Review

Anterior atticotomy technique in otology: A review article

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ABSTRACT

Techniques used in modern otology have been developed and refined over the years to maximize effectiveness. Mastoidectomy using a posterior approach is favored in chronic otitis media surgery, but we believe that exploration of anterior atticotomy, or the excision of the lateral wall of the attic, would be useful. During atticotomy, the attic is revealed and the opening is then extended to the antrum and mastoid cells. Atticotomy avoids unnecessary procedures, such as a wide (extended) mastoidectomy and provides better exposure of the sinus tympani, facial recess, and hypotympanum. It avoids the complications involved with Korner's septum, an anterior sigmoid sinus, and a low-lying dura. In this article, we review indications, techniques, and complications and present the advantages and disadvantages of this technique in detail.

Keywords: Atticotomy; inside out technique; review.

Techniques used in modern otology have been developed and refined over the years to maximize effectiveness. As new methods have been developed, the importance of some classic techniques has been acknowledged. Anterior atticotomy using the transcanal approach is one of the techniques that can be applied to chronic otitis media with or without cholesteatomas. Posterior atticotomy via mastoidectomy is favored, but we believe that it would be useful to emphasize anterior atticotomy, which is not described specifically in otology textbooks and surgical atlases. We aim to review the indications, techniques, and complications and to present the advantages and disadvantages of this technique with our experience in detail.

Atticotomy is the excision of the lateral wall of the attic region (Figure 1). This region can be exposed via both the external auditory canal in anterior atticotomy and the mastoid cavity in posterior atticotomy. During anterior atticotomy, the attic is opened and the opening is then extended to the antrum and mastoid cells (Figure 2a). In the posterior approach, a mastoidectomy is performed and the attic is approached via this cavity (Figure 2b).

Anatomy

As it is known, the attic or epitympanic space forms the upper one-third of the tympanic cavity, bounded superiorly by the tegmen tympani, anteriorly by the bone that separates the cavity from the middle cranial fossa, inferiorly by the horizontal plane passing through the most superior level of the pars tensa, posteriorly by the antrum and mastoid cavity, and medially by

Received: October 10, 2018 **Accepted:** November 02, 2018

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Doi: http://dx.doi.org/10.5606/Tr-ENT.2018.41736

Citation:

Uyar Y, Saltürk Z, Başkadem Yılmazer A. Anterior atticotomy technique in otology: A review article. Tr-ENT 2018;28(3):145-153.

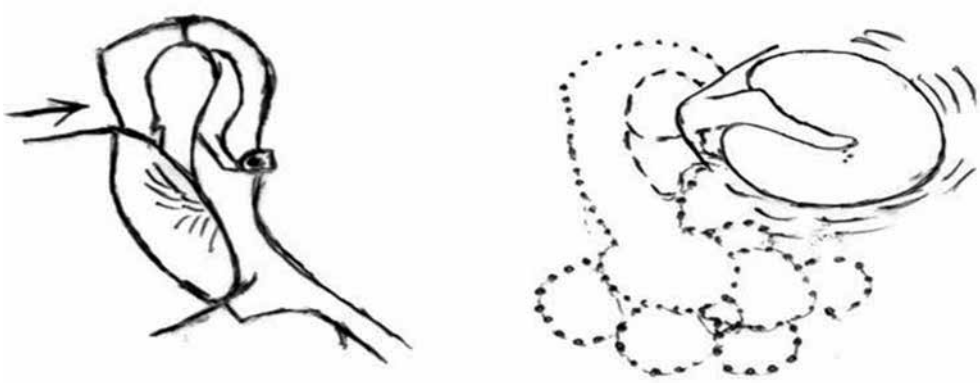

Figure 1. *Lateral view of attic at coronal section.*

the facial nerve, geniculate ganglion, and lateral and superior semicircular canals. It contains the head of the malleus and the body of the incus, which are suspended by ligaments dividing it into medial and lateral compartments.

History

Panse[1] performed a transcanal lateral atticotomy alongside the malleus and incus in order to remove a cholesteatoma in 1898, but he reported a preference for radical mastoidectomy. Chandler and Freeman[2] suggested this limited and exteriorizing operation for only one hearing ear. Dingley and Zwiefach[3] suggested limiting it for cholesteatoma surgery. Donald et al.[1] stated that they used this technique for extirpation of a limited cholesteatoma and mobilization of the fixed ossicular chain. Fleury et al.[4] also described a technique based on transcanal atticotomy. Thus far, there are only a few recent articles on atticotomy.[5-7]

Patient selection

Atticotomy is accepted as a routine procedure in otolaryngology practice. All chronic otitis media patients with or without cholesteatomas can be a candidate for anterior atticotomy technique. Following a detailed otologic examination via microscope or endoscope, a pure tone audiometer and a computed tomography (CT) of the temporal bone are used to evaluate the ossicular chain, the structure of the mastoid cavity, facial canal and semicircular canals, and the position of the sigmoid sinus. Moreover, a magnetic resonance image (MRI), especially diffusion weighted (DW) echo-plane one, can also be selected for complicated cases.[8] Since cholesteatoma can be

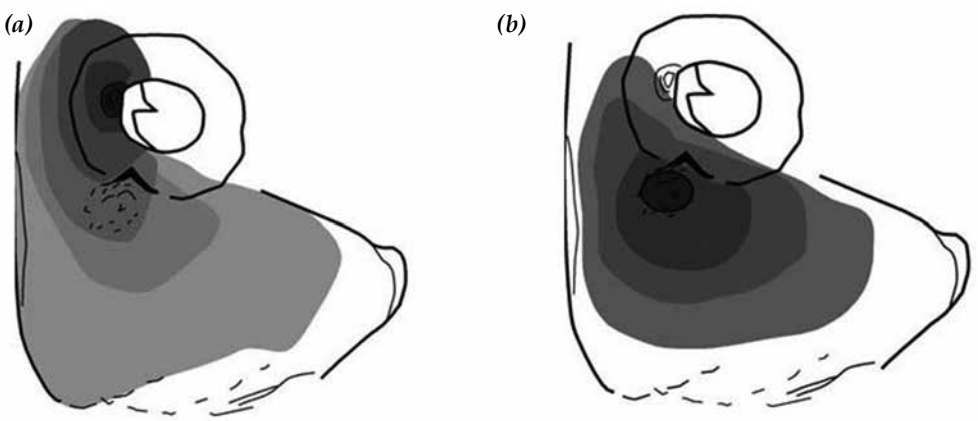

Figure 2. *Attico-antro-mastoidectomy approach:* ***(a)*** *anterior (inside-out),* ***(b)*** *posterior (outside-in).*

differentiated from soft tissue via Echoplanar MRIs,[9] follow-up of patients after surgery can be performed with the help of MRI.

Indications of anterior atticotomy:

- Retraction pockets
- Cholesteatoma
- Mobilization of fixed ossicles
- Congenital ossicular abnormalities

Operation Steps

Skin incision

A postauricular or endaural approach can be used (Figure 3) following local injection of lidocaine 2% with 1:100,000 epinephrine. The cartilage graft with its perichondrium is obtained from the tragus cavum concha. The perichondrium is elevated only from the convex side of the cartilage.

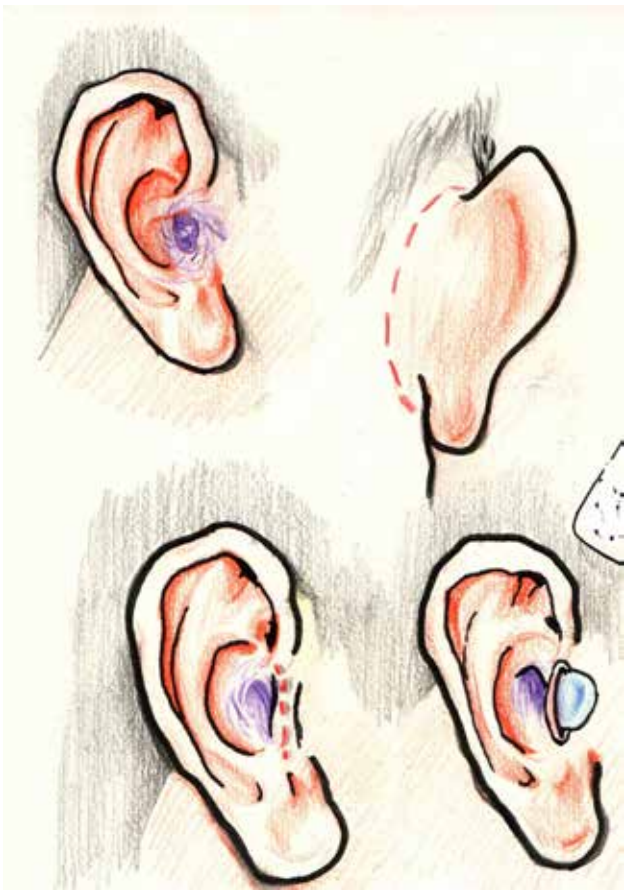

Figure 3. Postauricular incision, endaural incision and removal of tragal cartilage.

a) Retroauricular approach: A retroauricular incision is made through only the skin, preserving the underlying fascia and periosteum.

b) Endaural approach: The incision includes the external segment between the helix and tragus, with the endomeatal segment performed on the external auditory canal. The preauricular segment is extended from the insertion of the auricula to its superior border. The endomeatal segment starts high on the anterior wall of the canal and extends from the bone-cartilage junction parallel to the tympanic membrane. The soft tissues and perichondrium adjoining the auricula are pushed laterally using a rasp rotary or elevator, leaving the suprameatal spine, tympanomastoid fissure, and mastoid cortex exposed. Two self-retaining retractors are placed to obtain a widely exposed operating field.

Meatal skin flap

The meatal flap and tympanic membrane are elevated from the bone (Figure 4). A bipedunculated tympanomeatal flap (TMF) is prepared and folded anteriorly to be kept away from the operating field. A superiorly pedunculated or inferiorly pedunculated TMF can be prepared by applying incisions to points at 6 or 12 o'clock, respectively. According to author's experiences, a superiorly pedunculated flap can be damaged by burring due to proximity to the atticotomy and in contrast, inferiorly pedunculated flaps are thin and can be easily damaged, leading to retraction pockets due to a

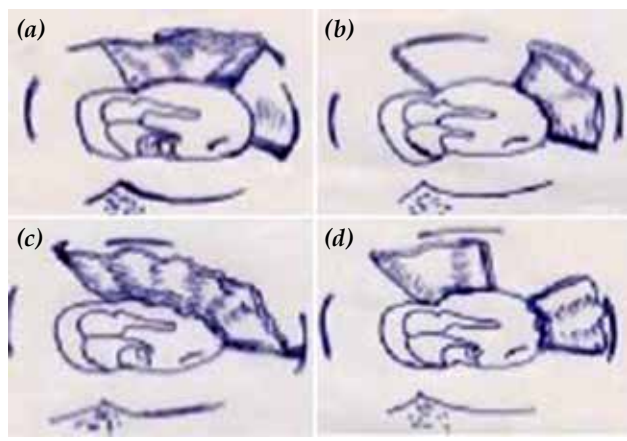

*Figure 4. Tympanomeatal flaps: **(a)** superior, **(b)** inferior, **(c)** bipedunculated, **(d)** swing-door.*

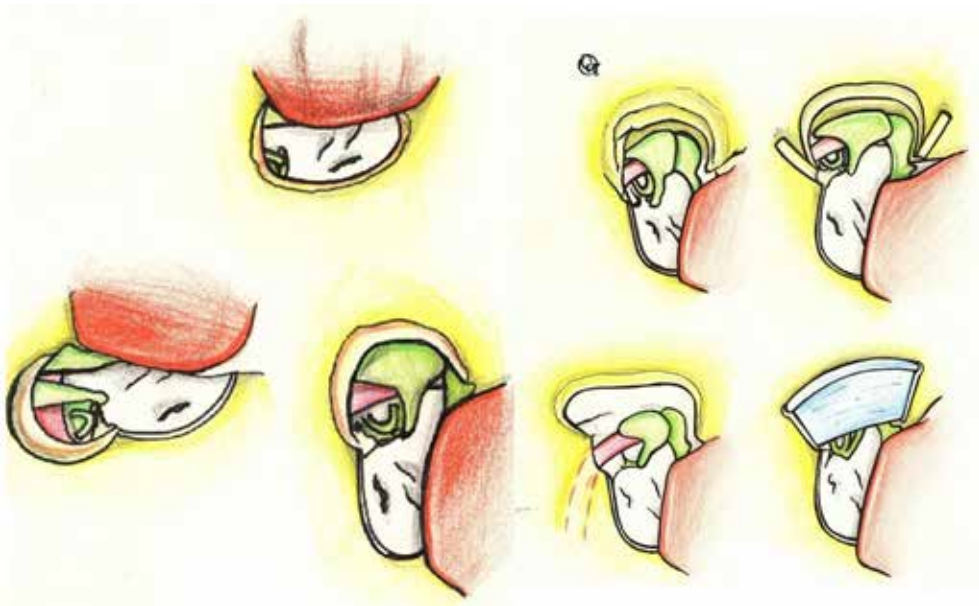

Figure 5. Anterior atticotomy.

weakened structure. Therefore, a bipedunculated flap is much more preferred by the author. Some surgeons occasionally apply a swing door flap.[10,11]

Evaluation of the middle ear

Anterior atticotomy: After exposing the bone of the superior and posterior portion of the canal, the lateral epitympanic wall is removed from the notch of Rivinius with small cutting burrs progressing superiorly, anteriorly, and posteriorly until the diseased area is fully exposed (Figure 5). Meanwhile, the tegmen tympani is manipulated by a Fisch rasp rotary. To avoid sensorineural hearing loss, the rotating burr must not be allowed to contact the ossicles. The incudostapedial joint is separated with a joint knife to avoid this complication when drilling close to the incus. The attic wall is removed with a burr until a thin layer is left over the ossicles. The bone layer is then removed with currets to expose the tegmen tympani, also exposing the incus, malleus, and stapedius. Pathologies, such as ossicular erosion and congenital fixation, can be corrected and mobilization of the incus and malleus can be restored. Mobility of the stapedius is examined. We prefer to perform reconstruction of the ossicular chain using a partial ossicular replacement prosthesis (PORP) or a total ossicular replacement prosthesis (TORP). Stapedotomy is performed in the second session.

Antrotomy and mastoidectomy: These procedures are commonly performed in cholesteatoma surgery. The bone is removed by following the capsule of the cholesteatoma to wherever it extends (Figure 6). If the cholesteatoma extends beyond the mastoid antrum into the mastoid, the mastoid cortex and cells are sufficiently removed to permit exenteration of the diseased tissue.[6] The usual landmarks are identified.

If needed, wide bone removal of the lateral semicircular canal, short process of the incus, facial canal, sigmoid sinus, middle fossa dura, sinodural angle, and digastric muscle is performed. The supratubal recess, facial recess, and sinus tympani should be adequately exposed. This can be controlled with endoscopes, if necessary. When the capsule of the cholesteaotma extends under the ossicles, the incus is removed and the head of the malleus is cut to provide wider exposure.

Removal of the cholesteatoma

The cholesteatoma capsule, including keratin and granulation tissue, must be removed. The

facial recess and sinus tympani are manipulated to remove the cholesteatoma capsule using 30- and 70-degree endoscopes.

Reconstruction

Posterosuperior canal wall: The cartilage obtained from the tragus or concha is used for this procedure. The perichondrium is elevated from the convex side of the cartilage and left attached to the opposite side. The cartilage is shaped to the desired size. Notching the bone helps to maintain the position of the cartilage, which is placed medially, and the perichondrial flap stabilizes the reconstructed canal wall on its lateral surface (Figure 7).

Tympanic membrane: The defect in the tympanic membrane can be covered by a cartilage-perichondrium flap as underlay techniques. The TMF is repositioned in its original place to support the anterior surface of the cartilage.

Wound closure

Wound closure is carried out using interrupted sutures of 4/0 monofilament nylon. Gelfoam pieces soaked with antibiotic solution are placed to preserve the meatal skin. The external canal is packed with a strip of gauze impregnated with antibiotic ointment.

Complications

Complications of this technique are comparable to those of other techniques that are used in these indications with facial complications, such as facial paralysis, dural injury, bleeding from the sigmoid sinus or jugular bulbus, being the most common. Steps can be taken to prevent common complications:

1) We switched from using temporalis muscle fascia to tragal cartilage-perichondrium grafts to avoid retraction of the tympanic membrane by increasing physical resistance.[6] Additionally,

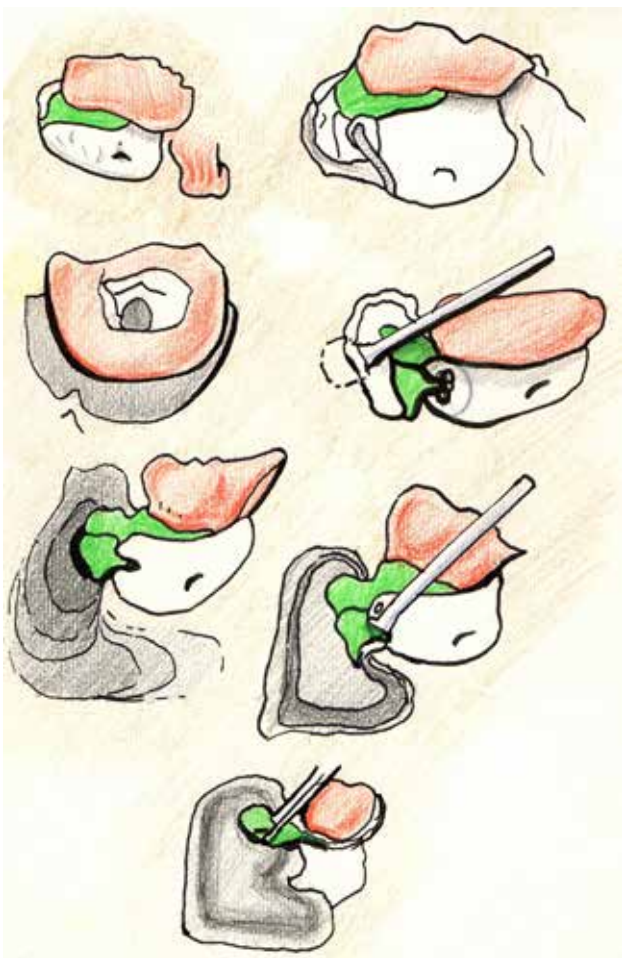

Figure 6. Anterior atticotomy and mastoidectomy in a case with cholesteatoma.

Figure 7. Reconstruction of external auditory canal with cartilage graft.

preservation of the ossicles contributes to prevention of retraction. Retraction is more common in cases in which the head of the malleus and the incus are removed because of the cholesteatoma.

2) We do not use an inferiorly pedunculated flap and instead use a bipedunculated flap, as detachment of the superior portion of the TMF led to decreased blood flow and a weaker flap.

The main disadvantage of anterior atticotomy is postoperative retraction, pocket formation, and cholesteatoma. According to our previous study, this rate is considerably lower than reported in the literature.[6] Therefore, in patients who underwent reconstruction with tragal cartilage, we recommend supporting the graft with a periosteal flap to prevent displacement, increase vascularization of the graft, and resist retraction.

DISCUSSION

Anterior atticotomy enables us to avoid perforation of the tympanic membrane and disturbance of the ossicular chain in chronic otitis media without cholesteatoma. Moreover, mastoid pathologies can be addressed without mastoidectomy after visualization using an endoscope through the auditus.[7,12,13] In contrast, posterior atticotomy requires a large mastoidectomy cavity. Part of the scutum should also be excised to expose and allow operation of the attic region.

The objectives of cholesteatoma surgery are to remove the diseased mucosal and bony tissue, achieve a healthy and dry ear, and restore hearing using the most suitable technique possible to prevent recurrence and residue. The choice of surgical technique in the treatment of cholesteatomas has been widely discussed. The canal wall down (CWD) and intact canal wall (ICW) tympanomastoidectomy procedures are the two major surgical techniques. The pros and cons of using either technique to eradicate cholesteatomas have long been a matter of debate (Table 1). Intact canal wall with anterior atticotomy is a limited procedure compared to classic mastoidectomy or CWD. Since it allows access to the cholesteatoma wherever it extends, if, during atticotomy, the cholesteatoma is found to have progressed toward the antrum and mastoid, the surgery may be expanded and the entire cholesteatoma may be removed by attic-antrum-mastoidectomy in inside-out manner. If the cholesteatoma is limited to the attic, this technique avoids unnecessary opening of the posterior mastoid cells, requiring shorter anesthesia and allowing quicker postoperative recovery.[14-16] If the ossicular chain is intact during anterior atticoantrotomy, disarticulation of the incudostapedial joint can prevent sensorineural hearing loss. The ossicles are exposed at the start of this technique, so that sensorineural hearing loss caused by the drill can be prevented. It may be helpful to burr opposite the ossicles to protect them from injury and the associated sensorineural hearing loss.

Körner's septum, which separates the more superficial mastoid cortex cells from the deeper cells and the antrum, represents the fusion of the squamous and petrous bones. It can be easily confused with the hard bone of the labyrinth and horizontal semicircular canal and is observed in 17.4% of patients with chronic otitis media.[14] In ears with Körner's septum, this

Table 1. The pros and cons of intact canal wall and canal wall down

	Intact canal wall	Canal wall down
Cholesteatoma recurrence	High rate	Low rate
Hearing	Better	Mild-moderate
Appearance	Normal	Enlarged meatus
Healing	Normal	Late
Cleaning	Not routinely	Routinely
Water tolerance	High	Low
Hearing rehabilitation	Easy	Difficult

technique may diminish complications being away from the septum. Moreover it can be a good solution where the sigmoid sinus is anteriorly located or the middle cranial fossa dura is low lying. Since these conditions limit access to the anterior epitympanum, posterior atticotomy may be problematic, though anterior atticotomy is certainly more demanding.[6]

The ICW tympanoplasty technique has a higher risk of chronic otitis media with recurrent or residual cholesteatoma, compared to the CWD technique.[6] Austin[17] reported recurrence rates of 4% and 39% in CWD and ICW, respectively, and Brown[18] reported 13% and 34% recurrence rates in CWD and ICW, respectively. Another study reported 17% and 35% recurrence rates in CWD and ICW, respectively. Because there is a high risk of recurrent cholesteatoma in patients in which the ICW technique is used, a second-look operation is recommended.[15,19-22] Atticotomy carries the advantages of both CWD and ICW and should be performed in cases of attic cholesteatoma, especially those located in the deep epitympanic recess. This technique reduces the risk of recurrence of attic cholesteatoma. In ears with uncomplicated cholesteatomas, single stage atticoantrotomy is sufficient and a second-look operation is unnecessary if the stapes-suprastructure and middle ear mucosa are intact.[6] Kim et al.,[23] Uyar et al.,[6] and Sakai et al.[24] reported recurrence rates of 3%, 4.8%, and 5%, respectively. Brown reported the rates of recurrence and residual cholesteatomas as 5% and 28% in ICW and CWD, respectively.[18] Stankovic[15] reported a 10% recurrence rate in children and 9.4% in adults. He proposed CWD for middle ear cholesteatomas and ICW for attic and antrum cholesteatomas.

Hearing function in patients who underwent attic reconstruction was good. The results of cholesteatoma cases are better in ICW compared to CWD. Kim et al.[23] reported a statistically significant decrease in the mean air-bone gap from 29.2±13.5 dB to 25.0±15.4 dB. The bone conduction level remained unchanged after surgery. Although it was statistically significant in attic reconstruction cases, it was not significant in obliterated ears. The results for osteoplastic atticoantrotomy were satisfactory in Gehrking's study.[25] Uyar et al.[6] reported a significant decrease in the air bone gap from 34.8±13.4 to 16.9±14.7 dB. The change in bone conduction was non-significant.[6]

An autologous cartilage graft is the most common material used in external auditory canal reconstruction, since it is easy to obtain and shape, and it has a reliable survival ability.[6,23,24,26-28] Long-term studies revealed resorption, distortion, and retraction problems in cartilage grafts.[27] Alternatively, Bacciu et al.[29] used bone pate. Some authors claimed that bone graft is more stable in the long-term.[25,27] On the other hand, bone grafts have risks of acute resorption and necrosis. Bone grafts are usually taken from the squamous portion of the temporal bone. In order to provide a vascular supply, it is covered by temporal muscle fascia or perichondrium and meatal skin flap. However, we support it using a periosteal flap to prevent infection and to provide stabilization and vascularization.[6] Alloplastic materials, such as bioactive glass, ceramics, hydroxyapatite, bone cement, and titanium, can also be used for reconstruction of the external auditory canal.[28-30]

We prefer tragal cartilage, which is usually sufficient for both reconstruction of the external auditory canal and the tympanic membrane. Conchal cartilage can be used in revision surgery. Tos suggested locating the cartilage by twisting its borders.[31] They used attic obliteration with cartilage plus cortical bone powder for prevention of retraction pockets. They claim that the retraction pocket rate was reduced with this method.

Other factors may affect the development of retraction pockets in the TMF, in addition to the reconstruction method of the lateral attic wall, as TMF protection is imperative during surgery. Fisch kept the elevated TMF out of the operating field using a small, malleable strip of aluminum.[32] When working with a burr, it is anchored to the retroauricular retractor.

Use of a bipenduculated flap is best due to its united structure. An inferiorly pedunculated flap is the most disadvantageous because the free border of the TMF is involved in the deflected area, predisposing it to the formation of retraction pockets and cholesteatomas.

To prevent the formation of retraction pockets and related cholesteatomas, obliteration of the attic was proposed. Kim et al.[23] performed attic reconstruction with cartilage palisades where there was a remaining head or short process of the malleus handle or without a short process. The open and empty epitympanic cavity space was obliterated with cartilage blocks. In the first group, hearing was improved with attic reconstruction using cartilage, but not in the second group. Postoperative retraction was seen in 18% of patients, but the rate was lower in the obliterated group. Sakai et al.[24] used cortical bone for obliteration and retraction occurred in 3.8% of cases. Gehrking[25] reported retraction in 6.5% and recurrent cholesteatomas in 9.7% of cases. Lee et al.[33] used abdominal fat for obliteration of the attic and mastoid. Aeration via the Eustachian tube is as important as the presence of the malleus and incus and should be evaluated. Retractions usually develop at the reconstruction site. In our previous study, we observed the retraction pocket rate of 6.3%.[6] This is lower than in literature, because we started to use bipenduncular flap instead of inferiorly pedunculated flap and cartilage-perichondrial graft for the repair of tympanic membrane instead of temporal muscle fascia.

In conclusion, anterior atticotomy is a method that enables the surgeon to access the attic region via a transcanal approach, avoids unnecessary procedures, such as a wide (extended) mastoidectomy, and lessens the duration of operations and anesthesia. It provides better exposure of the sinus tympani, facial recess, and hypotympanum while avoiding the complications involved with Korner's septum, an anterior sigmoid sinus, and a low-lying dura. This approach results in better postoperative hearing levels. Nikolopoulos considered this technique as a third method for atticotomy/limited mastoidectomy in addition to ICW and CWD.[5] There are many problems waiting to be solved and we believe new approaches are necessary.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

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