

## Clinical Report

# Endoscope-Assisted Surgery for Petrous Bone Cholesteatoma with Hearing Preservation

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**OBJECTIVES:** Petrous bone cholesteatoma is a rare pathologic entity and may be a difficult surgical challenge because of potential involvement of the facial nerve, carotid artery, dura mater, otic capsule and superior petrosal or lateral sinus. The objective of this article is to present the endoscope-assisted surgery for petrous bone cholesteatoma.

**MATERIALS and METHODS:** Eight patients (nine ears) who underwent endoscope-assisted petrous bone surgery for cholesteatoma. Pure tone audiogram, magnetic resonance imaging were performed at preoperatively, and at approximately 12 months postoperatively.

**RESULTS:** Endoscope assisted surgery was performed in 8 patients and 9 ears. Of these patients, 6 were male and 2 were females. Median age was 19,5 (range 7-52) years. Hearing was able to preserved in 8 ears (8/9). Recurrence disease was observed one ear in long term follow up (1/9). In another one patient, cholesteatoma pearl was removed in the office.

**CONCLUSION:** Endoscope-assisted surgery can allow removal of cholesteatoma of petrous apex with preserving hearing. It also provides to remove the cholesteatoma via transmastoid approach for perilyabyrinthine space as “minimally invasive surgery” instead of middle fossa approach that is standard surgical procedure. In apical and peri-labyrinthine cholesteatomas, endoscopes allow to preserve hearing with middle fossa approach instead of trans-otic/ trans-labyrinthine/trans-cochlear approach.

**KEYWORDS:** Petrous apex, endoscopic surgery, cholesteatoma, hearing loss

## INTRODUCTION

Congenital or acquired petrous bone cholesteatoma (PBC) is used to describe an epidermoid cyst of the petrous portion of the temporal bone <sup>[1]</sup>. It may extend along the other portion of the temporal bone and may be asymptomatic if the tympanic membrane is initially intact. However, in the advanced stage of the disease, complications such as hearing loss, facial paralysis, headache, and dizziness can be seen. Surgical treatment may be difficult because of the cochlea, facial nerve, dura mater, otic capsule, and internal carotid artery adjacent to this region.

Various surgical techniques have been described according to the disease location, spread of the pathology, and preoperative hearing status <sup>[1-7]</sup>. The approach should be adapted to each situation, taking into account the extent and location of the disease, anatomic variation and the status of hearing, and facial nerve function <sup>[8,9]</sup>. The recurrence rates ranged from 17% to 70%, with high rates of postoperative complications including hearing loss and facial nerve weakness <sup>[10]</sup>.

Sanna et al. <sup>[11]</sup> have classified PBCs into five groups: supralabyrinthine, infralabyrinthine, infralabyrinthine-apical, massive, and apical PBC. Besides, these terms describe both the extent and the location of the lesion. Moffat et al. <sup>[9]</sup> proposed a new classification system in which supralabyrinthine-apical and massive labyrinthine-apical type were added to the Sanna's classification. These classification systems aim to decide the safe surgical technique.

Recently, endoscope-assisted ear surgery has become increasingly popular because of a detailed visualization of middle ear cavity and hidden anatomic areas of the temporal bone. Thus, endoscopy instruments have opened a new era in traditional ear surgery. This study aimed to describe the detailed our endoscope-assisted surgical technique in PBC and to report its follow-up outcomes.

## MATERIALS AND METHODS

A retrospective chart review was conducted with the approval of the Institutional Review Board of Istanbul University School of Medicine (IRB No. 1424-291576) on patients who underwent the endoscope-assisted petrosectomy for PBC by the author between March 2011 and January 2016 at our tertiary institution. An informed consent form was obtained from each patient or parents of those under 18 years of age. All patients' preoperative symptoms, examination findings, pure tone audiograms (PTA), magnetic resonance imaging (MRI) and computed tomography findings and surgical reports, postoperative course details were obtained. The patients were evaluated at the end of first year in the postoperative period. Control MRI including diffusion-weighted images were obtained to detect the possible recurrence of the disease. Facial nerve functions were assessed by means of the House-Brackman grading system, and PTAs were performed [12].

## Surgical Technique

**Endoscope-assisted middle fossa approach:** This approach was used in patients with apical and massive cholesteatoma but serviceable hearing levels. After performing 5×4 cm craniotomy, geniculate ganglion and greater petrosal nerve were identified. Epidermoids were removed with assistance of endoscope to visualize inferior as-

pect of the cochlea, medial surface of petrous part of internal carotid artery, and petrous apex, rigid 0° and 45° endoscopes (2.7 mm wide, 18 cm in length) (Karl Storz, Tuttlingen, Germany) and a connected HD camera system (Karl Storz, Tuttlingen, Germany) were used. Because standard ear surgery instruments were inadequate for this surgery, epidermoid removal from infralabyrinthine and medial surfaces of the carotid arteries were carried out by instruments of the endoscopic sinus surgery (Figure 1).

**Endoscope-assisted transmastoid supralabyrinthine approach:** If the cholesteatoma entered in supralabyrinthine and perilabyrinthine space, transmastoid approach was preferred. After performing canal wall-down mastoidectomy, incus and malleus were removed. Cholesteatoma and epidermoid that were located in the middle ear were removed by oto-microscope. Supralabyrinthine spaces and internal acoustic canals could not be able to be visualized by oto-microscope, since superior semicircular canal restricted the access to these areas. Therefore, rigid 45° and 70° endoscopes (2.7 mm wide, 18 cm in length) (Karl Storz, Tuttlingen, Germany) and a connected HD camera system, (Karl Storz, Tuttlingen, Germany) were again used to visualize and remove the cholesteatoma from medial and superior surface of the superior semicircular canal and internal acoustic canal (Figure 2). Hence, middle fossa approach was not necessary in these patients. Geniculate ganglion and labyrinthine segment of the facial nerve were identified with the assistance of the nerve integrity monitoring (NIM-Response® 2.0, Medtronic, Dublin, Ireland) to avoid the injury. Angled instruments and suction were also used with the endoscope. Perilabyrinthine defect was obliterated with temporal fascia graft.

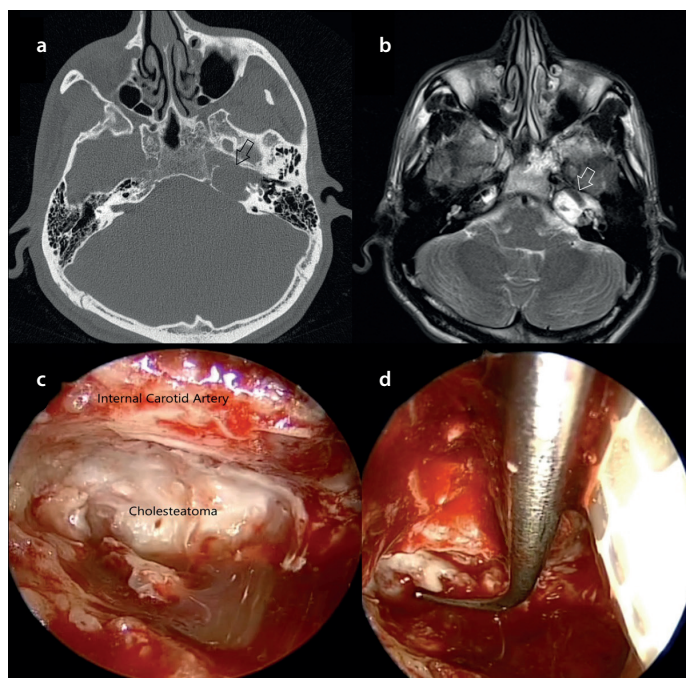
## RESULTS

Eight patients who underwent endoscope-assisted surgery for PBC were included in the study. One of those patients had bilateral surgery; therefore, nine ears were evaluated. Of these patients, six were male and two were females. The median age was 19.5 (range 7–52) years.

Physical examination revealed intact tympanic membrane in four patients. Of these patients, three of them presented with facial paralysis, and one had persistent headache and vertigo. Preoperative PTAs of four ears were in normal hearing levels. Remaining five ears presented with purulent otorrhea and mild-to-moderate conductive hearing loss (CHL). Physical examination of the patients revealed attic cholesteatoma in three patients (four ears) and marginal perforation and mesotympanic cholesteatoma in one patient (Table 1).

Endoscope-assisted middle fossa approach was performed in four patients. Of these patients, three had supralabyrinthine-apical, and one had massive PBC. In-patient with massive cholesteatoma that was extending to medial part of the internal carotid artery, infralabyrinthine, and supralabyrinthine space, hearing was not being able to be preserved. In this patient, the cochlear lumen was exposed by removing the lesion (Figure 3). In the remaining three patients, cholesteatomas were removed with hearing preservation.

Canal wall-down mastoidectomy with tympanoplasty was performed in four pediatric patients (in five ears). They had acquired cholesteatoma. All cases had similar pathologies and were as follows. The epithelium was filling mastoid cavity and the epitympanum. The



**Figure 1. a-d.** High-resolution temporal computed tomography shows petrous cholesteatoma (arrow) (a), T2 weighted magnetic resonance imaging shows hyperintense lesion in the petrous apex. Petrous part of the internal carotid artery is surrounded by the cholesteatoma (arrow) (b), Endoscopic view through middle fossa shows cholesteatoma and internal carotid artery (c), Instrument of endoscopic sinus surgery that is ostium seeker is used to remove cholesteatoma (d).

**Table 1.** Demographic data and preoperative symptoms of the patients

Patients no.	Age (years)	Gender	Pathologic side	Preoperative symptoms	Preoperative findings
1	41	Male	Left	Facial paralysis for 4 years	Normal tympanic membrane, HB grade 5 Facial paralysis, normal hearing
2	44	Female	Left	Facial paralysis for 3 years, vertigo	Normal tympanic membrane, HB grade 6 facial paralysis, normal hearing
3	52	Female	Right	Headache, vertigo	Normal tympanic membrane, normal facial nerve functions, normal hearing
4	25	Male	Right	Facial paralysis for 6 months, vertigo	Normal tympanic membrane, HB grade 4 facial paralysis, normal hearing
5	13	Male	Left	Otorrhea, hearing loss	Attic perforation, cholesteatoma, moderate CHL
6	13	Male	Left	Otorrhea, hearing loss	Marginal perforation on posterosuperior portion of TM, whitish lesion behind the anterior portion of TM, mild CHL
7	14	Male	Right	Otorrhea, hearing loss	Attic perforation, cholesteatoma, moderate CHL
8 (Left ear)	7	Male	Left	Otorrhea, hearing loss	Attic perforation, cholesteatoma, moderate CHL
8 (Right ear)	7	Male	Right	Otorrhea, hearing loss	Attic perforation, cholesteatoma, moderate CHL

HB: House–Brackman; TM: Tympanic membrane; CHL: Conductive hearing loss

**Table 2.** Patients' features of diseases, management, and follow up

Patients No.	According to Moffat-Smith classification for PBCs	Surgical approach	Preoperative audiogram	Postoperative audiogram/ ossiculoplasty method	Postoperative facial nerve function	Recurrence disease
1	Massive labyrinthine-apical	Middle fossa, endoscope-assisted	Normal	Total hearing loss	HB grade 5 paralysis (same as preoperatively)	Limited recurrence disease at postoperative 4 <sup>th</sup> year, observation
2	Supralabyrinthine-apical	Middle fossa, endoscope-assisted	Normal	Normal	HB grade 6 paralysis (same as preoperatively)	No recurrence at 5 <sup>th</sup> year
3	Supralabyrinthine-apical	Middle fossa, endoscope-assisted	Normal	Normal	Normal	No recurrence at 3 <sup>rd</sup> year
4	Supralabyrinthine-apical	Middle fossa, endoscope-assisted	Normal	Normal	HB grade 2 Paralysis (preoperative Grade 4)	No recurrence at 2 <sup>nd</sup> year
5	Supralabyrinthine	Transmastoid, perilyabyrinthine endoscope-assisted	BCT: 15 dB ACT: 52 dB	BCT: 12dB ACT: 32 dB/ Incus interposition	Normal	Cholesteatoma pearl was observed at 2 <sup>nd</sup> year. It was removed under local anesthesia
6	Supralabyrinthine	Transmastoid, perilyabyrinthine endoscope-assisted	BCT: 2 dB ACT: 32 dB	BCT: 3dB ACT: 25 dB/ Incus interposition	Normal	No recurrence at 2 <sup>nd</sup> year
7	Supralabyrinthine	Transmastoid, perilyabyrinthine endoscope-assisted	BCT: 0 dB ACT: 45 dB	BCT: 0 dB ACT: 31 dB/ Type III stapes columella tympanoplasty	Normal	No recurrence at 18 <sup>th</sup> month
8 (Left ear)	Supralabyrinthine	Transmastoid, perilyabyrinthine endoscope-assisted	ABR: Wave V was observed at 60 dB	BCT: 2 dB ACT: 25 dB/ Bone cement reconstruction	Normal	No recurrence at 18 <sup>th</sup> month
8 (Right ear)	Supralabyrinthine	Transmastoid, perilyabyrinthine endoscope-assisted	ABR: Wave V was observed at 40 dB	BCT: 2 dB ACT: 23 dB/ Bone cement reconstruction	Normal	No recurrence at 1 <sup>st</sup> year

BCT: Bone Conduction Threshold; ACT: Air Conduction Threshold; HB: House–Brackman

perilabyrinthine space where between labyrinth, internal acoustic canal and middle fossa dura, was invaded by the cholesteatoma. Petrous apex and internal carotid canal were not involved. Cholesteatoma or epithelium located around the perilabyrinthine space was removed with endoscope assistance, and those around the mastoid antrum and epitympanum were removed with an oto-microscope. Ossiculoplasty was performed including incus interposition, bone cement reconstruction, and type III stapes columella tympanoplasty for hearing rehabilitation (Table 2). The open mastoid cavities were obliterated with inferiorly based periosteal flap to reduce the volume of the cavities in these cases.

## DISCUSSION

Petrous apex has difficulties in surgical approach because important structures such as facial nerve, labyrinth, and carotid artery restrict access. Various techniques such as middle fossa, translabyrinthine, transotic, infratemporal fossa, and supralabyrinthine approaches have been reported for the management of the PBC. Infratemporal fossa approach that was used to preserve hearing was described by Fisch in 1977 [13]. However, it requires craniotomy, compression on important neurological structures, and afford hardly access [14]. Although translabyrinthine or transcochlear approaches sacrifice hearing, they allow best access to and a wide exposition of the pathology. On the other hand, some studies have showed that hearing function may be preserved in modified translabyrinthine approach. Nevertheless, these reports have also announced that complete neurosensory hearing loss was encountered as an unsatisfactory result in postoperative period of their case series [15-17]. On the other hand, another notion has been suggested that radical removal of pathologic tissue must be the target of the surgical treatment, and the surgeon should not hesitate to remove the otic capsule to accomplish it when the contralateral ear is normal [11]. Recently, some studies have described "minimally invasive cholesteatoma removal" that were aimed to preserve hearing and facial nerve functions for treatment of the PBC [18, 19].

Sanna M. et al. presented an algorithm for PBC surgery. If there is serviceable hearing without any evidence of a fistula in the basal turn of the cochlea, middle fossa combined with transmastoid approach was recommended depending on the extension of the disease in supralabyrinthine cholesteatoma. However, hearing preservation is usually not possible in infralabyrinthine-apical and massive PBC with standard transotic and transcochlear approaches [7]. In the literature, the rates of hearing preservations in most studies were usually undesirable and reported between 17% and 33% [1, 8, 9, 20], but Senn et al. presented that hearing was preserved in 18 (87%) of 21 patients with PBC in postoperative period [19]. Our hearing preservation rate was 89% (8/9) in PBC, but there were only four cases with apical and infralabyrinthine cholesteatoma.

Endoscope has become an extremely popular instrument. It has been used alone or in assistance to a microscope in the ear surgery. Since, the petrous apex contains hidden anatomic areas and the presence of major structures such as internal carotid artery and facial nerve, endoscopes are very useful to visualize this area. Mattox et al. presented endoscope-assisted surgery of petrous apex in five cases. Of these cases, four had cholesterol granuloma and one had cholesteatoma [20]. Presutti et al. presented endoscope-assisted petrosectomy in nine patients. Of these patients, six had cholestea-

toma, two had cholesterol granuloma, and one had low-grade tumor [21]. Kojima H. et al. presented a case of endoscope-assisted surgery via the middle cranial fossa approach for a petrous cholesteatoma originating from a supralabyrinthine portion and extended to medial portion surrounding the cochlea and internal carotid artery. A 70° rigid endoscope was used to visualize the internal carotid artery and the inferior surface of cochlea. Cholesteatoma was successfully removed with preservation of hearing [22]. Iannella et al. reported combined microscopic and endoscopic approach for giant PBC [23]. Kumral et al. presented that endoscope-assisted surgery allows to remove residual cholesteatoma around the carotid artery, dura and facial nerve in the petrous apex resulting in less invasive surgery and less recurrence in blind spots [24].

In our surgical technique, we did not need middle cranial fossa approach in supralabyrinthine cholesteatoma, because we were able to visualize this space and remove the cholesteatoma with angled endoscopes through transmastoid approach. In three out of four patients with infralabyrinthine and apical cholesteatoma, we were able to preserve residual hearing with endoscope-assisted middle fossa approach instead of transotic/transcochlear/trans-labyrinthine approaches. We were able to access and remove the cholesteatoma in infralabyrinthine and apical portion of the petrous apex with angled endoscopes. Although, middle cranial fossa approach has some disadvantages such as morbidity of craniotomy and temporal lobe retraction, we think that preserving the hearing is an important achievement.

In our experience, endoscope-assisted surgery in the petrous apex has some advantages. Residual hearing can be preserved; middle and inner ear structures are preserved to avoid balance and hearing problems. Obliteration of the surgical area or making blind sac of external ear canal is not necessary. Nevertheless, there are also disadvantages of the endoscopic surgery. One-handed surgery is a disadvantage for surgical manipulation. Using angled instruments can be more difficult with two-dimensional view of monitor. Bleeding and fogging obscure the endoscopic vision, and it needs experience of endoscopic surgery.

## CONCLUSION

Endoscope-assisted surgery can allow removal of cholesteatoma of petrous apex with preserving hearing. It also provides to remove the cholesteatoma via transmastoid approach for perilabyrinthine space as "minimally invasive surgery" instead of middle fossa approach that is standard surgical procedure. Thus, complications of craniotomy can be avoided. On the other hand, in apical and infra labyrinthine cholesteatoma, endoscopes allow to preserve hearing with middle fossa approach instead of trans-otic/trans-labyrinthine/transcochlear approach. In conclusion, endoscope-assisted surgery can be a safe and minimally invasive method in PBC.

**Ethics Committee Approval:** Ethics committee approval was received for this study from Ethics Committee of Istanbul University Faculty of Medicine (Ref no: 12/10/2018-1424)

**Informed Consent:** Written informed consent was obtained from patients who participated in this study.

**Peer-review:** Externally peer-reviewed.



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## REFERENCES

1. Omran A, De Denato G, Piccirillo E, Leone O, Sanna M. Petrous bone cholesteatoma: management and outcomes. *Laryngoscope* 2006; 116: 619-26. [\[CrossRef\]](#)
2. Aubry K, Kovac L, Sauvaget E, Tran Ba Huy P, Herman P. Our experience in the management of petrous bone cholesteatoma. *Skull Base* 2010; 20: 163-7. [\[CrossRef\]](#)
3. Cremers CW. Cholesteatoma in the medial part of the petrous bone and the modified transotic approach. *Ned Tijdschr Geneesk* 1985; 129: 1193-5.
4. Hasegawa J, Kawase T, Hidaka H, Oshima T, Kobayashi T. Petrous bone cholesteatoma removed by trans-superior semicircular canal approach: long-term hearing results in three cases. *Acta Otolaryngol* 2012; 132: 896-902. [\[CrossRef\]](#)
5. House WF, Hitselberger WE. The transcochlear approach to the skull base. *Arch Otolaryngol* 1976; 102: 334-42. [\[CrossRef\]](#)
6. Jiang L, Ma Y, Jiao Y. Decompression and monitor of facial nerve during cholesteatoma surgery in petrous part of temporal bone. *Lin Chuang Er Bi Yan Hou Ke Za Zhi* 2006; 20: 741-3.
7. Sanna M, Pandya Y, Mancini F, Sequino G, Piccirillo E. Petrous bone cholesteatoma: classification, management and review of the literature. *Audiol Neurotol* 2011; 16: 124-36. [\[CrossRef\]](#)
8. Grayeli AB, Mosnier I, El Garem H, Bouccara D, Sterkers O. Extensive intratemporal cholesteatoma: surgical strategy. *Am J Otol* 2000; 21: 774-81.
9. Moffat D, Jones S, Smith W. Petrous temporal bone cholesteatoma: a new classification and long-term surgical outcomes. *Skull Base* 2008; 18: 107-15. [\[CrossRef\]](#)
10. Tomlin J, Chang D, McCutcheon B, Harris J. Surgical technique and recurrence in cholesteatoma: a meta-analysis. *Audiol Neurotol* 2013; 18: 135-42. [\[CrossRef\]](#)
11. Sanna M, Zini C, Gamoletti R, Frau N, Taibah AK, Russo A, et al. Petrous bone cholesteatoma. *Skull Base Surg* 1993; 3: 201-13. [\[CrossRef\]](#)
12. House JW, Brackmann DE. Facial nerve grading system. *Otolaryngol Head Neck Surg* 1985; 93: 146-7. [\[CrossRef\]](#)
13. Fisch U. Infratemporal fossa approach for extensive tumors of the temporal bone and base of the skull. In Silverstein H, Norrel (eds): *Neurological Surgery of the Ear* Birmingham, AL: Aesculapius 1977.
14. Franklin DJ, Jenkins HA, Horowitz BL, Coker NJ. Management of petrous apex lesions. *Arch Otolaryngol Head Neck Surg* 1989; 115: 1121-5. [\[CrossRef\]](#)
15. Hong SJ, Lee JH, Jung SH, Park CH, Hong SM. Can cochlear function be preserved after a modified translabyrinthine approach to eradicate a huge cholesteatoma extending to the petrous apex? *Eur Arch Otorhinolaryngol* 2009; 266: 1191-7. [\[CrossRef\]](#)
16. Magliulo G, Parrotto D, Stasolla A, Marini M. Modified translabyrinthine approach and hearing preservation. *Laryngoscope* 2004; 114: 1133-8. [\[CrossRef\]](#)
17. Sanna M, Mazzoni A, Saleh E, Taibah A, Mancini F. The system of the modified transcochlear approach: a lateral avenue to the central skull base. *Am J Otol* 1998; 19: 88-97.
18. Kim MJ, An YS, Jang MS, Cho YS, Chung JW. Hearing and facial function after surgical removal of cholesteatomas involving petrous bone. *Clin Exp Otorhinolaryngol* 2014; 7: 264-8. [\[CrossRef\]](#)
19. Senn P, Haeusler R, Panosetti E, Caversaccio M. Petrous bone cholesteatoma removal with hearing preservation. *Otol Neurotol* 2011; 32: 236-41. [\[CrossRef\]](#)
20. Mattox DE. Endoscopy-assisted surgery of the petrous apex. *Otolaryngol Head Neck Surg* 2004; 130: 229-41. [\[CrossRef\]](#)
21. Presutti L, Alicandri-Ciufelli M, Rubini A, Gioacchini FM, Marchioni D. Combined lateral microscopic/endoscopic approaches to petrous apex lesions: pilot clinical experiences. *Ann Otol Rhinol Laryngol* 2014; 123: 550-9. [\[CrossRef\]](#)
22. Kojima H, Tanaka Y, Yaguchi Y, Miyazaki H, Murakami S, Moriyama H. Endoscope-assisted surgery via the middle cranial fossa approach for a petrous cholesteatoma. *Auris Nasus Larynx* 2008; 35: 469-74. [\[CrossRef\]](#)
23. Iannella G, Savastano E, Pasquariello B, Re M, Magliulo G. Giant petrous bone cholesteatoma: combined microscopic surgery and an adjuvant endoscopic approach. *J Neurol Surg Rep* 2016; 2: e46-e9. [\[CrossRef\]](#)
24. Kumral TL, Uyar Y, Yıldırım G, Berkiten G, Mutlu AT, Kılıç MV. Does endoscopic surgery reduce recurrence of the petrous apex cholesteatoma? *Indian J Otolaryngol Head Neck Surg* 2013; 65: 327-32. [\[CrossRef\]](#)