Indian J Otolaryngol Head Neck Surg
(January–March 2010) 62(1):6–24; DOI: 10.1007/s12070-010-0007-7

Invited Article

Endoscopic transcanal middle ear surgery

Muaaz Tarabichi

Abstract The advantages and limitations of the microscope have defined postauricular access as the surgical intervention of choice for the treatment of diseases of the middle ear. The wide-angle view provided by the endoscope enables transcanal access to the tympanic cavity, and its otherwise difficult-to-reach extensions: The attic, sinus tympani, facial recess, and hypotympanum. These areas are the primary sites of disease and surgical failure to cure. The endoscope also allows an all encompassing view of the three main elements in tympanoplasty surgery: The ear canal, tympanic membrane, and the tympanic ring. This report is a summary of the author's two 17 years of experience with the use of transcanal operative endoscopy as the primary approach to the management of middle ear disease.

Keywords Endoscope · Ear surgery · Cholesteatoma · Tympanoplasty

M. Tarabichi
Department of Otolaryngology,
American Hospital Dubai,
Dubai, UAE

M. Tarabichi (✉)
E-mail: tarabichi@yahoo.com

Introduction

Although it has been two decades since the first use of operative endoscopy for the exploration of old mastoid cavities, the endoscope is used infrequently in the day-today surgical management of ear disease around the globe for several reasons [1]. The role of the endoscope as defined by many prominent otologists is so marginal that most surgeons have not felt compelled to master newer techniques and instrumentation for its use [2–6]. In effect, the use of the endoscope did not significantly benefit either the patient or the surgeon. In addition, most physicians have focused on the use of smaller diameter endoscopes for ear surgery, which is very frustrating blinded manuscript Click here to download blinded manuscript: Endoscopic Transcanal Middle Ear Surgery pdf and eliminates the main (and possibly the only) advantage of endoscopy (the wide field of view provided by the endoscope is greater than that of the microscope). This author first used the endoscope in ear surgery in 1993 during years of practice in the US. In recent years, it has replaced the microscope as the instrument of choice for use in middle ear surgery [7–10]. The endoscope offers a new perspective of cholesteatoma and related surgical procedures by increasing the surgeon’s understanding of that disorder and its progression through the temporal bone. Clinicians who use the endoscope during ear surgery realize how the microscope and its limitations have colored the clinical perception of cholesteatoma and have dictated its management. The endoscope also allows a transcanal all encompassing view of the three main elements in tympanoplasty surgery: The ear canal, tympanic membrane, and the tympanic ring even in the presence of an anterior overhang.

History

The introduction of the binocular operating microscope, which was a landmark event in the development of modern otology, clearly changed the scope and character of ear surgery. Despite continuous technical improvements, however, basic optical principles and their limitations have remained the same over the last the decades. The use of the endoscope in various surgical procedures was extrapolated to otologic surgery, and the diagnostic and photographic use of that instrument in the examination of the tympanic membrane and the ear canal has been widely publicized [2]. Transtympanic middle ear endoscopy was initially reported by Nomura [3] and Takahashi and colleagues [4] Poe and Bottrill used transtympanic endoscopy for the confirmation of perilymphatic fistula and the identification of other middle ear pathologic conditions [5]. Kakehata used microendoscopy and transtympanic endoscopy for evaluation of conductive hearing loss and inspection of retraction pockets [11–13]. Thomassin and colleagues reported on operative ear endoscopy for mastoid cavities and designed an instrument set to be used for that purpose [1]. Badrel-Dine and El-Messelaty reported on the value of endoscopy as an adjunct in cholesteatoma surgery and documented a reduced risk of recurrence when the endoscope was used [14–15]. The reduction in residual disease was further confirmed by Yung [16] and Ayache [17]. Abdel Baki reported on using endoscopic technique to evaluate disease within the sinus tympani [18]. Mattox reported on endoscopyassisted surgery of the petrous apex [19]. Magnan and Sanna [20], Bader-el-Dine and El-Garem [21–23], and Rosenberg and colleagues [24] reviewed the role of the endoscope in neurotologic procedures. McKennan described the second-look endoscopic inspection of mastoid cavities that was achieved through a small postauricular incision [6]. More recently, Presutti and Marchioni, have described primary transcanal endoscopic ear surgery in a similar fashion to the experience reported here [25–26].

Instrumentation

In the procedures described in this report, 4 mm wide-angle zero-degree and 30° Hopkins II telescopes that were 18 cm in length were most often used. More recently, a smaller 3 mm endoscope that have a very similar field of view to the 4 mm endoscope is being used. Other smaller diameter scopes were used sparingly. Video equipment consisted of a 3-chip video camera and a monitor. All procedures were performed directly off the monitor and were recorded. Instruments used in conjunction with routine microscopic ear surgery included picks, elevators, and curettes. In the surgical suite, the monitor was placed opposite the surgeon and was positioned across the patient's head. A Mayo stand was used to hold the camera and scope above the patient's head. Most of the procedures were performed after the patient had received a local anesthetic. An absorbent pad soaked with antifog solution was pasted on the drapes above the patient's ear (Fig. 1).

Fig. 1 Operating room setup. The surgeon is operating while watching the monitor, which is positioned across the operating room table. The surgical assistant also has a clear view of the monitor

Discussion

The rational, advantages, limitations, technique, and long-term results of the technique will be discussed in the following sections.

Rationale for endoscopic cholesteatoma surgery

Acquired cholesteatoma is usually a manifestation of advanced retraction of the tympanic membrane that occurs when the sac advances into the tympanic cavity proper and then into its extensions such as the sinus tympani, the facial recess, the hypotympanum, and the attic [27]. Only in advanced cases does a cholesteatoma progress further to reach the mastoid cavity proper. Most surgical failures associated with a postauricular approach seem to occur within the tympanic cavity and its hardto-reach extensions rather than in the mastoid [28–29]. Therefore, the most logical approach to the excision of a cholesteatoma involves transcanal access to the tympanic membrane and tympanic cavity and the subsequent step-by-step pursuit of the sac as it passes through the middle ear. Mainstream ear surgery has usually involved the mastoid and the postauricular approaches because operating with the microscope through the auditory canal is a very frustrating and almost impossible process, The view during microscopic surgery is defined and limited by the narrowest segment of the ear canal (Fig. 2).

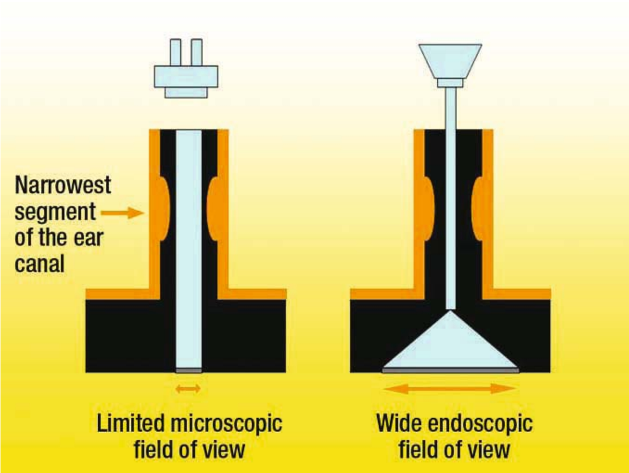

Fig. 2 The view from the microscope during transcanal surgery is defined and limited by the narrowest segment of the ear canal. In contrast, the endoscope bypasses this narrow segment and provides a very wide view that allows the surgeon to "look around corners," even when the zero-degree scope is used

This basic limitation has forced surgeons to create a parallel port through the mastoid to gain keyhole access to the attic, the facial recess, and the hypotympanum (Fig. 3). In contrast, transcanal operative endoscopy bypasses the narrow segment of the ear canal and provides a wide view that enables surgeons to look "around the corner," even when a zerodegree endoscope is used (Fig. 2). Another anatomic observation that supports transcanal access to the attic, which is the most frequent site of cholesteatoma [30], is the orientation of the ear canal in relation to the attic. Figure 4 shows a coronal computed tomographic (CT) section through the temporal bone, which reveals that an axis line drawn through the ear canal ends in the attic rather than the mesotympanum. The only structure that is in the way is the scutum, and its removal allows wide and open access to the attic, which is the natural cul de sac of the external auditory canal. Rediscovering the ear canal as the access port for cholesteatoma surgery is the main story and the main advantage of endoscopic ear surgery. This allows a more natural and direct access and pursuit of cholesteatoma within the middle ear cleft. In contrast, traditional approaches to the attic and facial recess have provided primarily keyhole access through postauricular mastoidectomy, and many surgeons use the ear canal to access the anterior part of the attic, even during postauricular tympanomastoidectomy. Other areas, such as the hypotympanum and sinus tympani, are minimally accessible even with extensive postauricular mastoidectomy. The wide view provided by the endoscope enables minimally invasive transcanal access to all those areas and facilitates the complete extirpation of disease without the need for a postauricular approach or incision.

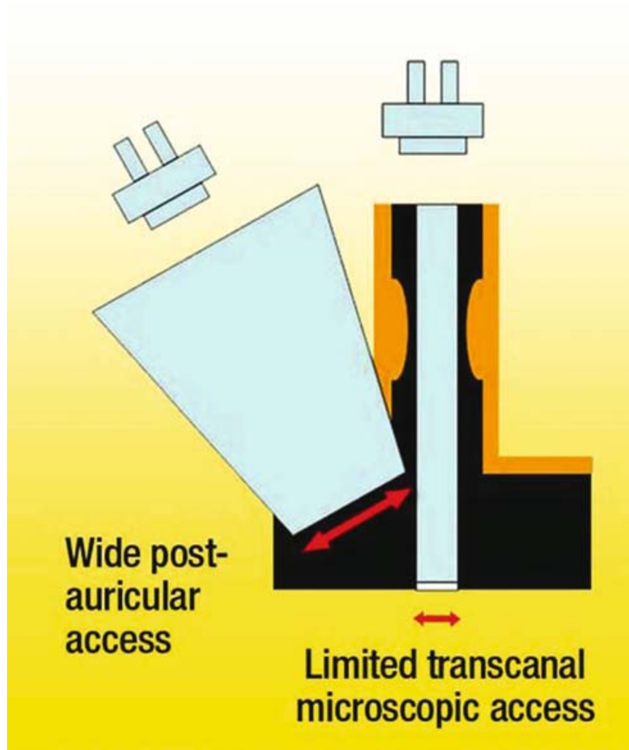

Fig. 3 The limited view provided by the microscope during transcanal procedures has forced surgeons to perform postauricular mastoidectomy, in which a port parallel to the attic is created after a considerable amount of healthy bone has been removed to enable anterior keyhole access to the attic

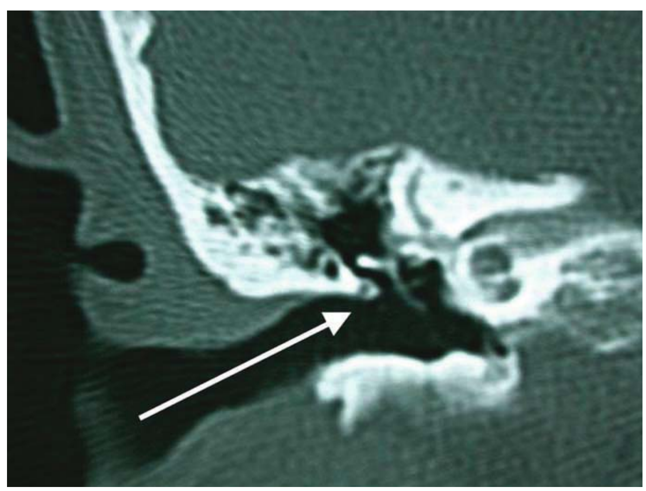

Fig. 4 A coronal CT section of the temporal bone, which shows that an axis line drawn through the ear canal ends in the attic rather than the mesotympanum. This almost universal anatomic orientation enables a natural transcanal access to the attic

Other advantages of using the endoscope include the ability to visualize past the shaft of larger surgical instruments, such as drills and curettes, and better visualization of structures that are parallel to the axis of the microscope. It is usually necessary to position structures such as the ear canal at a right angle to the axis of the microscope for adequate visualization. However, there are usually two issues of feasibility that raise the most questions about the use of the endoscope in ear surgery. The first issue is the use of a 4 mm endoscope, which is thought of as too large for the ear canal. During this author's 17 years of experience in performing endoscopic surgery on patients as young as 3 years, that concern proved unfounded. Using smaller sized scopes does not work because it reduces the field of view which makes it almost impossible to operate (becasue of the loss of orientation) and it also takes away the primary advantage of endoscopic ear surgery: The wide field of view. The only limitation with bigger scopes is the inability to advance the scope enough into the middle ear to see further into the mastoid cavity proper or to be able to use an angled-view endoscope. More recently, the industry have introduced a smaller 3 mm endoscope that carries a very similar field of view to the 4 mm endoscope and that can be advanced much more into the tympanic cavity. Howerver, one needs to be careful using the smaller endoscopes becase of the possibility of tip injury to middel ear structures. The the size of the larger 4 mm scope provides an extra safety margin because it is almost impossible to advance it enough into the tympanic cavity to cause injury. The second issue is one handed surgery and the lack of suction with the possibility of excessive bleeding.

Many otologists have long practiced microscopic transcanal surgery using one hand to hold the speculum and the other to operate. Also, one should not transpose previous experience with postauricular procedures (where many layers of tissue are violated along with tremendous amount of healthy bone removal during cortical mastoidectomy) on transcanal endoscopic approach where the surgical trauma is quite limited (with less bleeding) and the dead end structure of the canal and cavity allows for interim packing of certain areas and control of bleeding. The amount of bone removal is also quite limited to a relatively thin scutum that is easily curetted out without a drill.

Other Physicians have expressed the sentiment that this limited approach to small cholesteatoma could be performed as well using the microscope. The limitations of the field of view of the microscope that were discussed earlier are the main reason why most of the people making such an argument can not recall approaching cholesteatoma through a transcanal approach over the last few years; in contrast, this has been the primary, every day, approach to cholesteatoma in my practice.

Safety concerns

There are two major safety concerns with endoscopic ear surgery:

1. Excessive heat dissipation: This was evident only when a Xenon light source was used. Adequate illumination of the middle ear space can be accomplished with lower settings on the regular light source (because of the size of the cavity) without the need for Xenon systems. As well, the tip of the endoscope requires continuous cleaning with anti-fog solution which probably helps in cooling the endoscope. It has been shown that while the tip of the endposcope heats up rather quickly, it does cool down rather quickly.(reference)
2. Accidental patient movement with secondary direct trauma by the tip of the endoscope: The relatively large diameter of the endoscope we use (4mm), and the anatomy of the ear canal and middle ear space will usually preclude the introduction of the endoscope beyond the tympanic ring.

Basic techniques and management algorithm for cholesteatoma

There are three basic approaches to the endoscopic management of cholesteatoma that echoes principles and lessons learned from traditional tympanomastoid surgical procedures. These are: 1-"transcanal management of limited cholesteatoma", 2-"open endoscopic management of cholesteatoma", and 3-"extended transcanal approach to cholesteatoma". While preoperative planning based on high resolution CT and endoscopic examination is important, the decision is finally made in the operating room and patients needs to understand the range of possible interventions. The first question to be answered is whether the ear canal is an adequate port for the complete removal of cholesteatoma. If the answer is yes, then a wide tympanomeatal flap is elevated, atticotomy performed, sac identified and pursued along with removal of overhanging bone, basically all the steps involved in "endoscopic management of limited cholesteatoma". If the answer is no, then the ear canal access is improved through an "extended transcanal approach" by removing the skin and enlarging the canal.

Disease is then dissected off the middle ear spaces starting from the area of retraction and pursued into the different spaces such as attic, sinus tympani and facial recess. Then issue of the mastoid will need to be addressed. A limited cholesteatoma that extends to the aditus antrum can be completely removed through a transcanal approach. If the mastoid is involved, then a decision need to be made whether the disease will be addressed through a postauricular mastoidectomy or whether it will be exteriorized by "endoscopic open cavity managment of cholesteatoma" with

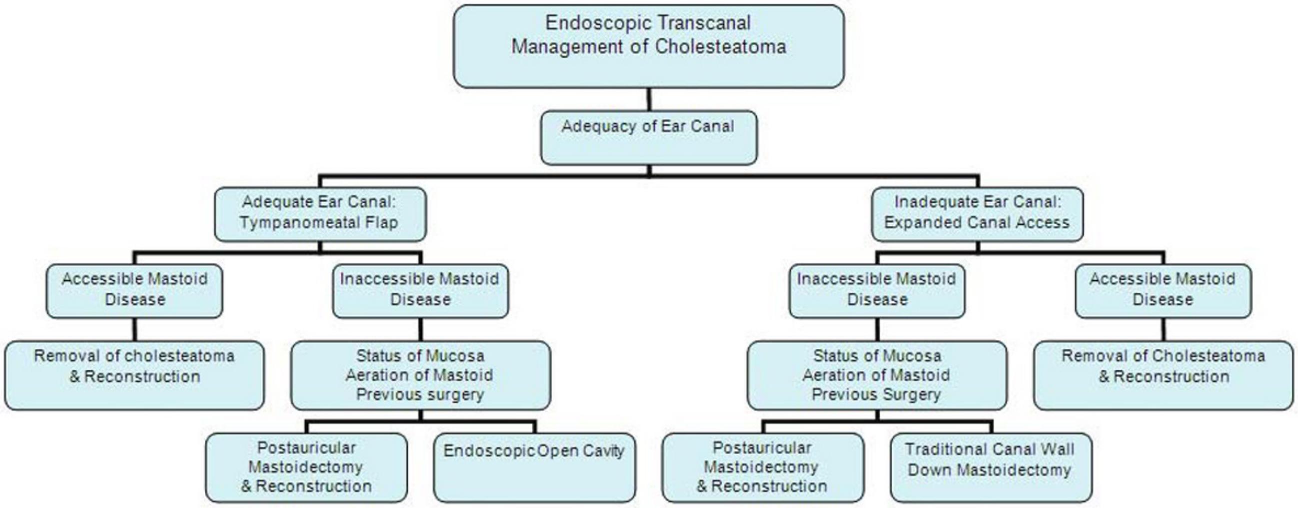

Diagram 1 The management algorithm for endoscopic transcanal managment of cholesteatoma

aggressive bone removal superiorly and posteriorly all the way to the mastoid cavity proper Chart 1.

"Endoscopic transcanal management of limited cholesteatoma"

The attic is the part of the ear in which cholesteatoma most often involves [19]. For many reasons, the attic is considered the "engine room" of a cholesteatoma within the middle ear. Attic involvement with this disorder seems to involve a thick, wellformed matrix that actively generates excessive debris. In contrast, mastoid disease tends produce more dermal debris in deposits formed by a fragmented yet viable attic matrix. The various ligaments and the ossicles in the attic provide opportunities for the entrapment of the sac and its contents. As described above, the attic (especially its anterior part) is poorly visualized via traditional approaches. An endoscopic approach enables the surgeon to retrace the sac, starting from the mesotympanum and continuing through its twists and turns around the ossicles and ligaments. This improved access also facilitates the better preservation of the ossicles while ensuring the complete removal of the matrix in toto rather than piecemeal and through different access ports.

Technique

Although I started out doing these procedures undel local anesthesia and intravenous sedation, today, most patients who undergo surgery for the removal of a cholesteatoma receive a general anesthetic. The ear canal is then infiltrated with a combination of lidocaine (Xylocaine) 1% with 1/60,000 epinephrine. A wide posterior tympanomeatal flap is elevated when the superior limb is positioned at the 11 o'clock position and the inferior limb is in the 6 o'clock position. As the annulus is elevated, the middle ear is entered, and the sac of the cholesteatoma is elevated from the middle ear structures (in continuity with the flap, when possible). The sac is then pursued under direct vision, and the bony rim is curetted or drilled just enough to enable dissection to continue under direct vision. During the 1st years of my experience, bone removal was performed primarily with a microdrill system. Later, that technique was abandoned in favor of using different sizes of bone curettes under continuous endoscopic monitoring.

The surgical field is irrigated frequently, and all drilling and curetting are confined to the area superior to an imaginary line that runs over the horizontal segment of the facial nerve and extends posteriorly into the ear canal. The body of the incus and the head of the malleus are either preserved or are removed according to the extent and site of disease. After the complete removal of disease has been confirmed, appropriate ossicular chain work is performed, and the attic defect is closed by means of a composite tragal graft with excess perichondrium to prevent later retraction from the area around the graft. The tympanic membrane defect is reconstructed with an underlay perichondrial graft. The tympanomeatal flap is then repositioned, and the ear canal is packed with an absorbable gelatin sponge (Gelfoam).

Results

Endoscopic office-based examination was incorporated into all routine office evaluations and follow-up assessments of 69 patients (22 men and 47 women). The youngest patient was 4 years old, and the oldest was 51 years. Nine patients were younger than 12 years at the time of surgery. Seventythree ear procedures were performed on the 69 patients; 65 of those individuals underwent unilateral surgery, and 4 underwent bilateral surgery with an interval of at least 8 months after the first procedure was performed on the opposite ear. The results of preoperative CT scanning of the temporal bone, which was performed in 46 ears, suggested cholesteatoma with the presence of bony erosion in 26 ears. Seven ears showed evidence of total opacification of the middle ear and mastoid air cells (without bone erosion), and isolated opacification of the middle ear and attic was evident in 11 ears. The results of audiologic testing showed an air-bone gap of 20 dB or more in 51 ears. The transcanal endoscopic approach was adequate for the removal of disease in all patients. There were no iatrogenic facial nerve injuries.

Bone thresholds were stable; i.e., no change of 10 dB or more was noted in average bone conduction thresholds at 500, 1000, 2000, or 3000 Hz. In 24 ears, the cholesteatoma was dissected from the malleus head and the body of the incus, both of which were preserved. The incus or its remnant was removed in 49 ears, and the head of the malleus was removed in 43 ears. Primary ossicular reconstruction was performed in 38 ears and was delayed in 17 ears. Most of the delayed cases occurred early in the author's experience, and primary reconstruction has been performed uniformly in all patients during the past 3 years. Follow-up was performed at 43 months, on average. Revision for recurrent and clinically evident disease was performed on 5 ears, but no such procedures have been required during the last 2 years of the author's experience. In 8 ears, a revision procedure was performed to correct a failed ossicular reconstruction or a persistent perforation. In one of those reconstruction failures, a small incidental pearl attached to the underlayer of the tympanic membrane was noted. Moderate-to-severe retraction in other areas of the tympanic membrane was evident in 28 patients, none of whom required further intervention. The results of audiologic testing during the last follow-up visit of each patient (a visit that included an audiogram and was not necessarily the last visit) showed closure of the air-bone gap to within 20 dB in 47 ears. Included in this total were 18 patients who required no ossicular reconstruction, 22 of the 38 who underwent primary reconstruction, 2 of the 5 who underwent secondary reconstruction, and 5 of the 8 in whom primary reconstruction failed and who underwent revision surgery.

Case History

A 46-year-old male patient with a long-standing history of problems (primarily blockage and failure to equalize) in both ears had recently experienced recurrent drainage from the right ear. More recently, while stationed in a mountainous area, his ear symptoms worsened and he noticed a significant deterioration in his hearing in his right ear. He was referred by his doctor to this author's practice for further care.

Initial evaluation showed severe retraction bilaterally and some granulation tissue and drainage from the right ear. After a week of medical treatment, his right ear showed clear evidence of severe retraction and debris within the cholesteatoma sac (Fig. 5). An endoscopic transcanal approach was undertaken, a wide tympanomeatal flap was elevated, and the middle ear was entered (Fig. 6). A wide atticotomy was performed with a curette (Fig. 7). The cholesteatoma sac was identified; it extended to the lateral attic and was pulled downward laterally to the body of the incus and medially to the removed scutum (Fig. 8). Another process of the sac had rotated posteriorly and medially

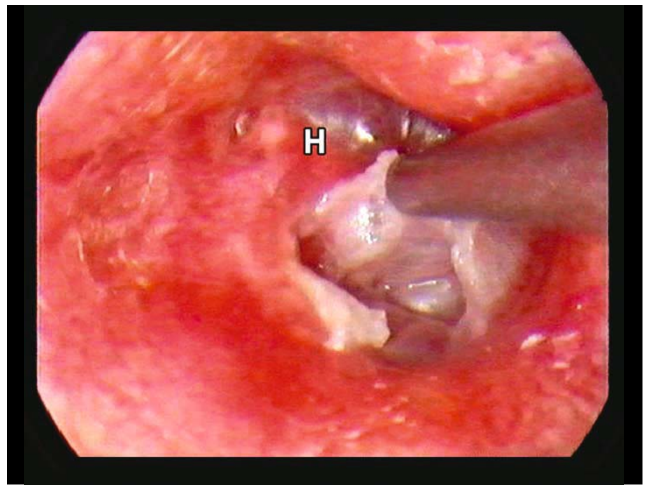

Fig. 5 Right ear: Note the retraction and cholesteatoma. H: Handle of malleus

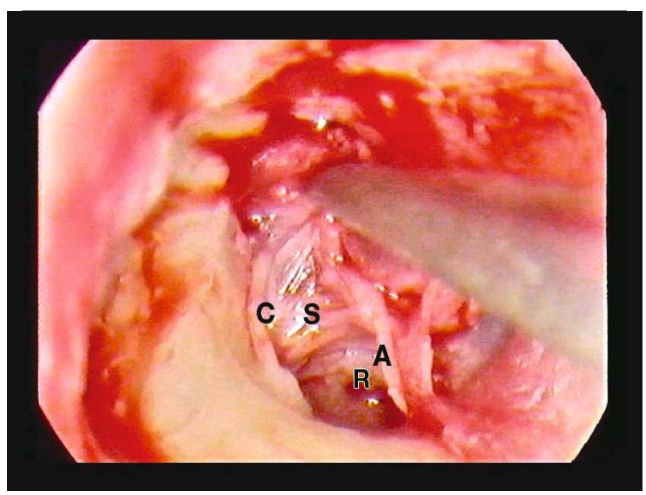

Fig. 6 Right ear: The tympanomeatal flap has been elevated, the middle ear has been entered, and the cholesteatoma sac has been exposed. C: Chorda tympani; S: Cholesteatoma sac; A: Annulus; R: Round window

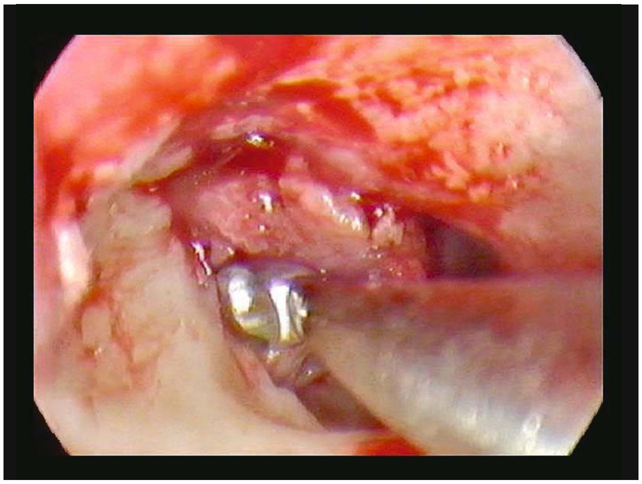

Fig. 7 Right ear: A wide atticotomy is performed with a curette

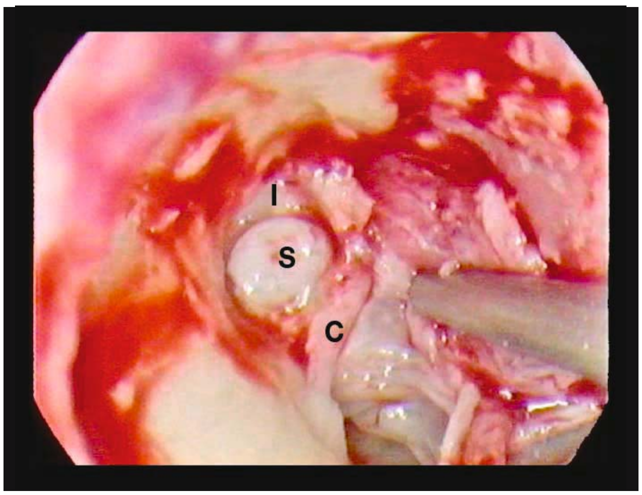

Fig. 8 Right ear: The sac (S) has been pulled down from the attic, lateral to the body of the incus and medial to the scutum. The body of the incus (I) can be seen. The chorda (C) forms a collar around the neck of the sac

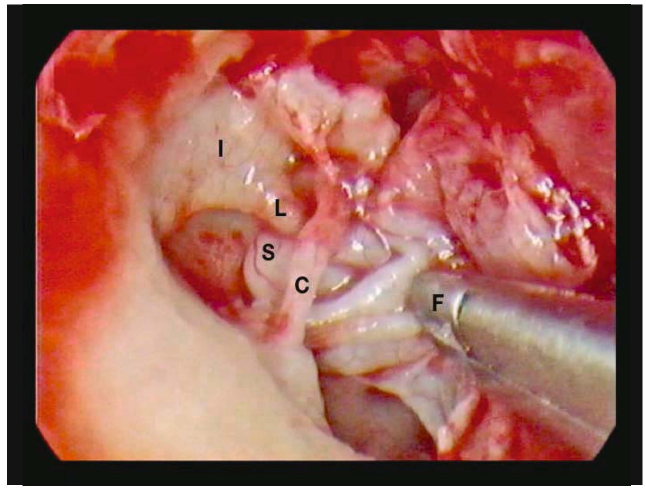

Fig. 9 Right ear: The sac has been completely pulled down from the area lateral to the body of the incus (I), but another process of the sac (S) has rotated posteriorly and medially around the incudostapedial joint and medial to the long process of the incus (L). A cuffed forceps (F) is used to pull the sac from underneath the chorda (C)

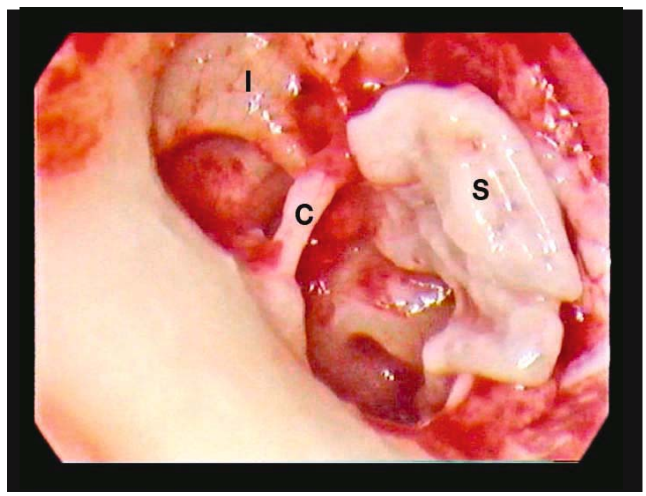

Fig. 10 Right ear: The sac (S) has been completely pulled out and deflected over the tympanomeatal flap with the incus (I) and the chorda (C) in view

around the incudostapedial joint and the superstructure of the stapes and had advanced medially to the long process of the incus (Fig. 9). The sac was pulled out completely and was deflected (Fig. 10). It was evident that the sac had eroded the incudostapedial joint (Fig. 11). A prosthesis was used to reconstruct the ossicular chain (Fig. 12). A piece of tragal composite graft with excess perichondrium was used to reconstruct the attic defect (Fig. 13). The tympanic membrane defect was reconstructed with a perichondrial underlay graft, and the tympanomeatal flap was repositioned (Fig. 14). The patient experienced an uneventful postoperative course. One month after the procedure, his tympanic membrane was intact, his hearing was good, and he returned to duty.

Endoscopic open cavity management of cholesteatoma

In canal wall down procedures, which have been viewed as the definitive treatment for cholesteatoma, all disease-containing cavities are exteriorized to provide natural aeration and direct access to the disease in the clinic setting. However, during the process of accessing the disease, large problematic cavities that require lifelong maintenance are created. In addition, unpredictable healing patterns, fibrosis, and closing of the meatus, which are common complications associated with postauricular canal wall down procedures, often prevent further ossicular reconstruction.

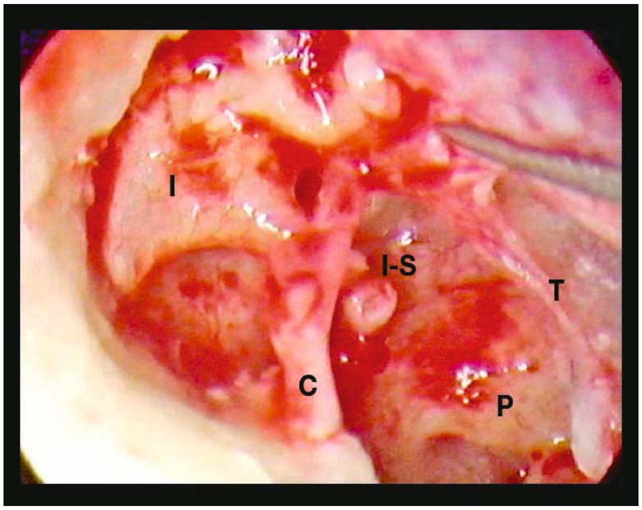

Fig. 11 Right ear: The sac is removed. The cholesteatoma has eroded the incudostapedial joint (I-S). The incus (I), the chorda (C), and the promontory (P) are clearly in view. The anterior edge of the tympanic membrane retraction (T), now a perforation, is also visible

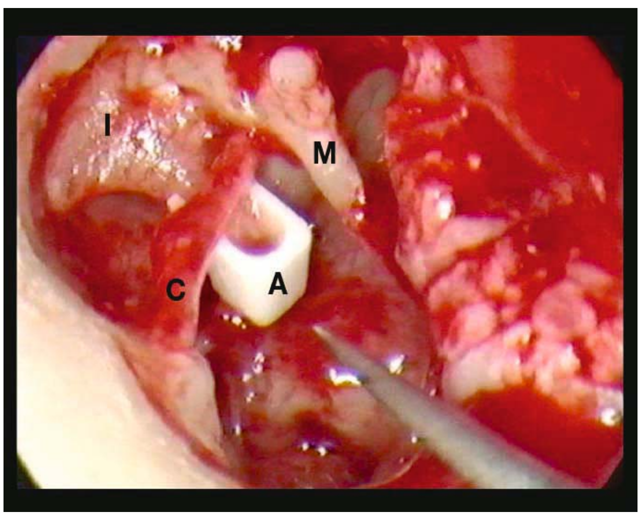

Fig. 12 Right ear: A prosthesis (A) is used to reconstruct the incudostapedial joint. The handle of the malleus (M) and the incus (I) and chorda (C) are visible

Endoscopic techniques allow transcanal exploration of the diseasecontaining cavities without opening up areas that are not involved in the cholesteatoma. Such techniques enable the surgeon to approach and reconstruct the ear in a highly predictable fashion. This in turn creates a better framework for ossicular and partial tympanic membrane reconstruction.

Surgeons have subjective preferences for the use of open versus closed technique (i.e., canal wall down vs canal wall up), although most clinicians recognize a distinct role for both approaches in practice. Exteriorizing the disease seems to be the more definite and fail-proof

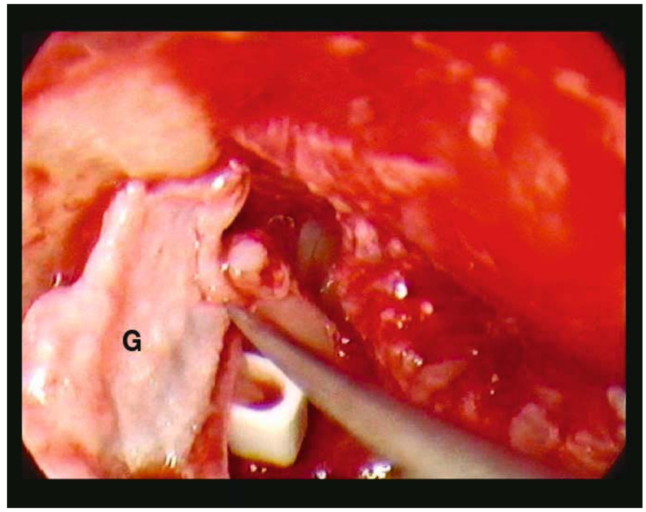

Fig. 13 Right ear: The attic defect is reconstructed by means of a composite tragal graft (G) with excess perichondrium to prevent retraction around the graft

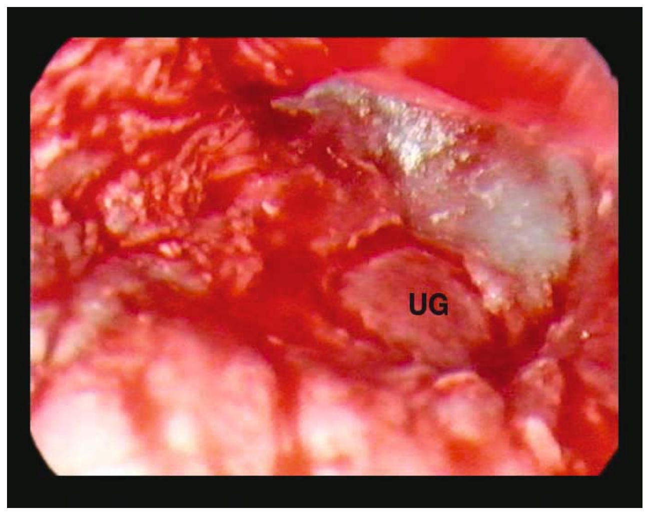

Fig. 14 Right ear: The tympanomeatal flap is repositioned over an underlay graft (UG) to reconstruct the retracted area of the tympanic membrane

approach to the management of a cholesteatoma. The traditional postauricular canal wall down procedure involves the creation of extensive cavities and the removal of a tremendous amount of healthy bone just to enable access to a limited area of disease. After having created such large cavity, the surgeon is faced with the option of either leaving a large problematic cavity that requires an equally large meatus to service it or obliterating the cavity and possibly concealing diseased areas that should be exteriorized. In contrast, the transcanal endoscopic approach opens up only diseased areas, preserves many healthy air cells, and leaves the cortical bone intact. It also allows for the creation of two independent cavities; the small reconstructed tympanic cavity that conducts sound in the middle ear and that is small enough to be serviced by the usually dysfunctional eustachian tube, and the larger attic, antrum, and mastoid cavities, which are joined to the ear canal and are exteriorized. Such an approach was described by Tos in 1982 [27]. He proposed a different approach to the treatment of attic cholesteatoma, which he summarized as follows: “Since 1970, I have applied my own modification of CAT (Combined-Approach Tympanoplasty) that is based on other surgical principles than the classic CAT and on a new philosophy, ie, to create such conditions in the attic that the retraction does not necessarily lead to recurrent cholesteatoma requiring re-operation, but most often to a peaceful small cavity with an acceptably wide access. Furthermore, any residual cholesteatoma can be observed through the atticotomy opening, replacing a second-look operation” [27]. Transcanal endoscopic access enhances the surgeon’s ability to accomplish such a task because a limited amount of bone is removed, there is less surgical trauma, the likelihood of fibrosis and unpredictable healing patterns is reduced, and the cavities can be visualized during surgery much as they can be viewed in the clinic a few months after surgery.

The improved eradication of disease that results from the traditional canal wall down procedure is usually balanced out by inferior hearing results and a diminished opportunity for adequate ossicular reconstruction. The presence of an open cavity did not seem to affect hearing in our patients; 55% of the study subjects achieved excellent hearing test results (an air-bone gap of less than 20 dB). The endoscopic transcanal approach allows for minimally invasive surgery that provides a better framework for ossicular reconstruction.

Other issues associated with the canal wall down procedure, such as water precautions, do not seem to be high on the list of patients’ priorities, and quite a few of this author’s patients have introduced water into their ear without experiencing a subsequent secondary infection (probably as a result of the small size and shallowness of the cavity).

The main concern of many surgeons is the possibility of closing the open attic. That concern is driven by the results of traditional open surgery of the mastoid, in which damage to the cartilaginous portion of the ear canal produces a vicious circle.

Trauma to the ear canal results in fibrosis and narrowing of the meatus, which forces the surgeon to design a more aggressive meatoplasty, which in turn results in more trauma, secondary fibrosis, and narrowing. A huge meatus must be created to compensate for that eventual fibrosis and narrowing. In contrast, the very limited trauma to the cartilaginous ear canal caused by endoscopic surgery allows surgeons to avoid those complications. It has been the experience of this author that closure of the cavities begins during the first few months after endoscopic surgery and continues until small, shallow, benign, problem-free cavities result.

Despite the small size of the resulting tympanic cavity, recurrent retraction has been observed in quite a few patients. In this author’s opinion, the retraction seems to be associated with attempts to reconstruct and seal off the tympanic cavity from all directions with a facial graft placed to bridge the gap between the horizontal segment of the facial nerve and the superior neotympanic membrane. Avoiding that procedure usually results in an open area for ventilation superiorly that prevents retraction.

Technique

In the endoscopic open cavity management of cholesteatoma, the wide posterior tympanomeatal flap is elevated as described above. A transcanal atticotomy is performed. The incudostapedial joint is dislocated if it is intact, and the attic is then emptied from the incus and the head of the malleus. It is important to separate the head from the handle of the malleus (by means of a malleus nipper) at a proximal site to preserve the ligaments that stabilize the handle. This is quite helpful when the tympanic membrane and ossicular chain are reconstructed. Aggressive bone removal is then performed to provide open endoscopic access into the attic and all the way posteriorly into the antrum. All squamous epithelium is removed, and the attic and antral defect are packed open. Tympanic membrane defects inferior to the horizontal segment of the facial nerve (including atelectatic areas) are reconstructed with a perichondrial graft, which is placed directly on and up to the horizontal segment of the facial nerve superiorly and on a bed of Gelfoam that is packed in the middle ear inferiorly. The ear canal and the open attic are then packed with Gelfoam.

Continuing office-based endoscopic examinations and follow-up evaluations should be performed. This technique should result in a small, closed, reconstructed tympanic cavity and membrane anteriorly and inferiorly (to service the impedancematching function of the middle ear) and an open attic and antrum posteriorly and superiorly (Fig. 15). Office-based procedures, including limited curettage of bone and removal of soft tissue, should be performed when necessary. There has been a clear trend toward more observation than intervention over the last few years with the realization that what might appear as an initial narrowing over the first 2–3 postsurgical months ultimately becomes a small shallow cavity over time.

Results

Eighty-five ear procedures were performed on 78 patients; 71 underwent unilateral surgery and 7 underwent bilateral surgery with an interval of at least 6 months between procedures. The youngest patient was 7 years old. Five

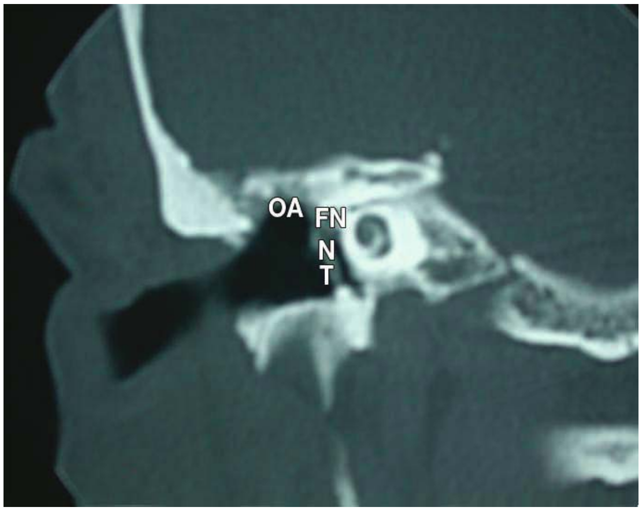

Fig. 15 Coronal CT views of a right ear subjected to endoscopic open cavity management of a cholesteatoma. The neotympanic membrane (NT) is reconstructed up to the level of the horizontal segment of the facial nerve (FN), and the attic is left open (OA)

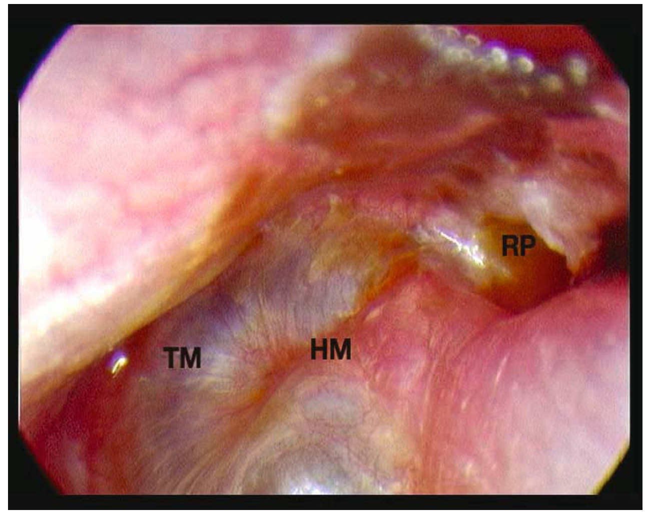

Fig. 16 Left ear. A large retraction pocket (RP) with evidence of recurrent prior episodes of infections and the formation of granulation tissue. HM: Handle of the malleus; TM: Tympanic membrane

patients were younger than 12 years at the time of surgery. Preoperative audiologic testing showed an air-bone gap of 20 dB or more in 72 ears. There were no iatrogenic facial nerve injuries. Bone thresholds were stable ("stability" was defined as no change of 10 dB or more in average bone-conduction thresholds at 500, 1000, 2000, and 3000 Hz) except in 1 patient who presented preoperatively with depressed bone thresholds, vertigo, and a perilymphatic fistula. The mean follow-up was 32 months. Closure of the air-bone gap to within 20 dB was accomplished in 47 ears. Six ears required revision surgery, and 10 required office-based minor procedures to maintain an open attic.

Four of the surgical failures resulted from complete closure of the open attic by a growth of overlying skin rather than by a step-by-step narrowing of the atticotomy.

This complication was usually evident early in the postoperative course and was managed by re-excising the overlying skin in a simple procedure. Most of the minor office procedures involved removing some soft tissue and sometimes the curettage of bone spurs. Those interventions were performed early in this author's experience. Recurrent retraction of the neotympanic membrane was evident in 14 ears and required no intervention.

Case history

A 41-year-old patient with a retraction pocket, recurrent granulation tissue, and drainage from the left ear that had responded to therapy with topical antibiotics presented for treatment. Figure 16 shows the large attic retraction pocket after it was emptied of dermal debris. A wide tympanomeatal flap was elevated, and the thick vascularized sac can be

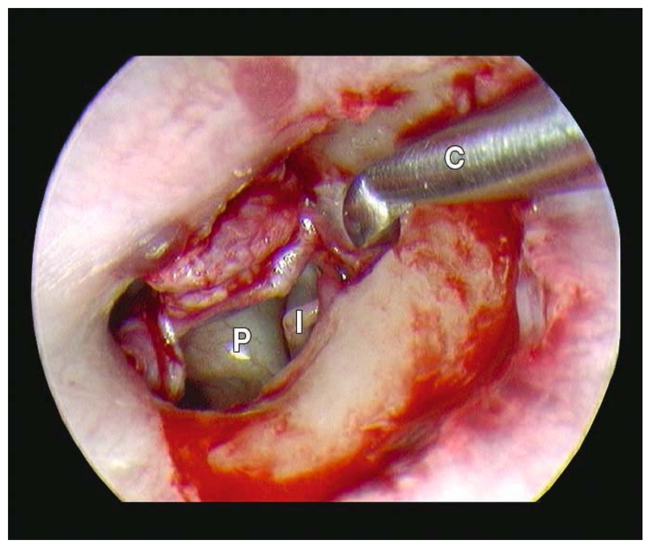

Fig. 17 Left ear: A wide tympanomeatal flap is elevated. The premonitory (P) and the incudostapedial joint (I) can be seen. A curette is used (C) to create the extended atticotomy

seen after the atticotomy was extended (Figs. 17 and 18). The incus and the head of the malleus were removed after the incudostapedial joint was dislocated (Figs. 19 and 20). The anterior epitympanum was cleared of all disease. The remainder of the sac posterior to the mastoid was removed after further widening of the atticotomy (Fig. 21). All disease was excised, and specific attention was paid to the attic and the tympanic cavity (Fig. 22). A prosthesis was used to reconstruct the ossicular chain (Fig. 23), and a composite cartilage graft was positioned on top of the prosthesis (Fig. 24). The tympanomeatal flap was divided longitudinally (Fig. 25). The inferior part was repositioned

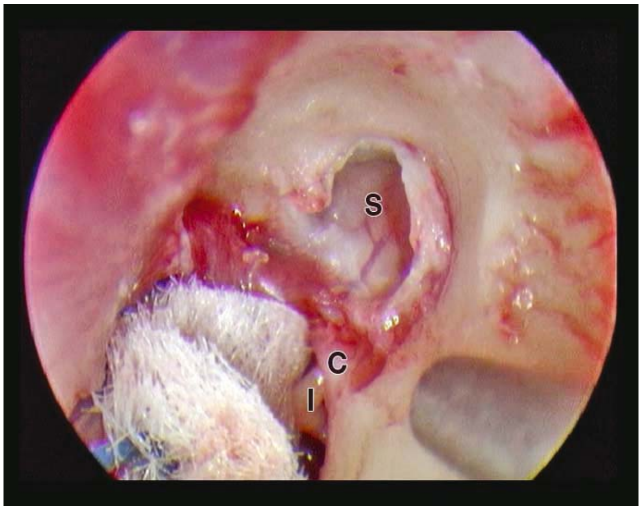

Fig. 18 Left ear: Note the extended atticotomy at the thick sac (S), the chorda tympani (C), and the incudostapedial joint (I)

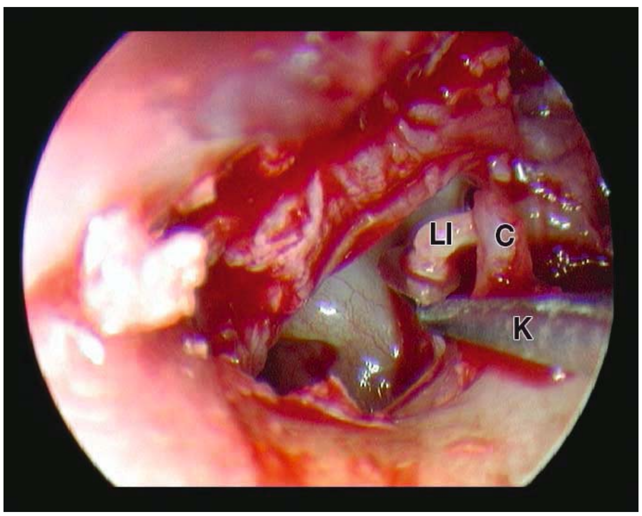

Fig. 19 Left ear: The incudostapedial joint (LI) is dislocated with a small round knife (K). C: Chorda tympani

over the ear canal, the superior part was draped over the horizontal segment of the facial nerve (Fig. 26), and the attic was packed open.

"Expanded transcanal access" to middle ear and petrous apex

Although the use of the endoscope allows much expanded transcanal access to the middle ear when compared with the microscope, the ear canal in some patients can be very limiting in size and angulation as not to allow for adequate exposure. Using a smaller endoscopes in these situations would not work because of the limited field of view associated with the smaller scopes as discussed earlier. As well, a limited canal

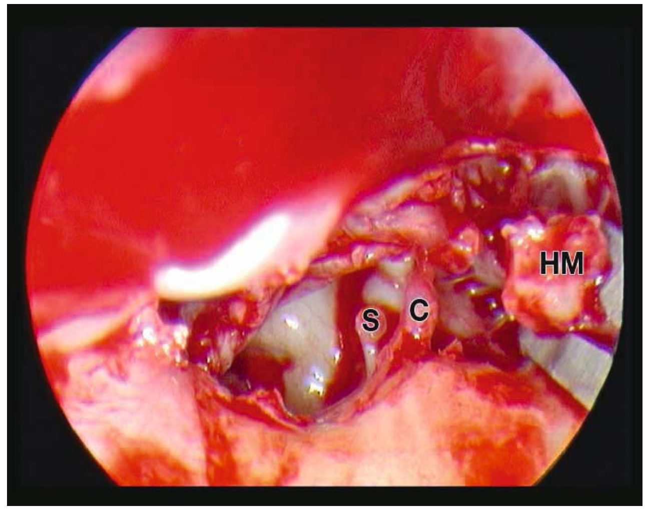

Fig. 20 Left ear: The incus has been removed, and the head of the malleus (HM) is extracted. Note that the head of the malleus is separated from the handle by means of a malleus nipper at a proximal site to preserve the ligaments stabilizing the handle of malleus. S: Stapes; C: Chorda tympani

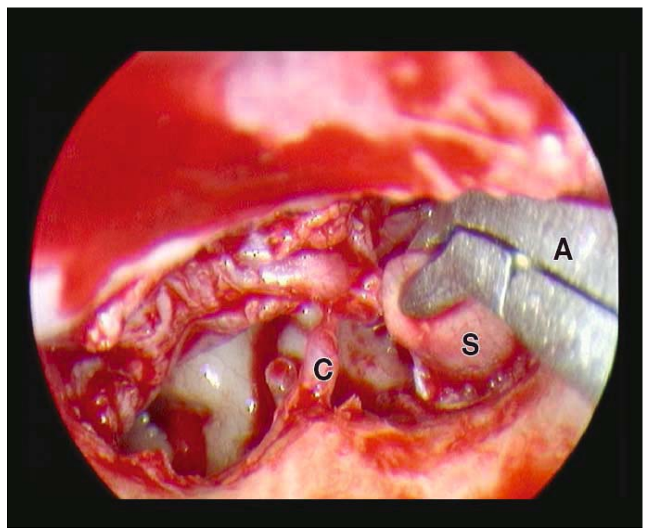

Fig. 21 Left ear: The thick sac (S) is being pulled with an alligator forceps (A). C: Chorda tympani

would create opportunities for incidental trauma to the ear canal and problematic bleeding from the skin of the canal. Addressing these limitations prior to addressing the disease is essential for performing adequate and safe endoscopic procedures.

Technique

After evaluation of the limiting elements in the ear canal in relation to location of the disease, a decision is made on whether to address these limitations. The location of disease

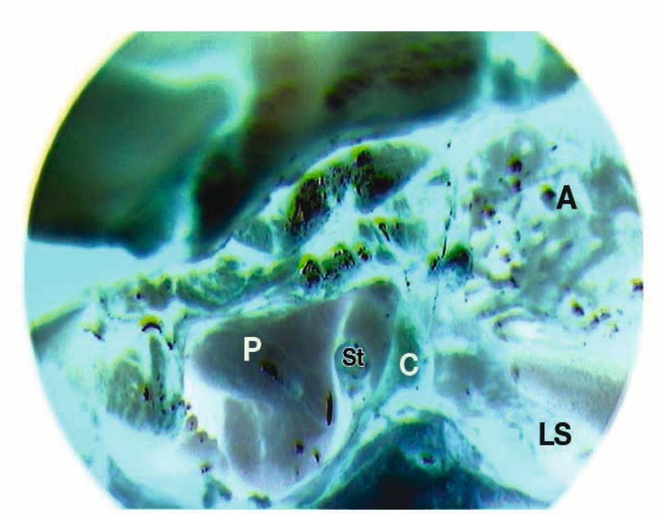

Fig. 22 Left ear: The sac has been removed completely. A: Attic; P: Promontory; C: Chorda tympani; S: Stapes; LS: Lateral semicircular canal

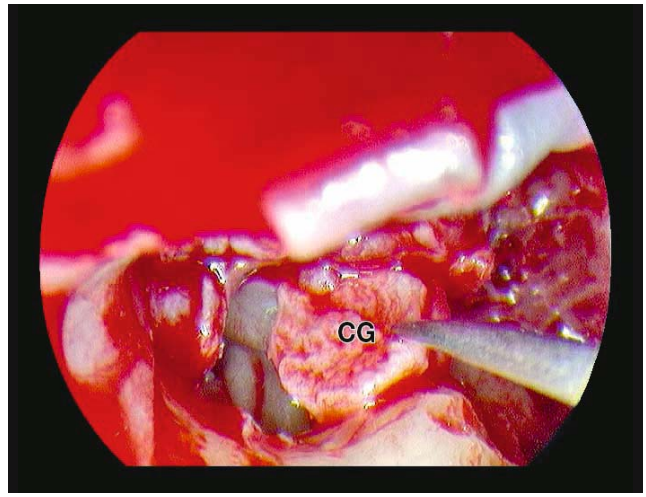

Fig. 24 Left ear: Composite tragal cartilage (CG) is used on top of the prosthesis

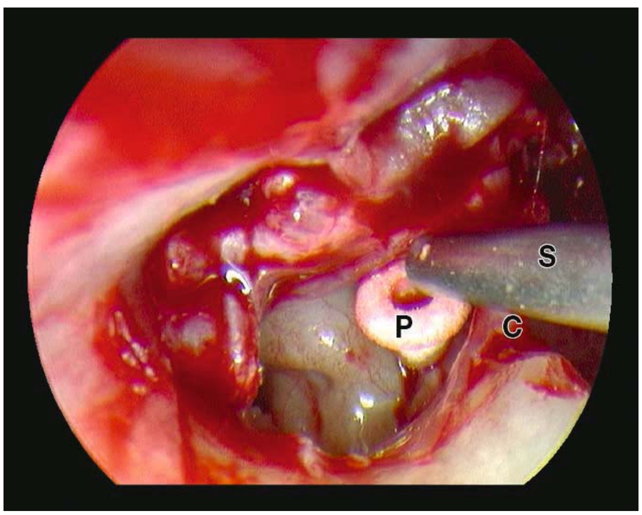

Fig. 23 The ossicular chain is reconstructed with the use of a prosthesis (P). C: Chorda tympani; S: Suction.

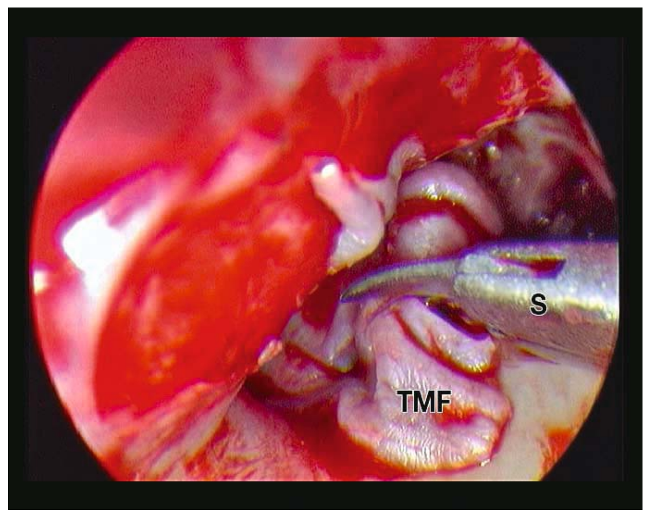

Fig. 25 Left ear: The tympanomeatal flap is cut longitudinally with middle ear scissors

and it's extent is determined by endoscopic examination of the ear and by careful review of high resolution CT of the temporal bone. More commonly than not, the limitation imposed by an anterior overhang does not interfere with access to the anterior attic. Anterior middle ear, eustachian tube, and significant disease within the hypotympanum will often require an expanded transcanal approach. When enlarging the the ear canal, the surgeon needs to be keenly aware of critical structures that lies in close proximity (Fig. 27). The bony annulus, the line seperating the ear canal from the middle ear, has tremendous variations [31] and one should think of all structures that borders the tympanic cavity proper when enlarging the ear canal.

Superiorly, the dura tends to be low laterally, but with thick bone protecting it and there usually is no need to do much curetting in the ear canal superiorly beyond the the removal of the scutum. Posteriorly, the facial nerve and an anterior signoid should be condsidered [32]. Inferiorly, a high jugular bulb can come lateral and borders the ear canal [33]. Breaching the glenoid fossa anteriorly is ususally a none event, but it can present a limiting factor anteriorly.

The technique echoes much of the steps in Sheehy's lateral graft tympanoplsty. The vascular strip and canal skin cuts would be performed with the skin of the ear canal removed along with the epithelial layer of the tympanic membrane and the vascular strip preserved. The ear canal would be enlarged as needed using a currette or a small drill. Then the annulus and fibrous layer of the tympanic membrane is elevated either completely or partially to provide access to the areas of interest. If the surgeon envisions removal of the head of malleus because of disease in the anterior attic, then the handle of malleus is separated from both the head

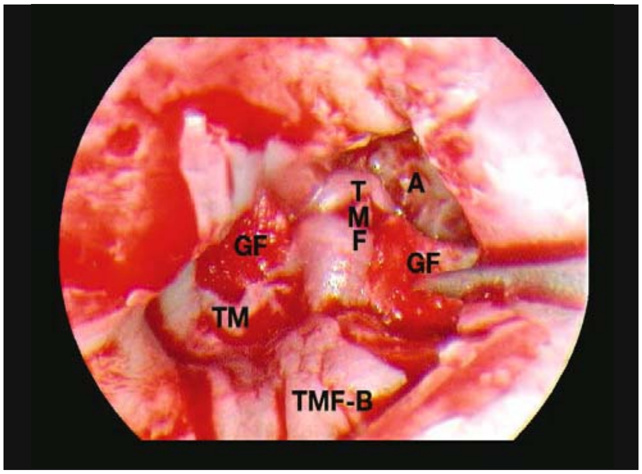

Fig. 26 Left ear: The inferior part of the tympanomeatal flap (TMF-B) is repositioned over the ear canal while the superior part of the tympanomeatal flap (TMF) is reflected over the horizontal segment of the facial nerve into the open attic (A). Small pieces of Gelfoam (GF) are used to pack the open attic and ear canal. TM: Tympanic membrane

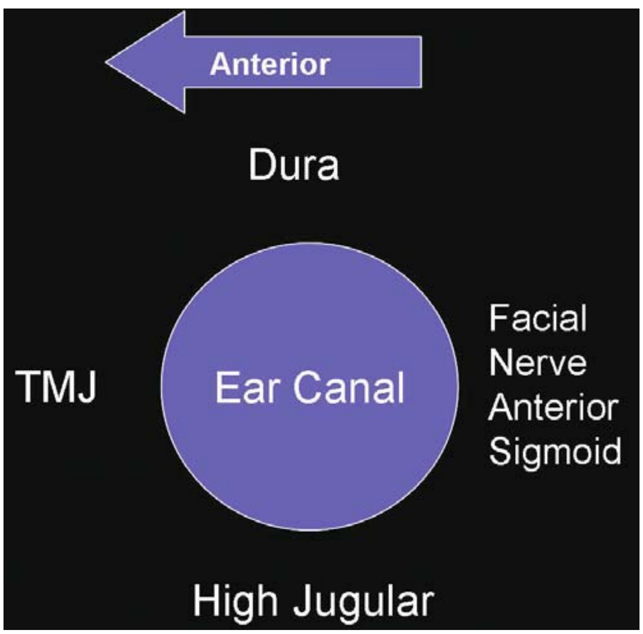

Fig. 27 Structures to be considered when enlarging the ear canal

of the malleus and the tensor tympani and is kept attached to the deflected fibrous tympanic membrane. If the malleus is to be preserved, then the handle of malleus is separated from the fibrous layer of the tympanic membrane. Then all overhanging bony annulus is curetted and wide access to the middle ear is gained for removal of any disease.

After the necessary ossicular chain work, the remaining part of the tympanic membrane is repositioned and a lateral graft is applied and the skin of the ear canal is repositioned and packed in place.

Results

The long term results with this technique are being submitted for publication. The results seem to mirror those reported earlier [9–10] for endoscopic management of limited cholesteatoam in terms of rate of failure, but less optimal in terms of hearing outcome. Special issues related specifically to this technique such the formation of transient granulation tissue and some narrowing and distortion of the ear canal and the neo-tympanic membrane are identified but do not pose a major issue for the patients.

Case presentation

Fourty-eight years old presenting with left ear cholesteatoma and a limited ear canal (Fig. 28). The vascular strip was outlined and preserved and the skin of the ear canal was elevated and removed in contiguity with the epithelial layer of the TM Figs. 29–30). The ear canal is then enlarged. The fibrous layer of the tympanic membrane is elevated (Fig. 31). The disease was extensive and the TM along with ossicles and is removed (Figs. 32–34). Then, the middle ear is packed with gelfoam, a TORP prosthesis was positioned on the footplate (Fig. 35). A piece of composite cartilage is used to cover the TORP (Fig. 36) and the fascia is positioned as a lateral graft (Fig. 37). Then, the skin of the canal is repositioned (Fig. 38) and the canal is packed with gelfoam.

Endoscopic management of congenital cholesteatoma

The endoscopic approach allows great access to the mesotympanum, especially anteriorlly and into the eustachian tube. This allows transcanal removal of congenital cholesteatoma. As reported earlier [7], three cases of congenital cho-

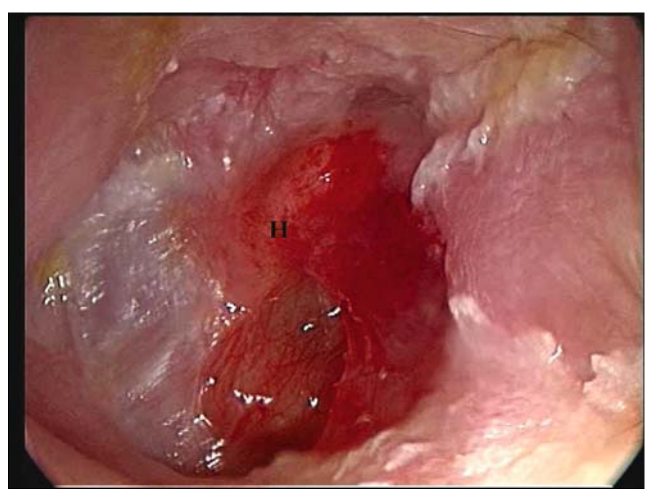

Fig. 28 Left ear with retraction and cholesteatoma with some granulation tissue. H: Handle of malleus

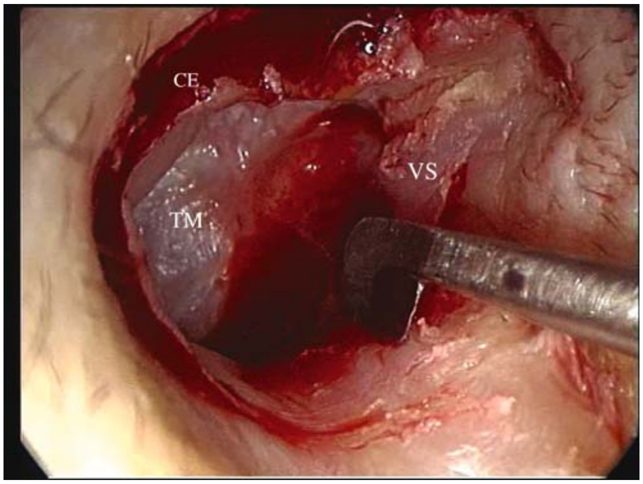

Fig. 29 Left ear: The vascular strip is oulined and the skin canal elevated. TM: Tympanic membrane; VS: Vascular strip; CE: The cut edge of the skin of the canal

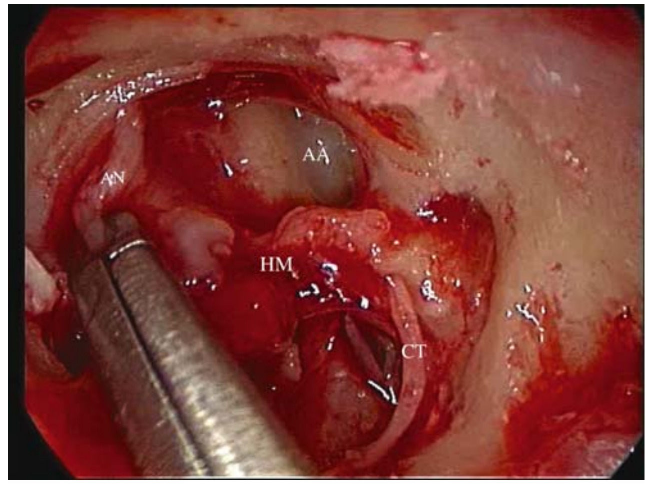

Fig. 31 Left ear: The fibrous layer is elevated and the anterior attic is visualized. AN: Annulus; AA: Anterior attic; HM: Handle of malleus; CT: Corda tympani

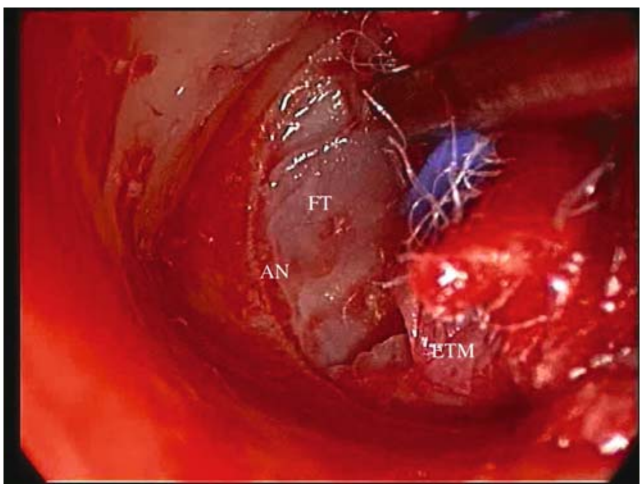

Fig. 30 Left ear: The skin of the ear canal is elevated in contiguity with the epithelial layer of the tympanic membrane. AN: The bony and fibrous annulus; FT: Fibrous layer of tympanic membrane; ETM: Epithelial layer of tympanic membrane

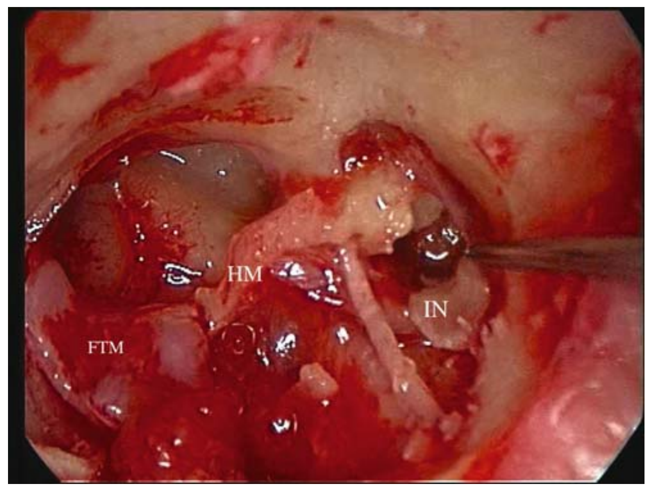

Fig. 32 Left ear: The incus remnant is being removed. HM: Handle of malleus; FTM: Fibrous layer of tympanic membrane; IN: Incus

lesteatoma were performed with no recurrence of disease coupled with the preservation of ossicular integrity.

Case report

A 3-year-old was referred by the pediatrician because of unusual otoscopic findings. The Child's hearing was normal. The patient underwent transcanal endoscopic removal of congenital cholesteatoma (Fig. 39).

Basic techniques for tympanoplasty

Depending on the anatomy of the ear canal and the size and location of the perforation, I practice one of two approaches for the grafting of tympanic membrane:

1-Endoscopic transcanal medial graft tympanoplasty for small and well exposed perforations, and 2- Endoscopic Sheehy's Lateral Graft tympanoplasty for total perforations, previous surgical failures and for limiting ear canals.

Endoscopic transcanal medial graft tympanoplasty

Medial graft tympanoplasty is a common and relatively successful procedure; central to it success is adequate and relatively free exposure to the whole tympanic perforation. Unfavorable ear canal anatomy or anterior perforation will make for technically challenging microscopic transcanal procedures, which is ultimately

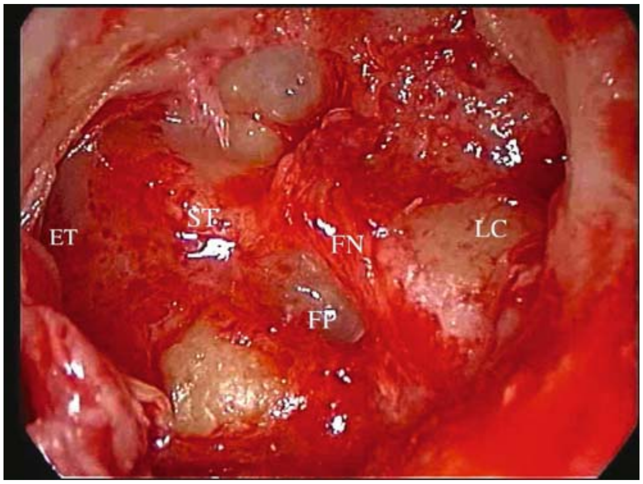

Fig. 33 Left ear: The view when using a zero degree scope after removal of disease, ossicles and tympanic membrane. FP: Footplate; FN: Facial nerve; LC: Lateral canal; ET: Eustachian tube

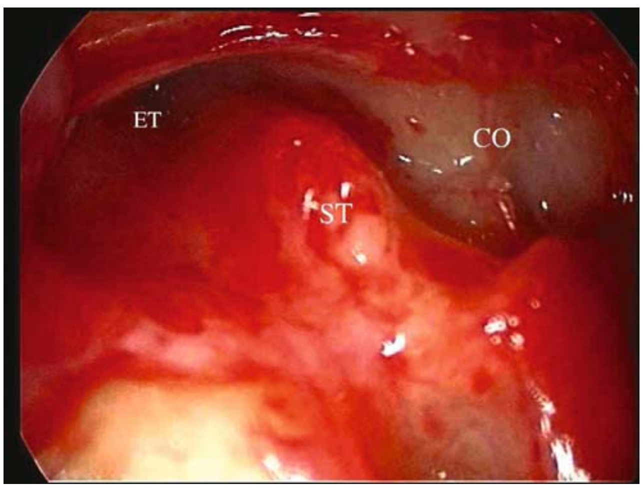

Fig. 34 Left ear: The view when using a 30° scope and looking anteriorly after removal of disease, ossicles and tympanic membrane. ET: Eustachian tube; ST: The cut edge of the the tensor tympani tendon and behind it the the muscle's bony encasement. CO: The "cog"

reflected as a high rate of failure. Experienced surgeons are more willing to consider postauricular approach to provide adequate microscopic procedure. The endoscope allows for wide transcanal, all encompassing view of all the elements in this surgery: The ear canal, tympanic ring and the tympanic membrane, without the need for the continuous repositioning of the microscope, even in the presence of an anterior overhang.

Technique

All tasks were performed with the endoscope. This included injection of the ear canal, debridement of the edges of the

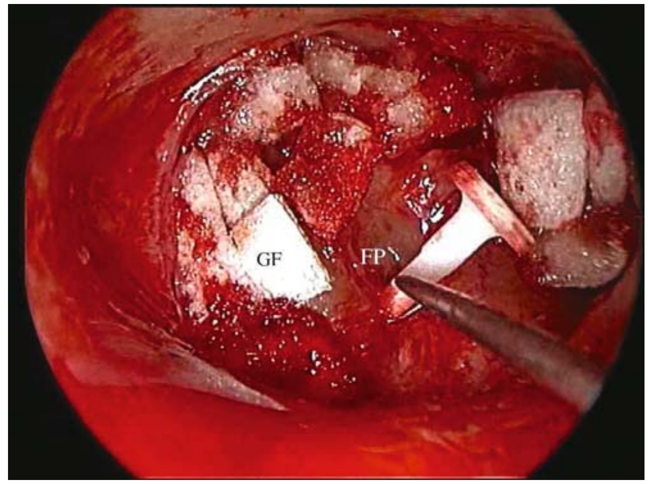

Fig. 35 Left ear: The gelfoam is packed into the middle ear and the TORP is being manipulated into position. GF: Gelfoam; FP: Footplate

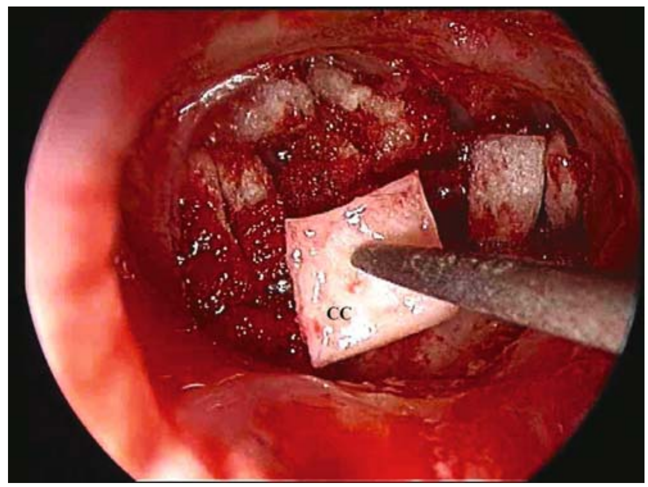

Fig. 36 Left ear: A piece of composite graft was used over the prosthesis. CC: Composite graft

Fig. 37 Left ear: The lateral temporalis muscle fascial graft is in position

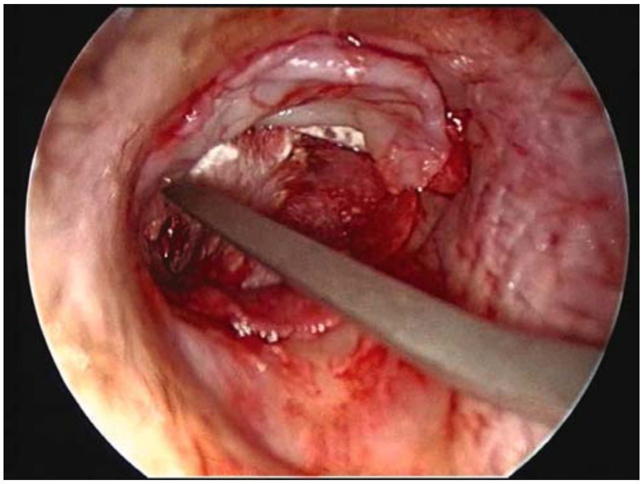

Fig. 38 Left ear: The skin of the ear canal is repositioned

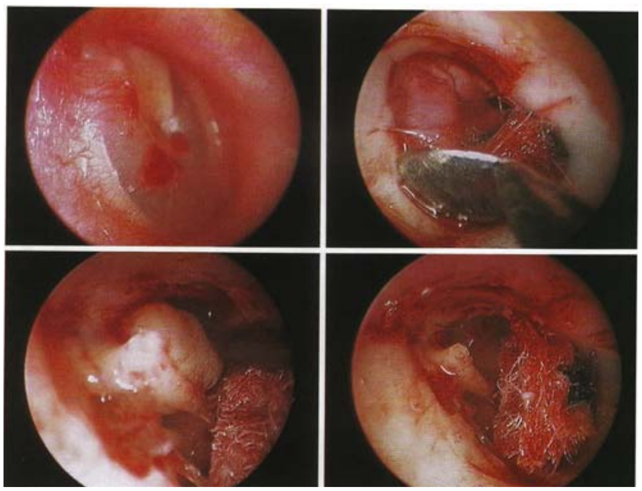

Fig. 39 Right ear: Top left: View of the tympanic membrane. Top right: Superiorly based tympanomeatal flap is elevated. Bottom left: Cholesteatoma is exposed anterior to the malleus. Bottom right: Middle ear inspection after removal of cholesteatoma

perforation, elevation of tympanomeatal flap, inspection of the middle ear for disease and ossicular integrity, positioning of a medial graft over a bed of gelfoam, repositioning of the tympanomeatal graft and the packing of ear canal with gelfoam.

Results

As reported earlier [7], 64 procedures were performed with no significant complications. Closure of perforation was evident in 59 ears, a success rate of 92% as compared to 88% success rate in a historic group of 50 microscopic procedures performed by myself prior to that. All endoscopic procedures were done transcanal as compared to 21/50 historic procedures performed prior to that when using the endoscope. The endoscope decreases the use of postauricular approach in medial graft tympanoplasty.

Case report

45-year-old involved in an MVA. He developed a persistent perforation with moderate conductive hearing loss (Figs. 40–41). Transcanal endoscopic medial graft tympaplasty performed and the incudo-stapedial joint dislocation was addressed with an Applebaum prosthesis (Figs. 42–43).

Endoscopic sheehy's lateral graft tympanoplasty

Lateral graft tympanoplasty has withstood the test of time as an effective surgical approach to large perforations. When compared to transcanal medial graft technique, it involves more extensive surgery but usually produces a higher success rates. Critical to it's success is an open and wide exposure of the ear canal which usually involves postauricular approach. The endoscope offers a wide transcanal access and view of the ear canal and the tympanic membrane without the need for postauricular approach.

Technique

Using transcanal endoscopy, the skin of the ear canal is elevated along with the epithelial layer of the tympanic membrane remnant with the preservation of vascular strip. The ear canal is then enlarged as needed. The middle ear is

Fig. 40 Right ear: View of the tympanic membrane perforation

Indian J Otolaryngol Head Neck Surg
(January–March 2010) 62(1):6–24

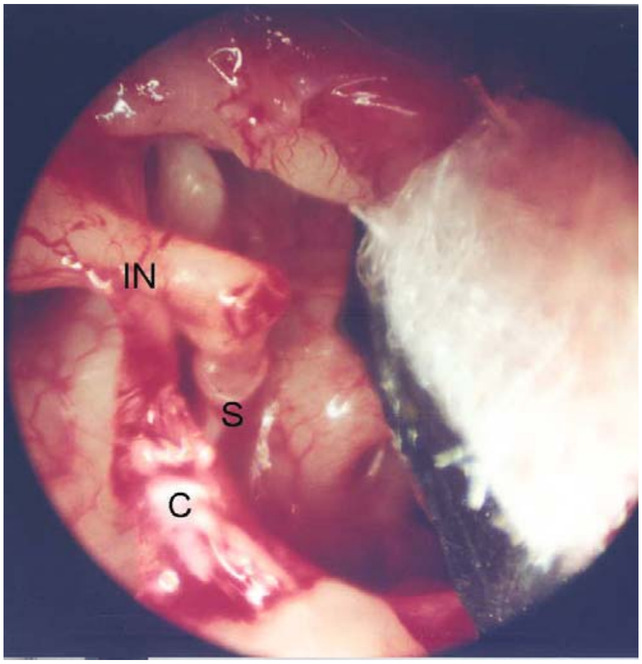

Fig. 41 Right ear: Dislocation of the incuostapedial joint is observed with the displacemnet of the chorda tympani anterior to the incus. IN: Incus; S: Stapes; C: Chorda tympani

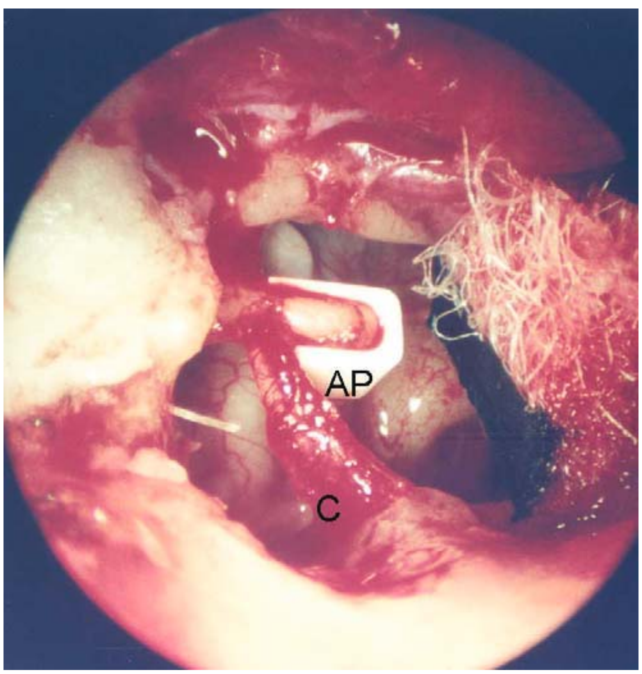

Fig. 42 Right ear: Applebaum prosthesis in position. AP: Applebaum prosthesis; C: Chorda tympani

packed with gelfoam. Then the graft is positioned lateral to the fibrous layer of the membrane and is tucked under the handle of malleus. The skin of the canal is then repositioned and the canal is packed with gelfoam.

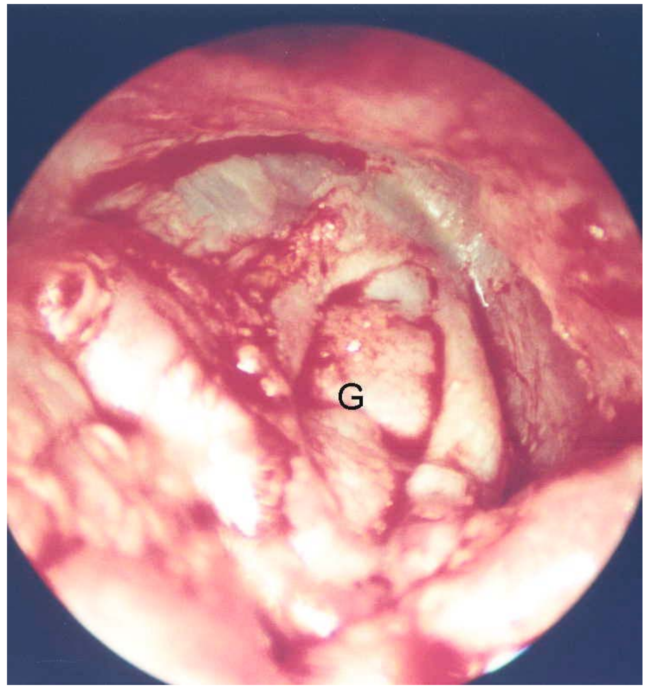

Fig. 43 Right ear: View after repositioning of the tympanomeatal flap over the underlay graft. G: Underlay graft

Results

As reported earlier [7], there were 18 procedures performed. Follow-up at 1 year showed closure of perforation in all patients. Two patients had blunting of the anterior sulcus and one patient had an epithelial pearl formation over the tympanic membrane.

Endoscopic stapedectomy

There are really no compelling reasons to use the endoscope instead of the microscope in stapes surgery. The area of the operative intervention is very limited and visualized well without the need for continuous repositioning of the microscope (Fig. 44). However, experienced endoscopic surgeons would probably prefer the endoscope. There are few issues that needs to be taken into consideration when using endoscope in stapes surgery. The first is that the endoscope wide angle allows great view of the footplate without much curetting of bone posteriorly. As the surgeon proceeds with his footplate related tasks, he then recognizes that the view does not translate into access using the traditional straight picks and drill pits. There is a need to overexpose these areas endoscopically in order to allow work to be done using our existing straight instruments. The second issue relates to the crimping of the wire over the handle of the incus. If the surgeon spends too much time

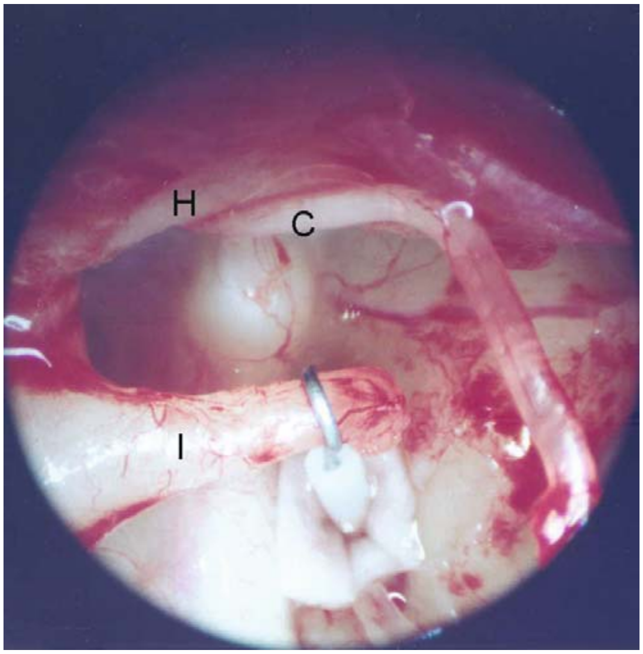

Fig. 44 Left ear: Piston wire stapes prosthesis in position. I: Incus; C: Chorda tympani; H: Handle of malleus

with the light of the endoscope directed at the piston wire prosthesis, the wire is heated heat and it the would un-crimp because of the memory of the metal used and its tendency to return to its original shape when heated. The third issue is that the endoscope would deprive the surgeon from using the two hands technique necessary for the placement of the bucket handle type prosthesis.

Results

Thirteen endoscopic stapedectomy procedures performed. Seven were followed up at 1 year with 6 having an air bone gap of <10 dB (pure tone average of 0.5,1, and 2 kHz). One patient had recurrence of conductive hearing loss.

Conclusion

The main story of endoscopic ear surgery is that of the re-discovering of the ear canal as the most logical, direct, and natural access point to cholesteatoma within the mesotympanum, attic, facial recess, sinus tympani, hpotympanum, and eustachian tube. It offers a fresh outlook on this disease and changes the surgical treatment paradigm of cholesteatoma. The endoscope can also be used in a host of other middle ear pathologies, but it's main area of advantage over the microscope is in cholesteatoma surgery

References

1. Thomassin JM, Korchia D, Doris JM (1993) Endoscopic-guided otosurgery in the prevention of residual cholesteatomas. Laryngoscope 103:939–943
2. Hawke M (1982) Telescopic otoscopy and photography of the tympanic membrane. J Otolaryngol 11:35–39
3. Nomura Y (1982) Effective photography in otolaryngology-head and neck surgery: Endoscopic photography of the middle ear. Otolaryngol Head Neck Surg 90:395–398
4. Takahashi H, Honjo I, Fujita A, Kurata K (1990) Transtympanic endoscopic findings in patients with otitis media with effusion. Arch Otolaryngol Head Neck Surg 116: 1186–1189
5. Poe DS, Bottrill ID (1994) Comparison of endoscopic and surgical explorations for perilymphatic fistulas. Am J Otol 15:735–738
6. McKennan KX (1993) Endoscopic 'second look' mastoidoscopy to rule out residual epitympanic/mastoid cholesteatoma. Laryngoscope 103:810–814
7. Tarabichi M (1997) Endoscopic management of acquired cholesteatoma. Am J Otol 18:544–549
8. Tarabichi M (1999) Endoscopic middle ear surgery. Ann Otol Rhinol Laryngol 108:39–46
9. Tarabichi M (2000) Endoscopic management of cholesteatoma: Long-term results. Otolaryngol Head Neck Surg 122:874–881
10. Tarabichi M (2004) Endoscopic management of limited attic cholesteatoma. Laryngoscope 114:1157–1162
11. Kakehata S, Futai K, Sasaki A, Shinkawa H (2006) Endoscopic transtympanic tympanoplasty in the treatment of conductive hearing loss: early results. Otol Neurotol 27(1):14–19
12. Kakehata S, Hozawa K, Futai K, Shinkawa H (2005) Evaluation of attic retraction pockets by microendoscopy. Otol Neurotol 26(5):834–837
13. Kakehata S, Futai K, Kuroda R, Shinkawa H (2004) Office-based endoscopic procedure for diagnosis in conductive hearing loss cases using OtoScan Laser-Assisted Myringotomy. Laryngoscope 114(7):1285–1289
14. Badr-el-Dine M (2002) Value of ear endoscopy in cholesteatoma surgery. Otol Neurotol 23:631–635
15. El-Meselaty K, Badr-El-Dine M, Mandour M, Mourad M, Darweesh R (2003) Endoscope affects decision making in cholesteatoma surgery. Otolaryngol Head Neck Surg 129:490–496
16. Yung MW (2001) The use of middle ear endoscopy: Has residual cholesteatoma been eliminated? J Laryngol Otol 115:958–961
17. Ayache S, Tramier B, Strunski V (2008) Otoendoscopy in cholesteatoma surgery of the middle ear. What benefits can be expected?. Otol Neurotol 29(8):1085–1090
18. Abdel Baki F, Badr-El-Dine M, El Saiid I, Bakry M (2002) Sinus tympani endoscopic anatomy. Otolaryngol Head Neck Surg 127:158–162
19. Mattox DE (2004) Endoscopy-assisted surgery of the petrous apex. Otolaryngol Head Neck Surg 130:229–241
20. Magnan J, Sanna M (2003) Endoscopy in neuro-otology. Stuttgart: Georg Thieme Verlag

21 Badr-El-Dine M, El-Garem HF, Talaat AM, Magnan J (2002) Endoscopically Assisted Minimally Invasive Microvascular Decompression of Hemifacial Spasm. Otology Neurotology 23:122–128

22. El-Garem HF, Badr-El-Dine M, Talaat AM, Magnan J (2002) Endoscopy as a Tool in Minimally Invasive Trigeminal Neuralgia Surgery. Otology and Neurotology 23:132–135

23. Badr-El-Dine M, El-Garem HF, El-Ashram Y, Talaat AM, Magnan J (2002) Endoscope Assisted Minimal Invasive Microvascular Decompression of Hemifacial spasm. Abstracts of the 9th International Facial Nerve Symposium. Otology Neurotology Suppl 23(3):68–72

24. Rosenberg SI, Silverstein H, Willcox TO, Gordon MA (1994) Endoscopy in otology and neurotology. Am J Otol 15:168–72

25 Presutti L, Marchioni D, Mattioli F, Villari D, Alicandri-Ciufelli M (2008) Endoscopic Management of Acquired Cholesteatoma: Our Experience. Otolaryngol Head Neck Surg 37(4)1–7

26 Marchioni D, Mattioli F, Ciufelli MA, Presutti L (2008) Endoscopic approach to tensor fold in patients with attic cholesteatoma. Acta Otolaryngol 19:1–9

27. Tos M (1982) Modification of combined-approach tympanoplasty in attic cholesteatoma. Arch Otolaryngol 108:772–8

28. Sheehy JL, Brackmann DE, Graham MD (1977) Cholesteatoma surgery: Residual and recurrent disease. A review of 1,024 cases. Ann Otol Rhinol Laryngol 86:451–462

29. Glasscock ME, Miller GW (1976) Intact canal wall tympanoplasty in the management of cholesteatoma. Laryngoscope 86:1639–1657

30. Kinney SE (1982) Five years experience using the intact canal wall tympanoplasty with mastoidectomy for cholesteatoma: preliminary report. Laryngoscope 92:1395–1400

31. Adad B, Rasgon BM, Ackerson L (1999) Relationship of the facial nerve to the tympanic annulus: A direct anatomic examination. Laryngoscope 109:1189–92

32. Gangopadhyay KP, McArthur D, Larsson SG (1996) Unusual anterior course of the sigmoid sinus: report of a case and review of the literature. J Laryngology Otology 110:984–986

33. Philip J (1994) Moore.The high jugular bulb in ear surgery: three case reports and a review of the literature. J Laryngology Otology 108:772–775