REVIEW

Endoscopic Management of Cholesteatoma

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The advantages and limitations of the microscope have defined transmastoid access as the surgical intervention of choice for the treatment of cholesteatoma. 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 are the primary sites of disease and surgical failure to cure. This report is a summary of the author's 15 years of experience with the use of transcanal operative endoscopy as the primary approach to the management of cholesteatoma.

Although it has been 15 years since the first use of operative endoscopy for the exploration of old mastoid cavities, the endoscope is used infrequently in the day-to-day 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.[2-7] 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 for the novice endoscopic surgeon and eliminates the main (and possibly the only) advantage of endoscopy (the wide view provided by the endoscope is greater than that of the microscope). This author first used the endoscope in ear surgery 10 years ago during years of practice in the United States. In recent years, it has replaced the microscope as the instrument of choice for use in middle ear surgery.[8-11] 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.

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 3 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] McKennan described the second-look endoscopic inspection of mastoid cavities that was achieved through a small postauricular incision.[6] Thomassin and colleagues reported on operative ear endoscopy for mastoid cavities and designed an instrument set to be used for that purpose.[1] Badr-el-Dine reported on the value of endoscopy as an adjunct to cholesteatoma surgery and documented a reduced risk of recurrence when the endoscope was used.[12] That reduction in residual disease was further confirmed by Yung.[13] Mattox[14] reported on endoscopy-assisted surgery of the petrous apex, and Magnan and Sanna[15] and Rosenberg and colleagues[7] reviewed at the role of the endoscope in neuro-otologic procedures.

MATERIALS AND METHODS

In the procedures described in this report, 4-mm wide-angle zero-degree and 30-degree Hopkins II telescopes that were 18 cm in length were most often 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 (Figure 1).

DISCUSSION

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

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Figure 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.

areas, such as the hypotympanum and sinus tympani, are minimally accessible. 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. The advantages, limitations, and long-term results of the technique will be discussed in the following sections.

Rationale for Endoscopic Ear Surgery

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.[16] Only in advanced cases, which now occur rarely, 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 hard-to-reach extensions rather than in the mastoid.[17-18] 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. In the past, 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, especially when the sac is excised from the mesotympanum. The view during microscopic surgery is defined and limited by the narrowest segment of the ear canal (Figure 2). 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 (Figure 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 zero-degree endoscope is used (Figure 2). Another anatomic observation that supports transcanal access to the attic,

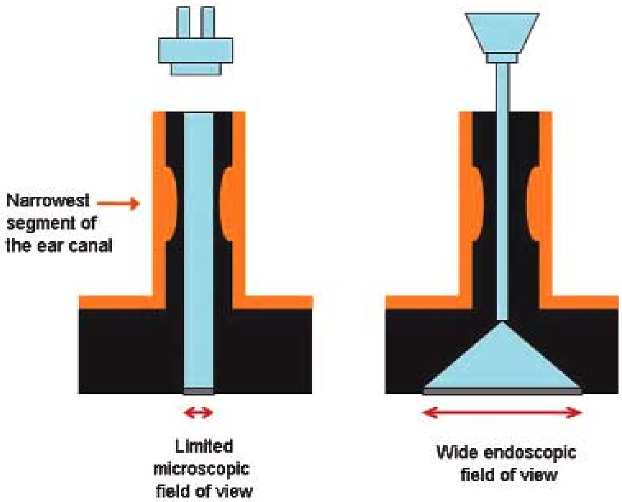

Figure 2: The view from the microscope during transcanal surgery is defined and limited by the narrowest segment of the ear canal. In contrast, the endoscope bypasses this narrow segment and provides a very wide view that allows the surgeon to "look around corners," even when the zero-degree scope is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

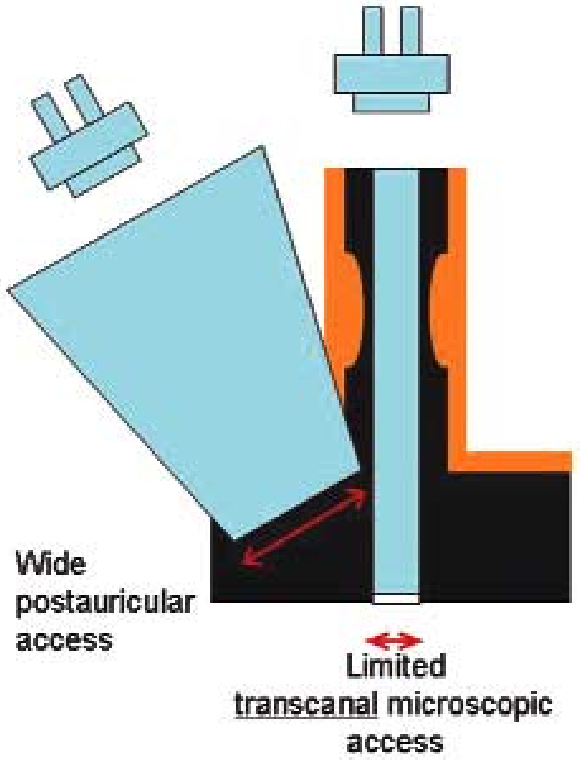

Figure 3: The limited view provided by the microscope during transcanal procedures has forced surgeons to perform postauricular mastoidectomy, in which a port parallel to the attic is created after a considerable amount of healthy bone has been removed to enable anterior keyhole access to the attic.

which is the most frequent auricular site of cholesteatoma, is the orientation of the ear canal in relation to the attic.[19] Figure 4 shows a coronal computed tomographic 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.

The use of the endoscope enables the surgeon to visualize past the shaft of larger surgical instruments, such as drills and curettes, and allows 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.

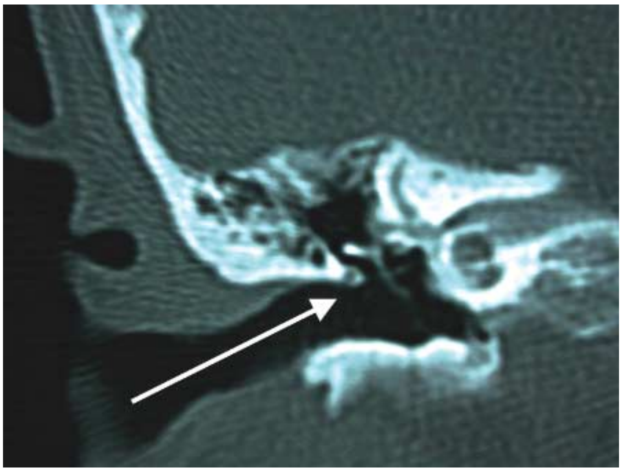

Figure 4: A coronal computed tomographic section of the temporal bone, which shows that an axis line drawn through the ear canal ends in the attic rather than the mesotympanum. This almost universal anatomic orientation enables a natural transcanal access to the attic.

However, there are usually 2 issues of feasibility that raise the most questions about the use of the endoscope in ear surgery. The first consideration is the use of an endoscope of 4 mm, which is large for the ear canal. During this author's 15 years of experience in performing endoscopic surgery on patients as young as 3 years, that concern proved unfounded. In addition, it is almost impossible to operate through a smaller scope because the field of view that is essential for orientation is lost. The second concern has arisen because during microscopic transcanal surgery, many otologists use one hand to hold the speculum and the other hand to operate. This type of one-handed surgery, the lack of suction, and the possibility of excessive bleeding can be problematic. Also, prior experience in performing postauricular procedures (in which many layers of tissue are violated and a tremendous amount of healthy bone is removed during cortical mastoidectomy) cannot be applied to the transcanal endoscopic approach, in which surgically induced trauma is quite limited, there is less bleeding, and the dead-end structure of the canal and cavity allows for the interim packing of certain areas to control bleeding. The amount of bone removed is also limited to a relatively thin scutum that is easily excised with a curette instead of a drill.

Some experts in the otologic community have stated that the transcanal approach to the removal of a cholesteatoma could be performed with the aid of a microscope. The limited view provided by the microscope is the main reason for which those making such an argument cannot recall excising a cholesteatoma via the transcanal approach over the last few years. However, this author uses primarily the transcanal approach for the removal of a cholesteatoma.

Safety Concerns

Two major safety concerns are associated with endoscopic ear surgery: excessive heat dissipation and secondary direct trauma from the tip of the endoscope, which is caused by unintentional movement of the patient. To avoid excessive heat dissipation that is associated with the size of the cavity, adequate illumination of the middle ear space can be accomplished with the use of lower settings on a Xenon light source to reduce heat. The tip of the endoscope also requires continual cleaning with an antifog solution, which may cool the endoscope. Although secondary direct trauma from the tip of the endoscope remains a concern, the diameter (4 mm) of the endoscope used by this author and the anatomy of the ear canal and middle-ear space usually prevent the introduction of the endoscope beyond the tympanic ring. Even during endoscopic stapedectomy, there is less need for curettage of the posterior and superior aspects of the canal to enable exposure. This provides a protective rim that prevents the advancement of the endoscope beyond the tympanic ring.

Endoscopic Management of Limited Attic Cholesteatoma

The attic is the part of the ear in which cholesteatoma most often develops.[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, well-formed 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 position of the attic 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 removal of the matrix in toto rather than piecemeal and through different access ports.

Technique

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. Years ago, 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 curettage 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. Seventy-three 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 computed tomographic 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; ie, 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 (Figure 5). An endoscopic transcanal approach was undertaken, a wide tympanomeatal flap was elevated, and the middle ear was entered (Figure 6). A wide atticotomy was performed with a curette (Figure 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 (Figure 8). Another process of the sac had rotated posteriorly and medially around the incudostapedial joint and the superstructure of the stapes and had advanced medially to the long process of the incus

(Figure 9). The sac was pulled out completely and was deflected (Figure 10). It was evident that the sac had eroded the incudostapedial joint (Figure 11). A prosthesis was used to reconstruct the ossicular chain (Figure 12). A piece of tragal composite graft with excess perichondrium was used to reconstruct the attic defect (Figure 13). The tympanic membrane defect was reconstructed with a perichondrial underlay graft, and the tympanomeatal flap was repositioned (Figure 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.

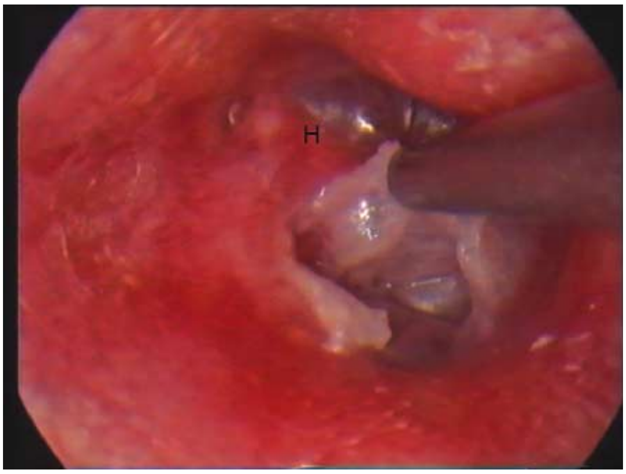

Figure 5: Right ear. Note the retraction and cholesteatoma. H, Handle of malleus.

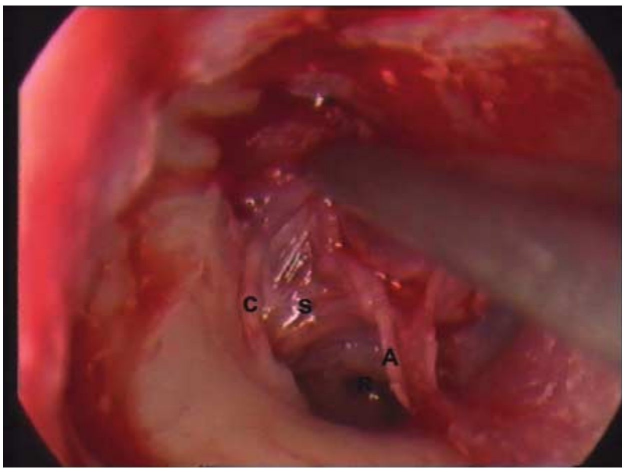

Figure 6: Right ear. The tympanomeatal flap has been elevated, the middle ear has been entered, and the cholesteatoma sac has been exposed. C, Chorda tympani; S, cholesteatoma sac; A, annulus; R, round window.

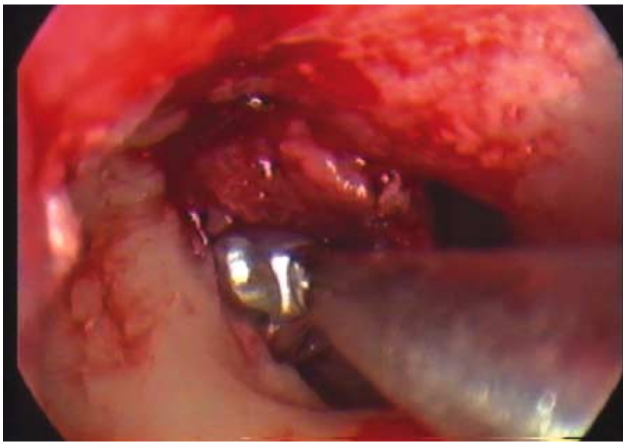

Figure 7: Right ear. A wide atticotomy is performed with a curette.

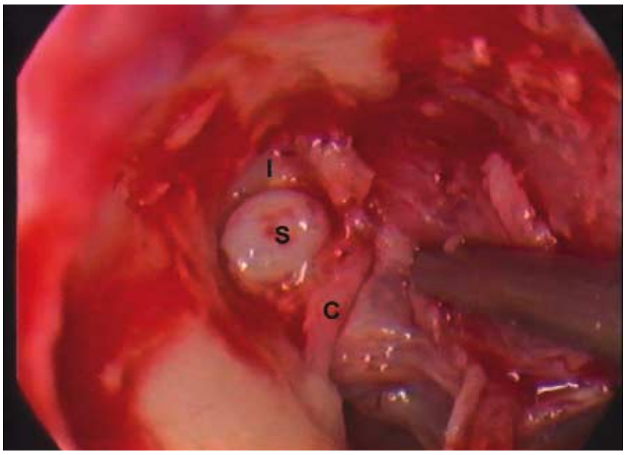

Figure 8: Right ear. The sac (S) has been pulled down from the attic, lateral to the body of the incus and medial to the scutum. The body of the incus (I) can be seen. The chorda (C) forms a collar around the neck of the sac.

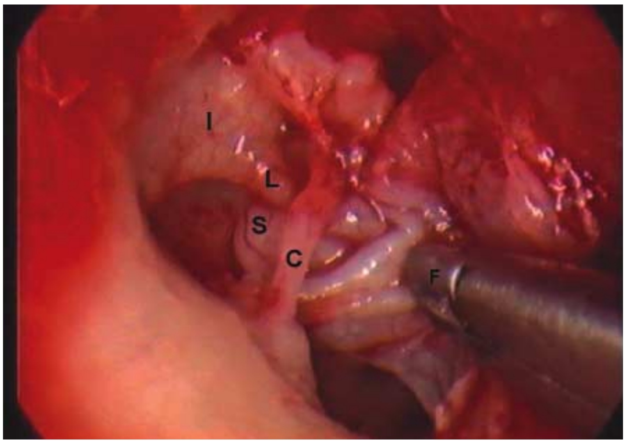

Figure 9: Right ear. The sac has been completely pulled down from the area lateral to the body of the incus (I), but another process of the sac (S) has rotated posteriorly and medially around the incudostapedial joint and medial to the long process of the incus (L). A cuffed forceps (F) is used to pull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

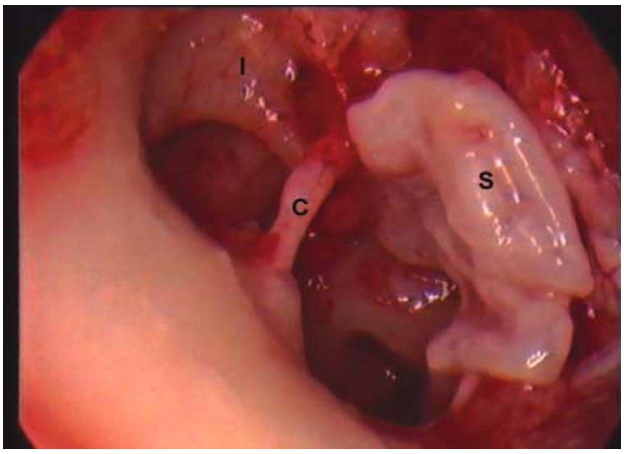

Figure 10: Right ear. The sac (S) has been completely pulled out and deflected over the tympanomeatal flap with the incus (I) and the chorda (C) in view.

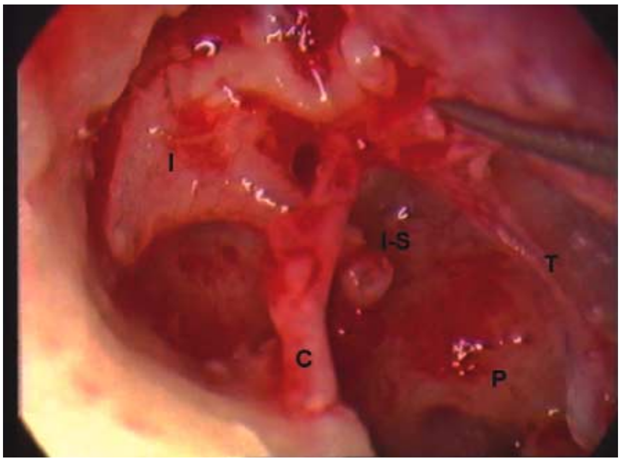

Figure 11: Right ear. The sac is removed. The cholesteatoma has eroded the incudostapedial joint (I-S). The incus (I), the chorda (C), and the promontory (P) are clearly in view. The anterior edge of the tympanic membrane retraction (T), now a perforation, is also visible.

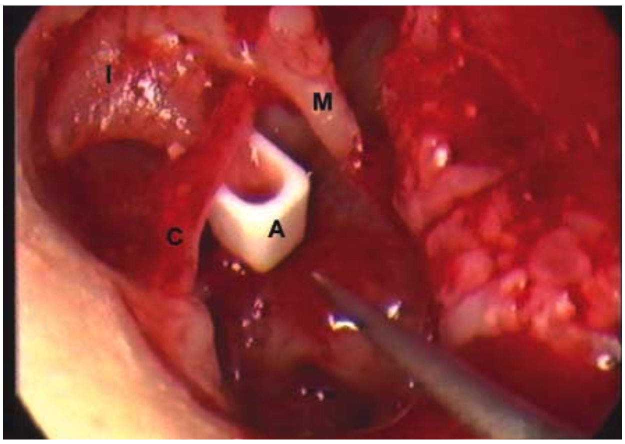

Figure 12: Right ear. A prosthesis (A) is used to reconstruct the incudostapedial joint. The handle of the malleus (M) and the incus (I) and chorda (C) are visible.

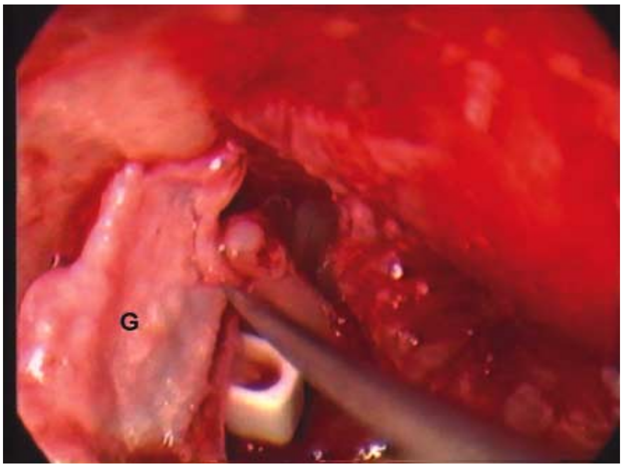

Figure 13: Right ear. The attic defect is reconstructed by means of a composite tragal graft (G) with excess perichondrium to prevent retraction around the graft.

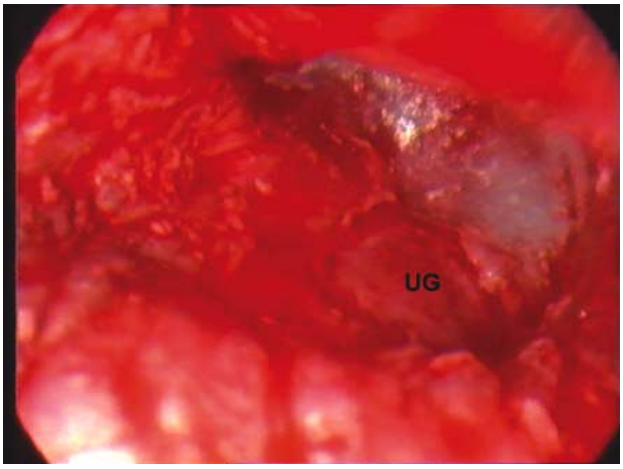

Figure 14: Right ear. The tympanomeatal flap is repositioned over an underlay graft (UG) to reconstruct the retracted area of the tympanic membrane.

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. Endoscopic techniques allow transcanal exploration of the disease-containing 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 (ie, 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 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 2 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 1982.16 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."[16] 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 impedance-matching function of the middle ear) and an open attic and antrum posteriorly and superiorly (Figure 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 to 3 postsurgical months ultimately becomes a small shallow cavity over time.

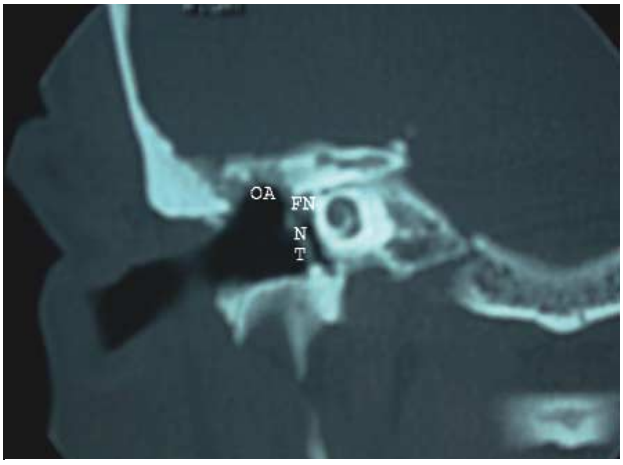

Figure 15: Coronal computed tomographic views of a right ear subjected to endoscopic open cavity management of a cholesteatoma. The neotympanic membrane (NT) is reconstructed up to the level of the horizontal segment of the facial nerve (FN), and the attic is left open (OA).

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 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 seen after the atticotomy was extended (Figures 17 and 18). The incus and the head of the malleus were removed after the incudostapedial joint was dislocated (Figures 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 (Figure 21). All disease was excised, and specific attention was paid to the attic and the tympanic cavity (Figure 22). A prosthesis was used to reconstruct the ossicular chain (Figure 23), and a composite cartilage graft was positioned on top of the prosthesis (Figure 24). The

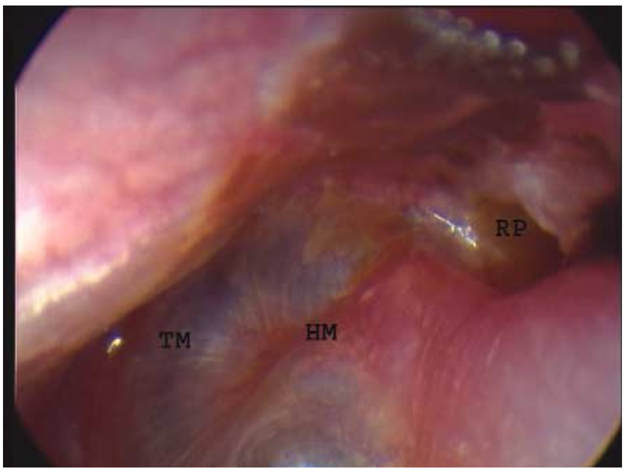

Figure 16: Left ear. A large retraction pocket (RP) with evidence of recurrent prior episodes of infections and the formation of granulation tissue. HM, Handle of the malleus; TM, tympanic membrane.

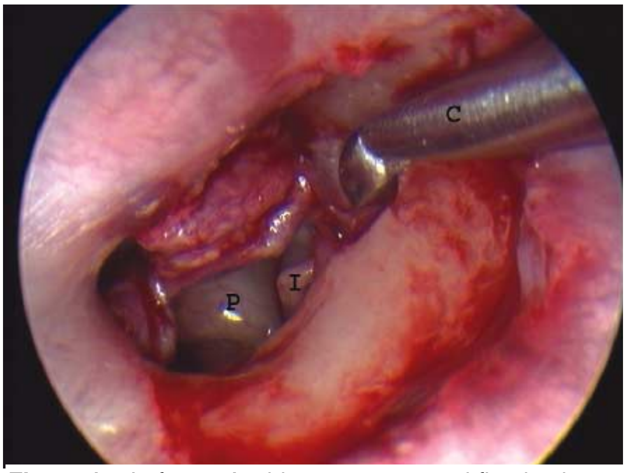

Figure 17: Left ear. A wide tympanomeatal flap is elevated. The premonitory (P) and the incudostapedial joint (I) can be seen. A curette is used (C) to create the extended atticotomy.

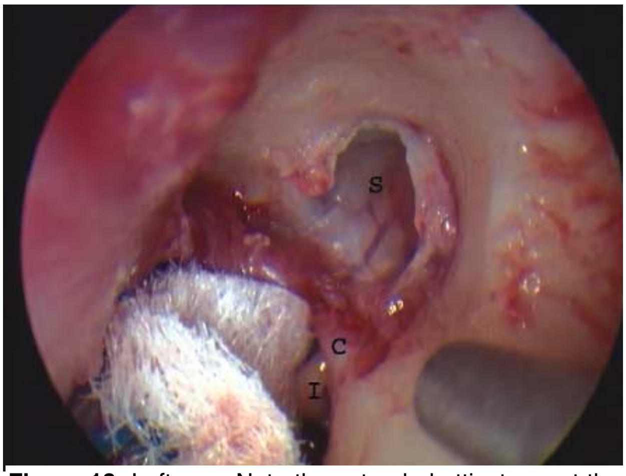

Figure 18: Left ear. Note the extended atticotomy at the thick sac (S), the chorda tympani (C), and the incudostapedial joint (I).

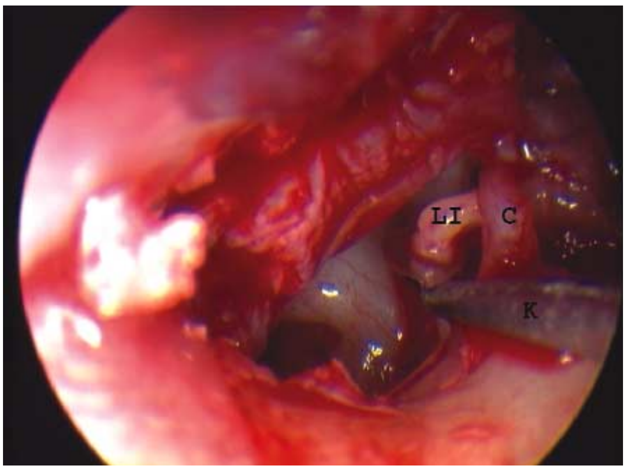

Figure 19: Left ear. The incudostapedial joint (LI) is dislocated with a small round knife (K). C, Chorda tympani.

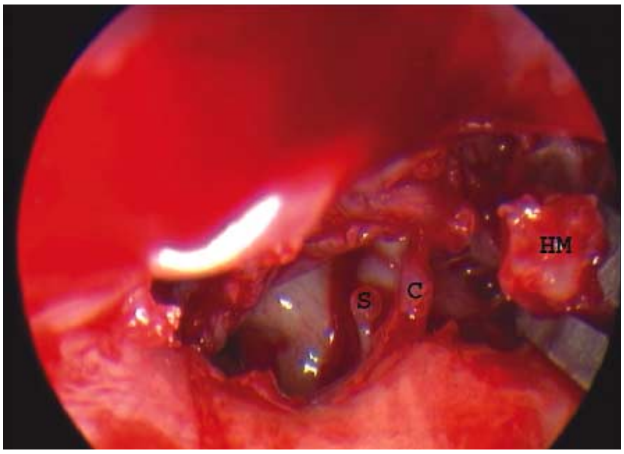

Figure 20: Left ear. The incus has been removed, and the head of the malleus (HM) is extracted. Note that the head of the malleus is separated from the handle by means of a malleus nipper at a proximal site to preserve the ligaments stabilizing the handle of malleus. S, Stapes; C, chorda tympani.

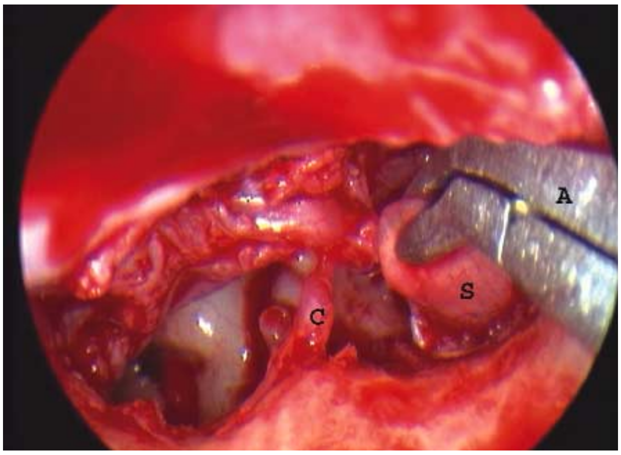

Figure 21: Left ear. The thick sac (S) is being pulled with an alligator forceps (A). C, Chorda tympani.

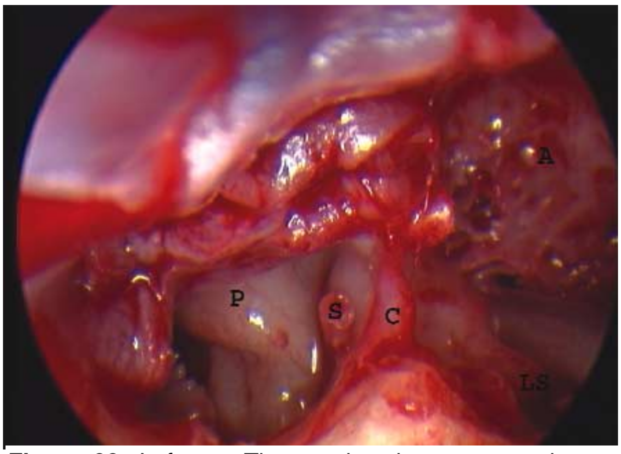

Figure 22: Left ear. The sac has been removed completely. A, Attic; P, promontory; C, chorda tympani; S, stapes; LS, lateral semicircular canal.

tympanomeatal flap was divided longitudinally (Figure 25). The inferior part was repositioned over the ear canal, the superior part was draped over the horizontal segment of the facial nerve (Figure 26), and the attic was packed open.

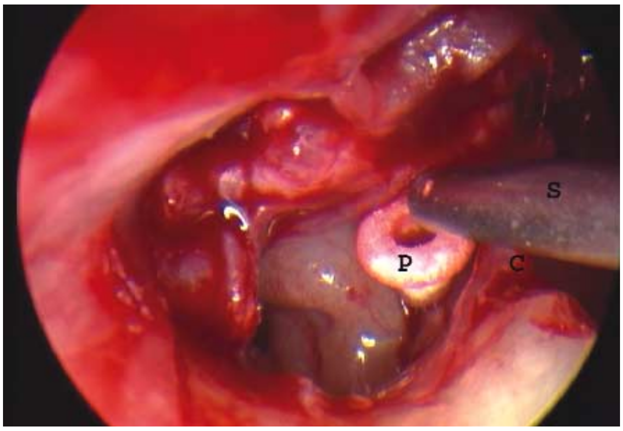

Figure 23: The ossicular chain is reconstructed with the use of a prosthesis (P). C, Chorda tympani; S, suction.

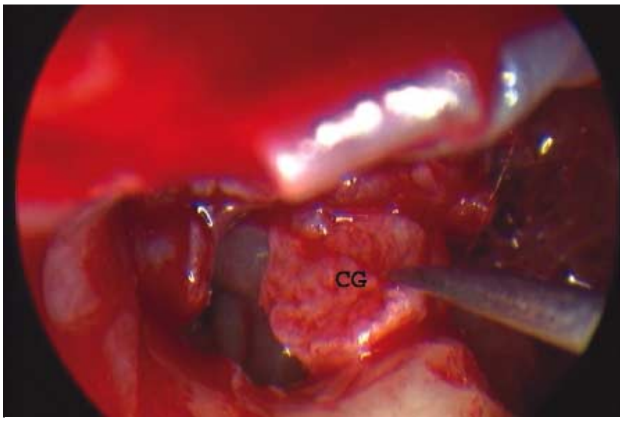

Figure 24: Left ear. Composite tragal cartilage (CG) is used on top of the prosthesis.

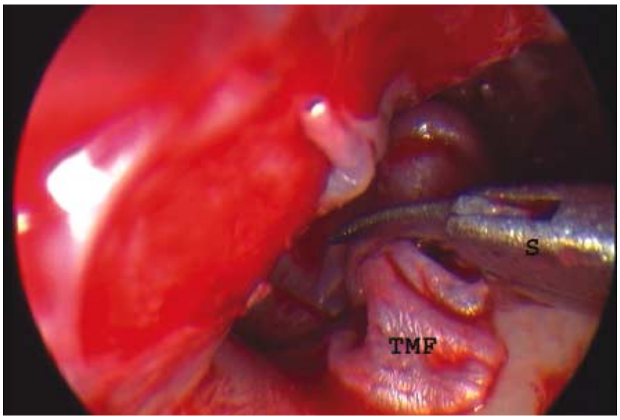

Figure 25: Left ear. The tympanomeatal flap is cut longitudinally with middle ear scissors.

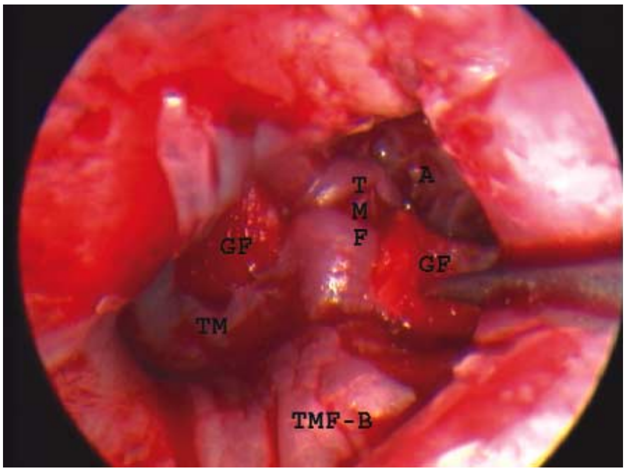

Figure 26: Left ear. The inferior part of the tympanomeatal flap (TMF-B) is repositioned over the ear canal while the superior part of the tympanomeatal flap (TMF) is reflected over the horizontal segment of the facial nerve into the open attic (A). Small pieces of Gelfoam (GF) are used to pack the open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

CONCLUSION

Transcanal endoscopic approach allows minimally invasive removal of cholesteatoma with results that compare well to traditional postauricular tympanomastoidectomy.

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