

ORIGINAL ARTICLE

Endoscopic approach to tensor fold in patients with attic cholesteatoma

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Abstract

Conclusion. The endoscopic approach to attic cholesteatoma allows clear observation of the tensor fold area and consequently, excision of the tensor fold, modifying the epitympanic diaphragm. This permits good removal of cholesteatoma and direct ventilation of the upper unit, preventing the development of a retraction pocket or attic cholesteatoma recurrence, with good functional results. **Objectives.** An isthmus block associated with a complete tensor fold is a necessary condition for creation and development of an attic cholesteatoma. During surgical treatment of attic cholesteatoma, tensor fold removal is required to restore ventilation of the attic region. Use of a microscope does not allow exposure of the tensor fold area and so removal of the tensor fold can be very difficult. In contrast, the endoscope permits better visualization of the tensor fold area, and this aids understanding of the anatomy of the tensor fold and its removal, restoring attic ventilation. **Patients and methods.** In all, 21 patients with limited attic cholesteatoma underwent an endoscopic approach with complete removal of the disease. Patients with a wide external ear canal were operated through an exclusively endoscopic transcanal approach; patients with a narrow external ear canal or who were affected by external canal exostosis were operated through a traditional retroauricular incision and meatoplasty followed by the endoscopic transcanal approach. **Results.** In 18/21 patients, the endoscope permitted the discovery of different anatomical morphologies of the tensor fold. Sixteen patients presented a complete tensor fold (one with an anomalous transversal orientation), one patient presented an incomplete tensor fold and one patient presented a bony ridge in the cochleariform region. In all 16 cases of complete tensor tympani fold, the fold was removed and anterior epitympanic ventilation was restored. The ridge bone over the cochleariform process was also removed with a microdrill.

Keywords: Endoscope, attic cholesteatoma, tensor fold, tympanic isthmus

Introduction

Although it is 20 years since the introduction of the operative endoscope to ear surgery in exploration of old mastoid cavities, there is currently a very limited role for the endoscope in the day-to-day surgical management of ear disease worldwide. Traditional approaches to the attic through a microscopic postauricular tympanomastoidectomy provide limited exposure of the attic, especially anteriorly.

Tarabichi [1] proposed an exclusive endoscopic approach to treat limited attic cholesteatoma; in his view, the transcanal endoscopic approach offers good access to the anterior epitympanic area, allowing complete removal of limited attic disease. Palva et al. have stressed an isthmus block associated with

a complete tensor fold, which interferes with the ventilation route between the mesotympanum and the attic, as an important condition for the creation and development of an attic cholesteatoma and the importance of tensor fold removal during surgical treatment of attic cholesteatoma to restore ventilation of the attic region [2,3].

The use of a microscope does not permit observation of the tensor fold area and so the surgeon is not able to remove it. Two different microscopic approaches to the tensor fold have been described. Using microdissection anatomical studies on frozen temporal bones of patients not affected by cholesteatoma, Palva et al. [4] proposed an endaural atticotomy extending to the supratubal recess to access the tensor fold, while Morimitsu et al. [5]

proposed an 'anterior tympanotomy' with a transmastoid approach to ensure complete removal of the anterior attic bony plate.

In this study, we propose an exclusively endoscopic approach to the tensor fold area. The tensor fold was removed during endoscopic surgery by an angled instrument; this operation ensures anterior epitympanic to protympanic communication, restoring ventilation of the upper unit. To our knowledge, this is the first study focused on understanding the complex anatomy of the tensor fold area in patients affected by attic cholesteatoma.

Patients and methods

Patients

From January 2006 to March 2007, we studied 87 patients affected by middle ear acquired cholesteatoma. Patients were selected on the basis of inclusion and exclusion criteria. Only subjects affected by limited attic cholesteatoma with or without a minimal posterior involvement of the antrum and a minimal inferior involvement of the second tract of the facial nerve were included. Subjects affected by middle ear cholesteatoma extending to the mastoid, mesotympanic or protympanic area were excluded. Patients affected by chronic otitis, simple pocket retraction of the membrane, temporal bone cholesteatoma, iatrogenic cholesteatoma, congenital cholesteatoma, and cholesterol granulomas were also excluded, as were patients already undergoing middle ear surgery. Out of 87 patients, 21 were finally included in the study.

All of the subjects were studied on the basis of preoperative and postoperative office-based endoscopic ear examination, audiometric testing, and high-resolution CT of temporal bone. They all underwent endoscopic middle ear surgery performed by two experienced surgeons from the clinic (L.P. and D.M.), both with a similar surgical endoscopic approach. The surgical approach was defined on the basis of clinical preoperative endoscopic ear examination as follows. Patients with a wide external ear canal were operated through an exclusively endoscopic transcanal approach; patients with a narrow external ear canal or affected by external canal exostosis were operated through a traditional retroauricular incision and meatoplasty, followed by an endoscopic transcanal approach.

The instrumentation consisted of 3 mm, wide angle (20 cm length) 0°, 30°, and 45° sinusscopes (Karl Storz). The video equipment consisted of a three-chip video camera (Karl Storz) and 20" high definition monitor; all procedures were performed

by working from the images on the monitor and were recorded with a DVD recorder.

Surgical technique

Exclusive endoscopic approach. A posterior tympanomeatal flap was created with the superior limb at the 1 o'clock position and the inferior limb at the 6 o'clock position. The tympanomeatal flap was elevated and transposed inferiorly; we entered into the middle ear under the annulus uncovering the epitympanic region. Transcanal atticotomy was performed with a microdrill system (Skeeter drill) and with endoscopic monitoring (Figure 1). Drilling was performed until the cholesteatoma sac was completely visible with the 3 mm 30–45° endoscope. The surgical field was irrigated frequently during all surgical maneuvers. The cholesteatoma sac was carefully removed from the attic region by an appropriately angled instrument.

When the cholesteatoma developed under the ossicular chain affecting the medial face of the posterior epitympanic recess, the body of the incus and the head of the malleus were removed (Figure 2). When the cholesteatoma developed posteriorly into the antrum, a wide posterior atticotomy was performed to permit us to remove the disease.

After cholesteatoma removal, we checked the tensor fold area with the endoscope and removed the tensor fold, restoring an anterior epitympanic ventilation. Endoscopic examination of the tensor fold area is possible using an endoscope of 3 mm diameter and with a 45° scope inserted in the protympanic region; this position allows good exploration of the inferior edge of the tensor fold (Figure 3).

The tensor fold was removed with an angled instrument and with endoscopic monitoring (Figure 4). In some cases, anterior atticotomy exposed the superior face of the tensor fold seen by the endoscope inserted into the anterior epitympanic region and rotated inferiorly (Figure 5). This surgical approach is very important to modify the epitympanic diaphragm and to create direct ventilation of the anterior epitympanum from the protympanum (Figure 6). The tympanic membrane defect and attic bone defect were reconstructed with a composite tragal graft.

When the body of the incus and the head of the malleus were removed, an ossicular chain reconstruction was performed with autologous incus.

Transcanal endoscopic approach with 'traditional' meatoplasty. In patients with a narrow external auditory canal, we performed a 'classic' retroauricular excision. A mucoperiosteal flap was elevated anteriorly and Henle's spine was identified. Simple

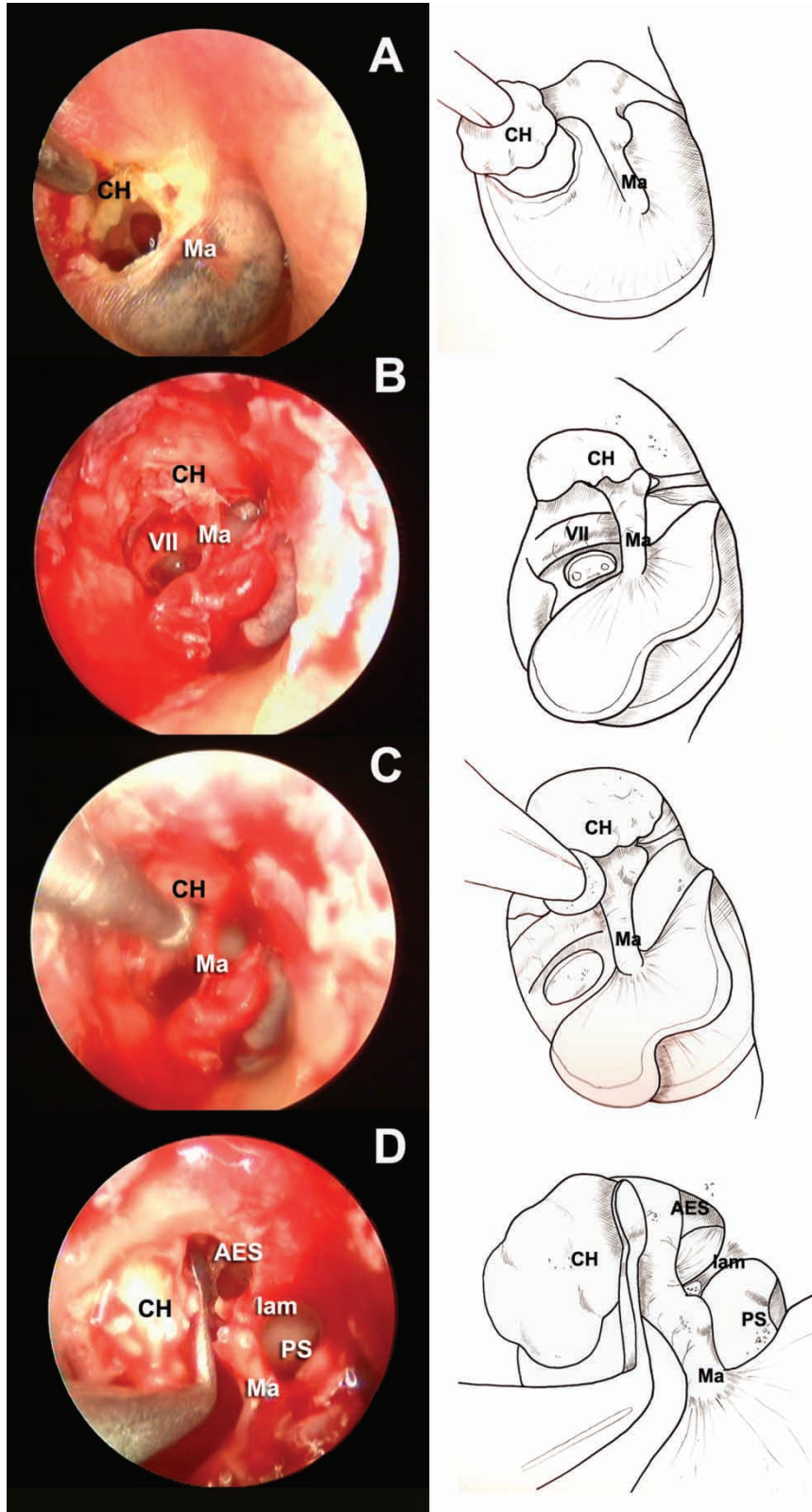


Figure 1. Right ear. (A) Attic cholesteatoma; (B) a posterior tympanomeatal flap creation; (C) transcanal atticotomy performed with a microdrill; (D) cholesteatoma removal by an appropriately angled instrument. CH, cholesteatoma; Ma, malleus; VII, facial nerve; AES, anterior epitympanic space; lam, anterior malleolar ligament; PS, protympanic space.

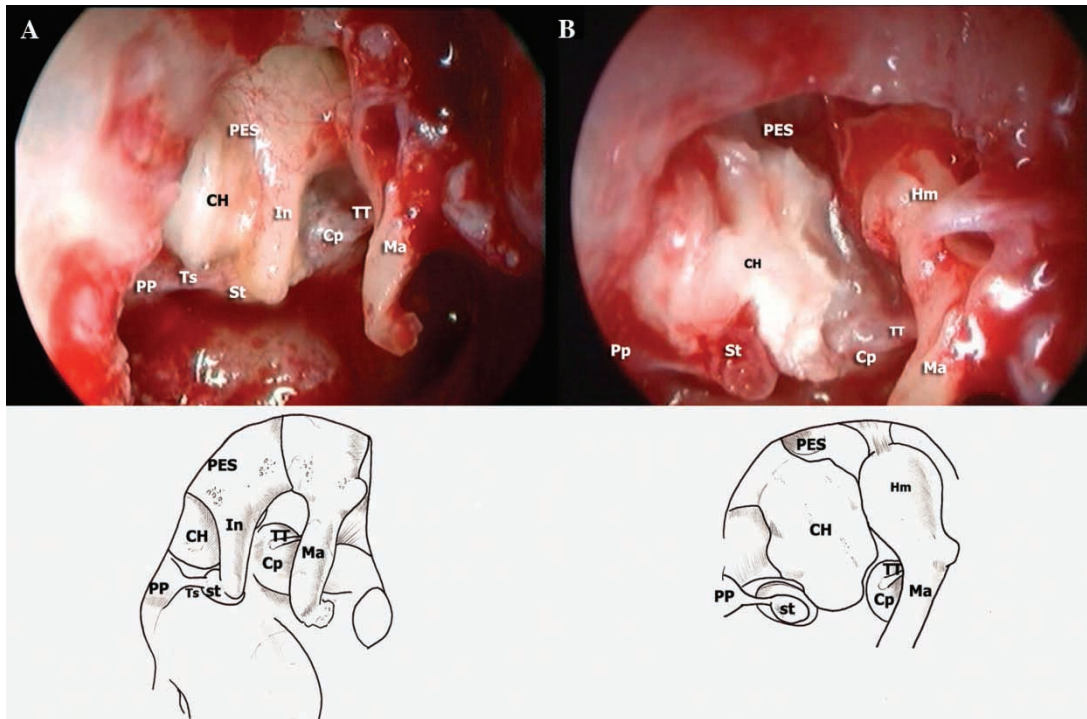


Figure 2. Right ear. (A) Cholesteatoma involving the medial part of the ossicular chain. (B) Endoscopic view after incus removal. CH, cholesteatoma; PES, posterior epitympanic space; Ma, malleus; TT, tensor tendon; Cp, cochleariform process; In, incus; St, stapes; PP, pyramidal process; Ts, stapedial tendon; Hm, head of the malleus.

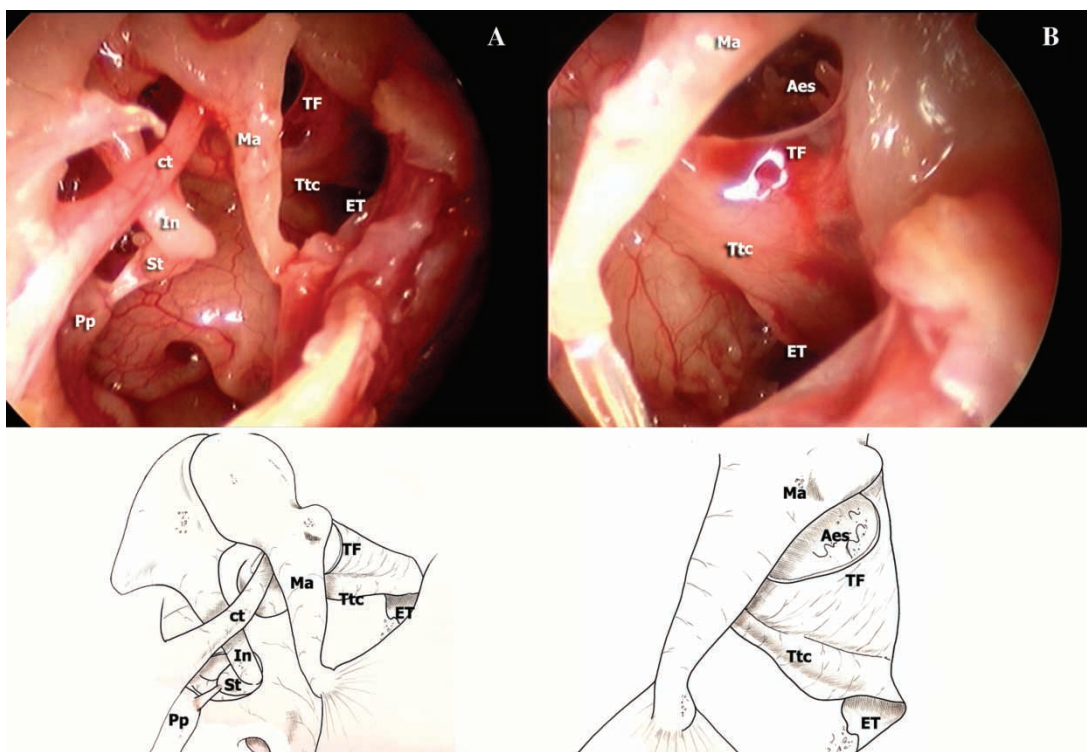


Figure 3. Right ear. (A) Endoscopic view of the inferior ridge of tensor fold. (B) Magnification of partial removal of tensor fold. Aes, anterior epitympanic space; Ma, malleus; TF, tensor fold; In, incus; St, stapes; Pp, pyramidal process; ET, eustachian tube; Ttc, tensor tympani canal; ct, corda tympani.

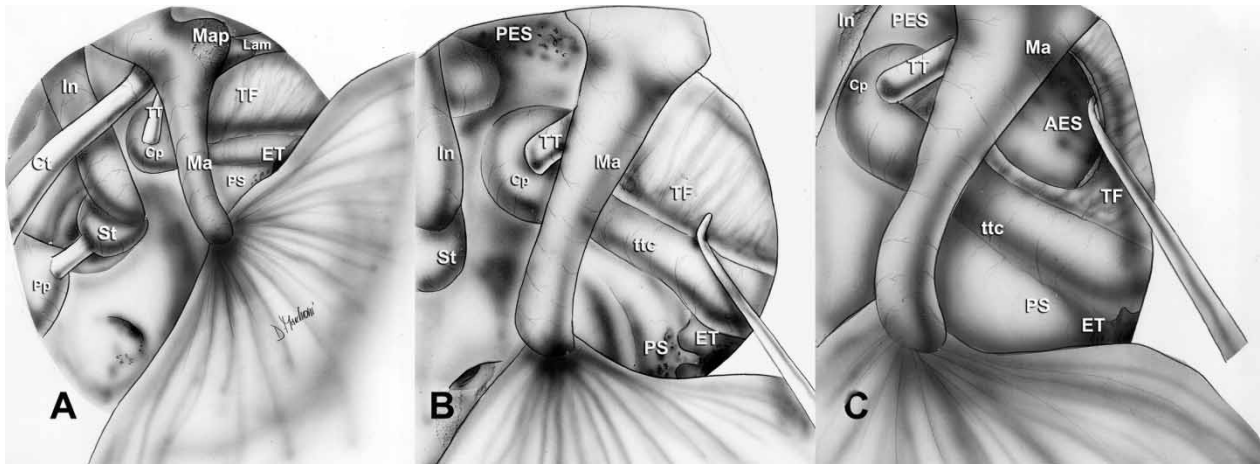


Figure 4. Right ear. (A–C) Tensor fold removal by angled instrument. AES, anterior epitympanic space; Ma, malleus; TT, tensor tendon; TF, tensor fold; In, incus; St, stapes; Pp, pyramidal process; ET, eustachian tube; ttc, tensor tympani canal; Ct, corda tympani; Map, short malleus process; Lam, anterior malleolar ligament; PS, protympanic space.

meatoplasty was carried out with the microscopic approach. We used a microdrill to remove any external canal exostosis or to enlarge the external canal. After this microscopic procedure, we continued the surgery with the transcanal endoscopic approach using the same steps as in the exclusive endoscopic approach.

Results

Our consecutive case series consisted of 21 patients with limited acquired attic cholesteatoma operated by an endoscopic (exclusive and transcanal with traditional meatoplasty) approach over a 1-year period; there were 17 males and 4 females, with a median age of 38.4 years. Audiological testing showed an air–bone gap of 25 dB or more (average of the air–bone gap at 500, 1000 and 2000 Hz) in 19 patients.

A preoperative HR-CT scan of temporal bone and an office-based endoscopic ear examination were performed in all patients. The preoperative study permitted us to decide the type of surgical approach. Thus, 19/21 patients underwent an exclusively transcanal endoscopic approach; in 5 of these, it was necessary to change to a traditional microscopic approach (3 patients presented excessive bleeding that prevented the endoscopic approach and in 2 patients we intraoperatively discovered a posterior involvement of the mastoid region that prevented complete removal by a transcanal endoscopic approach).

Two of the 21 patients underwent a traditional microscopic meatoplasty followed by a transcanal endoscopic approach. No facial nerve or tegmen tympani dehiscence was identified during surgery.

Primary ossicular reconstruction, using autologous incus, was performed in 14/21 (66.7%) patients; 8/14 patients presented an ossicular chain erosion and in 6/14 the cholesteatoma sac was developed in the medial portion of the ossicular chain and we had to remove the incus and the head of the malleus.

In 7/21 (33.3%) patients, where the cholesteatoma had involved only the anterior epitympanum, it was possible to eradicate the disease without disarticulation of the ossicular chain.

When the endoscopic approach was possible, the use of a 45° endoscope allowed us to identify the tensor fold area. The use of an angled optical instrument, introduced in the protympanic region, permitted good exposure of the inferior face of the tensor fold without ossicular chain disarticulation. Moreover, an atticotomy extended anteriorly allowed better visualization of the superior face of the tensor fold and consequently aided dissection.

Identification of the tensor fold area was not possible in 3/21 patients who underwent a traditional microscopic meatoplasty for extreme bleeding during surgery.

In 18/21 patients, endoscopy allowed us to discover different anatomic morphologies of the tensor fold. Fifteen patients presented a complete tensor fold (the folds were attached anteriorly to the superior limit of the eustachian tube, and posteriorly to the tensor tendon and the cochleariform process dividing the anterior epitympanum from the protympanum). One patient presented an incomplete tensor fold (the fold presented a minor communication area between the protympanum and the epitympanum region); in this case, the cholesteatoma developed in the protympanum from the anterior epitympanic region through this little perforation in

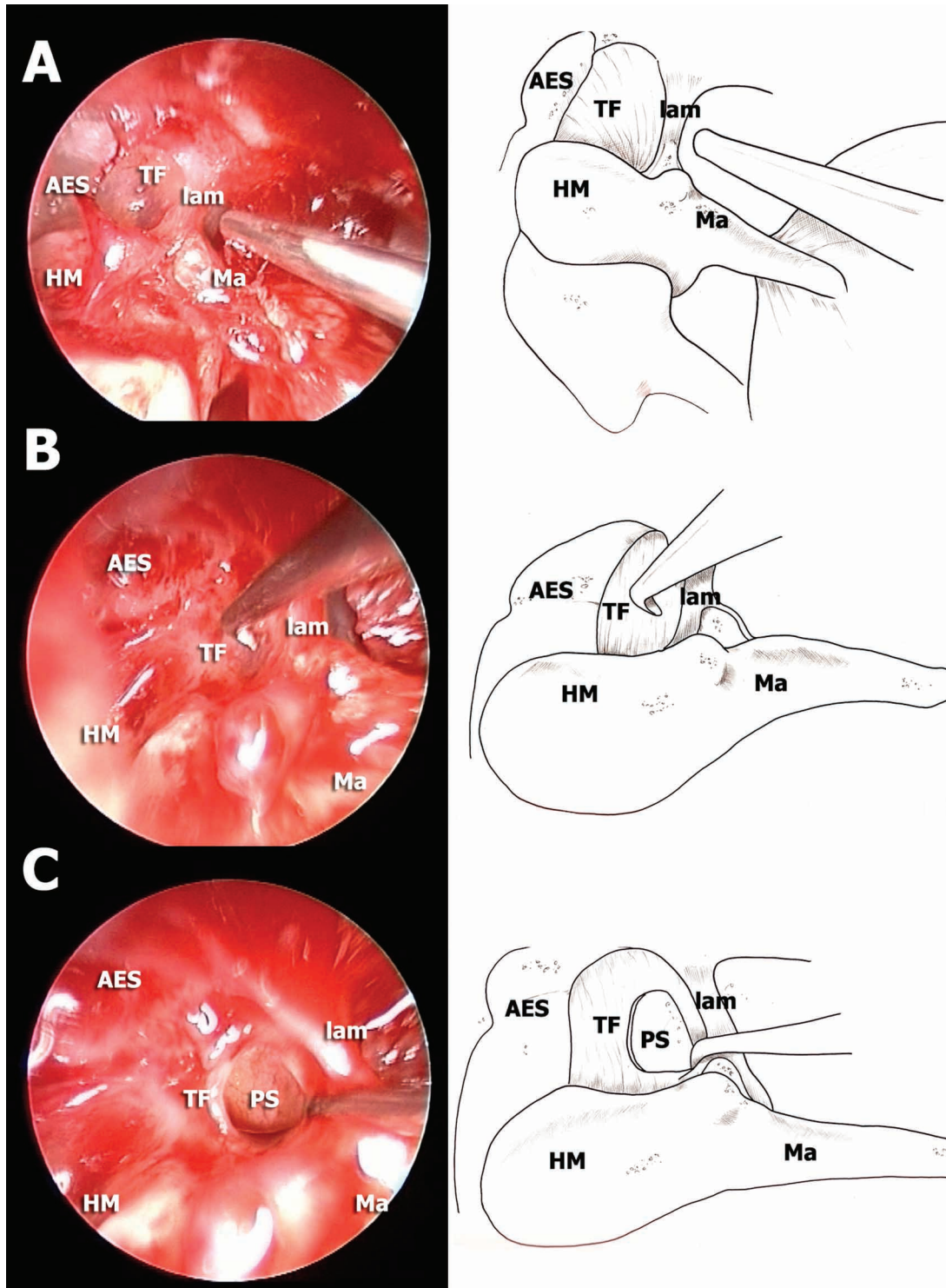


Figure 5. (A, B) Anterior atticotomy exposing the superior face of the tensor fold. (C) Tensor fold removal. AES, anterior epitympanic space; Ma, malleus; TF, tensor fold; lam, anterior malleolar ligament; PS, protympanic space; HM, head of the malleus.

the tensor fold. One patient presented a bony ridge in the cochleariform region causing an isthmus block attached anteriorly to a small tensor fold (also in this case, the epitympanic region was separated from the protympanum). Another patient presented a com-

plete tensor fold with an anomalous transversal orientation (the fold was attached laterally to the medial portion of the malleus, inferiorly to the tensor tendon and the cochleariform process, and superiorly to the attic region dividing the anterior

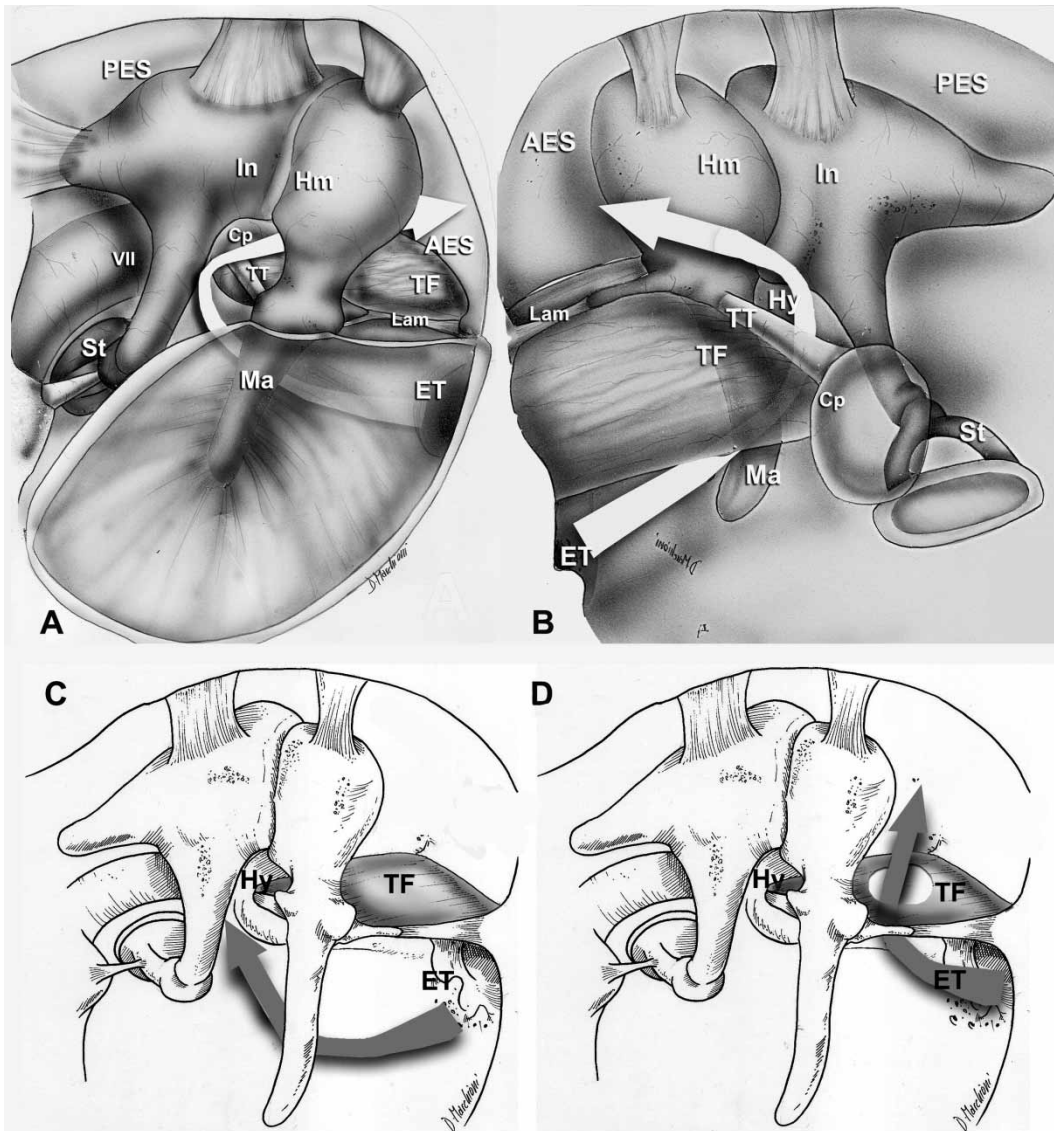


Figure 6. (A, B) Aeration of the anterior epitympanic area via the large tympanic isthmus between the medial part of the posterior incudal ligament and the tensor tendon; (A) anterior view; (B) posterior view. (C, D) Tympanic isthmus block and dysventilation of the upper unit; tensor fold removal restoring ventilation of the upper unit. AES, anterior epitympanic space; Ma, malleus; TF, tensor fold; Lam, anterior malleolar ligament; Hm, head of the malleus; PES, posterior epitympanic space; Cp, cochleariform process; TT, tensor tendon; St, stapes; ET, eustachian tube; In, incus; Hy, tympanic isthmus; white arrow, protympanic to anterior epitympanic pattern of ventilation.

epitympanum into two areas: the anterior and posterior portion).

All 21 patients presented a cholesteatoma mass causing an isthmus block. In all 16 cases of complete tensor tympani fold with an isthmus block causing an exclusion of the anterior epitympanum we removed it, thus restoring an anterior epitympanic ventilation. In the patient with an isthmus block caused by a ridge bone over the cochleariform process, we removed it with a microdrill. In the patient with an incomplete tensor fold, we enlarged the minor communication from the protympanic to

the epitympanic region. In all cases, the scutum was reconstructed using a tragal graft.

All patients were discharged 1 day after surgery without any complications. Mean follow-up was 23 months. No patients required revision for recurrent or clinically evident disease. HR-CT performed 1 year post-primary surgery was negative for recurrence in all cases. A moderate epitympanic retraction area was evident in one patient but no further intervention was required.

Audiological testing at the last follow-up visit for the individual patients showed closure of the

air–bone gap to within 25 dB (average of the air–bone gap at 500, 1000, and 2000 Hz) in 18 patients.

In this series, there was no morbidity or complication secondary to the use of the endoscope in the middle ear.

Discussion

In 1946, Chatellier and Lemoine [6] formulated the concept of ‘the epitympanic diaphragm’. The authors described different ligament and membranous folds, which together with the malleus and incus, form the floor of a large epitympanic compartment. This space represents the upper unit and is aerated from the protympanic space through the tympanic isthmus. During recent years, the anatomy of the epitympanic diaphragm was studied by Palva and co-workers [7–9]. The author described the ‘epitympanic diaphragm’, which consists of three malleal ligamental folds (the anterior, lateral, and posterior), the posterior incudal ligamental fold, and two purely membranous folds (the tensor fold and the lateral incudomalleal fold) together with the malleus and incus. All epitympanic compartments receive their aeration via the large tympanic isthmus between the medial part of the posterior incudal ligament and the tensor tendon (Figure 6).

The aeration pathway from the eustachian tube leads directly to the mesotympanic and hypotympanic spaces, whereas the epitympanum is away from the direct air stream and is only aerated through the tympanic isthmus, not including any possible auxiliary pathways.

Palva et al. [3] studied children affected by an isthmus block and who had undergone a tympanostomy tube placement; the author observed the persistence of inflammatory materials and cholesterol granuloma in the superior attic despite the tympanostomy tube. This condition may be the basis of attic cholesteatoma developing from a pocket retraction. Children with incomplete or absence of tensor fold presented good ventilation of the anterior attic. These data confirmed the importance of tensor fold removal during the surgical treatment of middle ear attic cholesteatoma for restoring ventilation of the attic region. Also, in surgery of the epitympanic retraction pocket, the surgeon’s aim – when the eustachian tube is functioning – should be to create a new ‘epitympanic diaphragm’ with one common air space from the protympanum to the anterior epitympanic recess to prevent development of an attic cholesteatoma.

In traditional microscopic middle ear surgery, some authors [4,5] have proposed different surgical approaches to visualize the tensor fold; otherwise, it is very difficult to observe this particular structure

with a microscope. In fact, the use of a microscope during canal wall up techniques did not permit the visualization of the tensor fold, because the working angle was through the ear canal and the tensor fold remained hidden behind the neck of the malleus. For this reason, Morimitsu et al. [5] proposed an ‘anterior tympanotomy’. These authors removed bone from the lateral attic to the zygoma. In this way, the working axis frontally became parallel to the axis of the ear canal. After this bone removal, it was possible to drill in front of the malleus head and remove the tensor fold.

Palva et al. [4] suggested tensor fold excision to create a large new attic aeration pathway during cholesteatoma surgery by an endaural atticotomy extending to the supratubal recess. When the ossicular chain was intact, the authors suggested cutting the neck of the malleus to allow lateral lifting of the manubrium. This approach exposed the tensor tendon and allowed excision of the tensor fold.

We propose an endoscopic approach to the tensor fold. The exclusive endoscopic approach allows a wide exposure of the anterior epitympanic compartment and, in some cases, the complete eradication of an anterior epitympanic cholesteatoma without dis-jointing the ossicular chain, an extremely difficult maneuver using only a microscope. The exclusive endoscopic approach also allows the surgeon to better highlight the tensor tympani fold, its angle-shot and structure (complete or partially complete) and at the same time to cut it off, restoring an adequate antero-posterior protympanic-epitympanic ventilation.

Using the endoscope in the protympanum cavity permitted us to observe the inferior face of the tensor fold, without disarticulation of the ossicular chain. When the visualization of the tensor fold was poor, it was possible to cut the tensor tendon near the malleus, creating a better view of the fold with a delicate maneuver causing malleus lateralization. The tensor fold was removed with an angled instrument during endoscopic surgery; this operation permitted anterior epitympanic to protympanic communication, restoring ventilation of the upper unit. Moreover, the endoscope allowed us to understand the complex anatomy of the epitympanic diaphragm and to describe the endoscopic anatomy of the tensor fold.

In all patients, the tensor fold separated the anterior epitympanum from the protympanum space. The posterior-inferior border of this structure was attached to the tensor tympani tendon, between the cochleariform process and the handle of the malleus. The orientation of the tensor fold was horizontal and anteriorly attached over the eustachian tube, but in one case we found a complete tensor fold with a

transverse orientation dividing the epitympanum into two portions. Also in this case, the posterior epitympanum was separated from the protympanic region. Only in one patient was there a bony ridge over the cochleariform process causing an isthmus block anteriorly continuing in a tensor fold.

However, an exclusively endoscopic approach presents several drawbacks. It is a one-handed surgery with loss of depth of perception and binocular vision. It involves working in a confined space, with the risk of damage to the ossicular chain due to inadvertent contacts, although in our experience there was no morbidity or complication secondary to the use of the endoscope in the middle ear.

In the case of considerable bleeding, it becomes a very frustrating and almost impossible process that forces the surgeon to adopt the traditional postauricular approach. When the surgical field was bleeding it was not easy to identify the tensor fold, and in this condition we had to revert to the microscopic approach in which we could not see the tensor fold area or remove the tensor fold.

We used a 3 mm diameter endoscope because it misted up less than the 2.7 mm endoscope, even though a larger diameter endoscope could be more difficult to manage while exploring very restricted areas, especially in patients with a narrow external auditory canal.

Conclusion

In our opinion, the endoscopic approach to attic cholesteatoma allows a clear observation of the tensor fold area and, consequently, the excision of the tensor fold, modifying the epitympanic dia-

phragm. This approach permits a good removal of cholesteatoma and direct ventilation of the upper unit, preventing the development of a retraction pocket or attic cholesteatoma recurrence, and with good functional results.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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