($p > 0.05$) (Table 6). Exteriorization is favour in an only hearing ear and second choice of option when eradication is not possible. Otherwise, obliteration is applied in profuse cerebrospinal fluid leakage, large dural and carotid exposure, complete facial paralysis and profuse hearing loss [15, 16].

Conclusion

Careful research should be conducted in patients with symptoms such as hearing loss and facial paralysis. Early diagnosis is important in preventing the risks of cholesteatoma. Petrous bone cholesteatomas have different techniques than classical temporal bone surgery.

During the surgery, the cholesteatoma around the dura, facial nerve and internal carotid artery can be diagnosed better via endoscopic assisted surgery. Obliteration should be avoided in the cases of infected or residual cholesteatoma. However, the disadvantages of a large cavity should also be considered.

Conflict of interest All authors had no conflict of interest on this study.

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