

ORIGINAL ARTICLE

Surgery of Sinus Tympani Cholesteatoma: Endoscopic Necessity*

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Objective: Residual cholesteatoma occurs as a consequence of growth of a fragmental remnant of the matrix inadvertently left behind at the time of primary surgery. Poor access is the major reason for residual disease, particularly in the sinus tympani (ST). The ST is a critical anatomic region considered the most hidden recess of the middle ear. The aim of our study was to highlight the importance of extension of cholesteatoma into the ST and to demonstrate the efficacy of oto-endoscopy allowing direct access to eradicate disease from this potentially dangerous site.

Materials and Methods: A total of 294 ears with acquired cholesteatoma (primary or secondary) were operated on. In this study, 212 cases were operated upon using canal wall up (CWU) technique, and 82 cases were operated upon using canal wall down (CWD) procedure. Oto-endoscopy was incorporated complementary to the microscope as a principal part of the procedure in all cases. Second-look endoscopic exploration was performed on some selected cases, depending on the operative details during the primary surgery and the postoperative findings of clinical and radiologic studies.

Results: In the primary surgery after completion of microscopic cleaning, the overall incidence of intraoperative residuals detected with the endoscope was (49 cases) 16.7%. Sinus tympani was the most common site of intraoperative residuals in both CWU and CWD groups (36.7%), followed by the facial recess (28.6%), and the undersurface of the scutum in the CWU cases (20.4%); and the anterior epitympanic recess (14.3%). Reconstruction of the hearing mechanism was performed during the primary surgery in 246 cases (83.7%) and postponed to the second stage in only 48 cases (16.3%). Out of the 212 CWU cases, 93 second-look endoscopic explorations (43.9%) were performed. Eight recurrences (8.6%) were identified: 5 cases showed one or more recurrent cholesteatoma pearls, and 3 cases showed a larger open cholesteatoma recurrence extending to the aditus and mastoid. In this series, no morbidity or complication was encountered secondary to the use of endoscopes in the mastoid or middle ear.

Conclusions: From our experience in endoscopic ear surgery we have come to the conclusion that the ability of endoscopes to peer into the recesses of middle ear and mastoid cavity proved without doubt its usefulness. The use of endoscope achieved significant higher degree of control over the disease and dramatically reduced the incidence of cholesteatoma recurrence particularly in those hidden recesses such as the sinus tympani.

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Residual cholesteatoma occurs as a consequence of growth of a fragmental remnant of the matrix inadvertently left behind at the time of primary surgery. Poor access is the major reason for residual disease, particularly in the sinus tympani (ST). The Sinus tympani (ST) has been a focus of clinical interest because of its tendency to be invaded by pathology; its visual obscurity; and the lack of a straight forward surgical approach by which it can be tackled.^[1] The ST is considered one of the most hidden

sites in the whole body. It is located at the far posterior mesotympanum, between the ponticulus and the subiculum. It lies medial to the pyramidal eminence, stapedius muscle and facial nerve and lateral to the posterior semicircular canal. It continues to be a challenge to ear surgery as it also presents marked anatomic variation regarding its shape, size and depth.^[2] The degree of posterior extension of the ST is highly variable and may be related to the overall status of the pneumatization of the involved temporal bone.

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It may even extend posteriorly beyond the limits of the mastoid segment of the FN.^[3,4] These anatomic variabilities emphasize the gravity of the problem in effectively removing pathology from the far deep portion of the ST. As a result, different surgical approaches were proposed trying to access the ST in a satisfactory efficient way.^[4]

Functional endoscopic ear surgery is opening new horizons and changing the vision the way cholesteatoma is treated.^[5-7] Before the introduction of endoscopic assisted surgery, inaccessible areas necessitated “loop-around ways” to fulfill the task. Surgeon was obliged to drill more healthy bone aiming to improve visualization. Over the past decade, the use of oto-endoscopy to visualize the recesses of the middle ear and mastoid cavity has been gaining more and more advocates. However, its intraoperative use to eradicate the disease and achieve total removal still carries lots of controversies. The objective of this study was to evaluate the effectiveness of oto-endoscopy to achieve total control over the disease particularly cholesteatoma extension into the ST. Hence, highlight the usefulness of oto-endoscopy as a tool that could influence surgical decision-making and promote functional ear surgery.

Materials and Methods

Between January 1995 and December 2007 a total of 294 ears with acquired cholesteatoma (primary or secondary) were operated upon in the Otology division, Main University Hospital. In this retrospective study, 212 cases were operated on using canal wall up (CWU) technique, and 82 cases were operated on using canal wall down (CWD) procedure. Oto-endoscopy was incorporated complementary to the microscope as a principal part of the procedure in all cases. Second-look endoscopic exploration was performed on 93 cases selected depending on the operative details during the primary surgery and the postoperative findings of clinical and radiologic studies. Microscopic, oto-endoscopic office examination and audiometry were performed in all patients. Computed tomography (CT) scan was

performed in selected cases, but recently multislice CT scan of the middle ear and mastoid was performed routinely in all cholesteatoma cases.

Rigid autoclavable endoscopes 6 cm or longer, 2.7 mm and 4 mm diameters, 30 and 45 degrees angles were used. Surgery was performed under video-endoscopic control using high resolution 3-chip video endoscopic camera or recently High Definition (HD) digital endoscopic camera. Illumination was provided using Xenon light source and connected with a fiber-optic light cable (Karl Storz, Germany). The endoscopes and light cables were immersed totally in 2% glutaraldehyde (Cidex(r)) for 20 minutes, followed by thorough washing with sterile water. The camera was wrapped with an autoclavable cover. Specially designed and adapted micro-endoscopic instruments provided by multiple different companies were used. Different forceps with variable curvatures as well as different curettes and excavators single or double curved, right or left, long or short all designed strictly to facilitate working with the 30° and 45° angled endoscopes. Suction cannulas fashioned for endoscopic surgery of different curvatures and lengths. The use of the new malleable-shaft instruments provided major advantages in the difficult-to-reach sites.

Surgical Technique: During the primary surgery and after complete cleaning of cholesteatoma using the operating microscope, the endoscopes were used to verify and detect any epidermal remnant left inadvertently in areas that are difficult to visualize with the operating microscope. The following areas were specially inspected in the following order: facial recess, sinus tympani, anterior epitympanic recess, eustachian tube, and hypotympanum. In case any remnant was detected, it was removed using endoscopic guided surgery.

We have consistently used the endoscope as a complementary tool to the microscope since 1995 but only at the end of the microscopic procedure when it was thought that complete eradication of disease had been achieved. Verification of cholesteatoma removal

proved possible through the magnified panoramic views obtained by the endoscopes.^[5] On detection of any cholesteatoma remnants, precise excision could be performed by using fine endoscopic techniques under high resolution video-endoscopic control (Figure 1). Recently endoscope and microscope were used interchangeably throughout the course of surgery. Endoscope was actively employed from the beginning of the eradication phase.

After achieving total removal of the cholesteatoma matrix using combined technique such as the transcanal and transmastoid approach, underlay myringoplasty using temporalis fascia graft was done. If there was any defect in the medial border of the scutum, complex repair using fashioned cartilage and/or bone pate/autograft was performed before placing the graft. The malleus and incus were usually removed when severely eroded, but whenever they were found intact, we could reuse them after meticulous cleaning from any surrounding pathology. In our experience, the reuse of intact ossicles after thorough cleaning did not influence the rate of cholesteatoma recurrence.^[5]

Regarding the second look operations, they were performed with a small, 2 cm incision, post-auricular approach and a limited tympanomeatal flap; then endoscope was passed transmastoid and transtympanic to rule out recurrence.

Results

This study presents results of 294 ears with acquired cholesteatoma (primary or secondary) operated on since 1995. Oto-endoscopy was incorporated complementary to the microscope as a principal part of the procedure in all cases. Canal wall up (CWU) was the standard technique and was used in 212 cases (72.1%), whereas canal wall down (CWD) technique was used in 82 cases (27.9%). All cases were approached through the standard post-auricular incision.

In the primary surgery after completion of microscopic phase i.e. after the surgeon had achieved comfortable eradication of pathology using the microscope, the overall incidence of intraoperative residuals detected with the endoscope was 49 cases (16.7%). Sinus tympani was the most common site of intraoperative residuals in both CWU and CWD groups (18 cases,

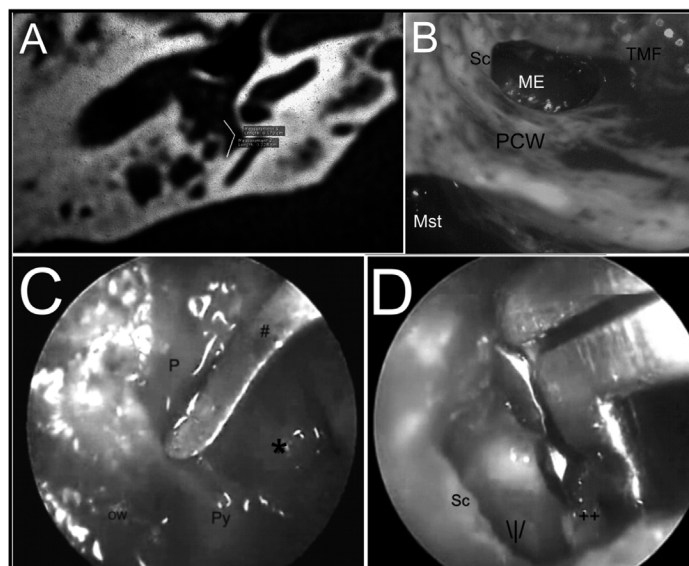


Figure 1. A. Right ear Multislice CT scan showing the detailed anatomy of the sinus tympani (White line) (angulated) with depth = 4 mm and width = 1.3 mm. B. Microscopic view of same right ear showing CWU mastoidectomy and middle ear cavity; Mst: mastoid cavity; Sc: scutum; PCW: posterior canal wall; TMF: reflected tympanomeatal flap. Note the intact scutum with limited view of the retrotympanum. C. Endoscopic dissection of cholesteatoma from over the promontory after finishing cleaning of the ST (*) using curved excavator (#); P: promontory; Py: pyramidal eminence; OW: oval window. D. 90° Cupped forceps removing remnant of cholesteatoma (++) from the facial recess. // denote cholesteatoma still hidden in the aditus behind an intact scutum; Sc: scutum.

36.7%), followed by facial recess (14 cases, 28.6%), and the undersurface of the scutum in the CWU group was involved in (10 cases, 20.4%); and last, the anterior epitympanic recess in (7 cases, 14.3%) (Table 1).

Reconstruction of the hearing mechanism was performed during the primary surgery in 246 cases (83.7%) and postponed to the second stage in only 48 cases (16.3%). The mean duration of follow-up was 28.2 (\pm 8.7) months. Minimum follow-up duration was 1 year. Out of the 212 CWU cases, 93 second-look endoscopic explorations (43.9%) were performed. Eight recurrences (8.6%) were identified: 5 cases showed one or more tiny residual cholesteatoma pearls, and 3 cases showed a larger open cholesteatoma recurrence extending into the aditus and mastoid. All residual pearls were endoscopically removed, then reconstruction was performed or checked. As for the 3 cases with extensive cholesteatoma recurrence, they were approached widely again using microscope and endoscope interchangeably trying to achieve complete eradication of the pathology. One case had to change into CWD technique because of extensive erosion of the scutum and posterior canal wall. Then reconstruction was attempted and the patients were instructed about the importance of thorough postoperative follow up. Out of the 82 CWD cases, 3 cases (3.7%) showed recurrent cholesteatoma pearls. The origin of the recurrence was in the ST in 2 cases while 1 case showed a tiny pearl in the anterior epitympanic recess. The 3 cases were reoperated and recurrences were endoscopically dissected and removed directly through the open cavity. Ossicular reconstruction was then checked and grafting when necessary performed. In this series, no morbidity or complication was encountered secondary to the use of endoscopes in the mastoid or middle ear.

Discussion

Our strategy is to allow the nature and extent of the pathology to determine the form the surgery will take. Canal Wall Up Tympanomastoidectomy (CWUTm) was the standard technique used in 212 cases (72.1%). Canal Wall Down Tympanomastoidectomy (CWDTm) was used in 82 cases (27.9%) based on the following criteria: extensive bone destruction of the posterior canal wall and scutum; or recurrent cholesteatoma cases previously operated using CWD technique. Destruction of posterior canal wall was judged extensive when it was severe enough to hamper stable canal wall reconstruction therefore risking recurrence caused by postoperative retraction pocket. Based on the same criteria, Hinohira et al used CWDTm in 26 (16.2%) out of 160 ears with attic cholesteatoma.^[8]

Cholesteatoma recurrence is due to either: residual cholesteatoma matrix left inadvertently by the surgeon during the primary surgery at locations in which access was difficult; or due to de-novo retraction (i.e. retraction pocket cholesteatoma) caused by scutum defects leading to recurrence of the primary pathology. Our results proved the effectiveness of endoscope to detect residual cholesteatoma in 49 cases (16.7%). Shelton and Sheehy reported residual cholesteatoma in one third of their cases and attributed it to poor control over areas difficult to reach with the microscope.^[9] Similarly, Yung studied the use of endoscope in cholesteatoma surgery and believed that endoscope provided more control over pathology in difficult-to-visualize areas.^[10] In the present study, ST was the most common site of intraoperative cholesteatoma remnant in both CWU and CWD groups (18 cases, 36.7%), followed by facial recess (14 cases, 28.6%), and the undersurface of the scutum in (10 cases,

Table 1. Different sites of residual cholesteatoma as detected by the endoscope surveillance during the primary surgery.

Site of residual disease	Number of patients	%
Sinus tympani	18	36.7
Facial recess	14	28.6
Medial surface of scutum	10	20.4
Anterior epitympanic recess	7	14.3
Total	49/294	16.7

20.4%); and last, the anterior epitympanic recess in (7 cases, 14.3%). Similarly, Thomasin et al, reported that sinus tympani, anterior epitympanic recess and eustachian tube were considered the main sites of recurrences.^[6] ST remains the most difficult site in the middle ear that contain disease and can be challenging to address. In the present study, ST was approached endoscopically. Our results showed that endoscope besides offering effective control over the disease, significantly decreased the risk, improved visualization and reduced operative time. Different surgical techniques were proposed to access the ST. The usual approach when using microscope is to perform blind probing with blunt excavators in an attempt to eradicate any retained epithelial remnants or granulation tissue.^[4] The anterior approaches with drilling the posterior wall of the EAC, delineation of the facial nerve and circumnavigation of the microscope around the patient's head. Even with all this careful dissection, only a minority of ST with limited depth (less than 1mm) could be adequately accessed by the anterior approach.^[11] Toran et al,^[12] described in detail the surgical steps to manage ST cholesteatoma. They described their technique of maximum drilling flush the facial ridge or until the pinkish hue of the FN is seen. They emphasized not only the flushing of the constant ledge of bone anterior to the FN as described by Fathi, et al^[13] but they went further in drilling away the pyramidal eminence to get wider exposure. Despite of all this critical drilling, they concluded that complete removal of pathology could not always be confirmed.^[12] On the other hand, posterior approaches, i.e. from the mastoid to the tympanic cavity, necessitated excessive drilling in the retrofacial region.^[14] These complicated approaches and lengthy detours, frequently risky and dangerous cannot be justified when dealing with benign pathology and are definitely longer and more time consuming. Ozturan, et al^[4] stated that the ST is the most often mentioned inconspicuous region for which endoscopic ear surgery has a place. However, they believe that while endoscopes may improve visualization of this area, they do not solve the problem of removing the disease. We disagree with

this statement, as in our experience using the 30° endoscope together with the specially adapted instruments, perfect control over the disease could be achieved (Figure 2). Only in those rare cases in which the pathology was very extensive with excessive bleeding in the field to the extent that will make the surgeon feel uncertain about total eradication of the disease that a second stage procedure was planned and explained to the patient.

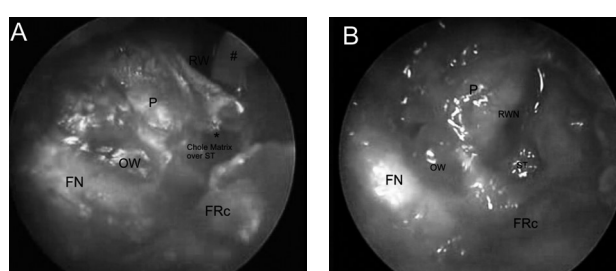


Figure 2. A. Right ear, 30° endoscopic view during cleaning of the cholesteatoma matrix covering the whole middle ear and retrotympa- num. (#)= curved excavator while removing the cholesteatoma matrix from over the sinus tympani (*). B. Panoramic 30° angled endoscopic view after cleaning of cholesteatoma matrix showing very wide sinus tympani. (*)ST= sinus tympani; FN: Facial nerve; FRc: Facial Recess; OW: Oval Window; RWN: Round Window Niche; P: Promontory.

Facial recess approach or posterior tympanotomy provides access to oval window region and facial recess, but it does not permit visually controlled surgery of the tympanic sinus.^[6] Facial recess approach was not performed in any of our patients. In fact, we do not believe that it would add more control over the pathology as long as the endoscope could be used. Wide-angle endoscopes particularly 30° and 45° give a panoramic views of oval window, facial recess as well as sinus tympani even with preservation of posterior canal wall and with no need for posterior tympanotomy.^[10,15] (Figures 1D and 3). We agree with Smyth^[16] that removal of the canal wall does not affect the frequency of residual disease and its incidence in the epi- and meso-tympanum will be the same in ears of both CWU and CWD. According to our experience, the 30° endoscope was most commonly used as it gave the best overall exposure of the middle ear recesses



Figure 3. Right ear, 30° endoscopic view showing curved suction cannula (#) removing a piece of cholesteatoma (++) from the Facial Recess (FRc). S= Stapes head; Sc= Scutum.

particularly ST (Figure 4). The 70° endoscope was occasionally used only to visualize the undersurface of the scutum. Similarly, Yung,^[10] and Youssef and Poe^[17] preferred the 30° endoscope because of its better forward view capabilities that facilitate introduction into the wound.

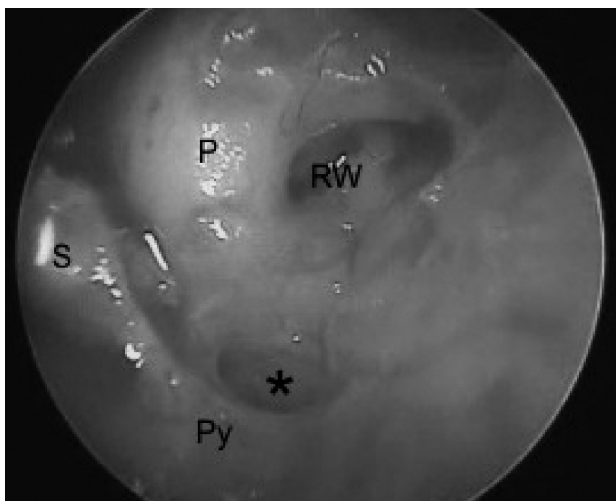


Figure 4. Endoscopic view after endoscopic cleaning of cholesteatoma from the sinus tympani and retrotympanum. Focus on the sinus tympani (*) using a 30° endoscope. RW = round window; P = promontory; S = stapes head; Py = pyramid.

Our experience showed that endoscope provided effective control over the disease thus reduced the need to drill superfluous bone “only for the sake of

visualization” therefore, establishing the concept of functional endoscopic ear surgery. Keeping in the back of our mind the pathogenesis of cholesteatoma together with the possibility of recurrence due to retraction (the primary reason of recurrent pathology) drilling of bone around the supporting areas especially that of the posterior canal wall near the internal border of the scutum is not justified as it is not physiologic. It jeopardizes the “bony-soft tissue inter-relation” and will favor the incidence of future retraction, consequently recurrence (Figure 5). We agree with Hinohira et al,^[18] that such exposure increases significantly the incidence of retraction even if followed with reconstruction. Conversely, when such defects are present due to bone destruction caused originally by the disease, complex repair by fashioned cartilage and/or bone pate/autograft should be performed (scutum plasty).^[18]

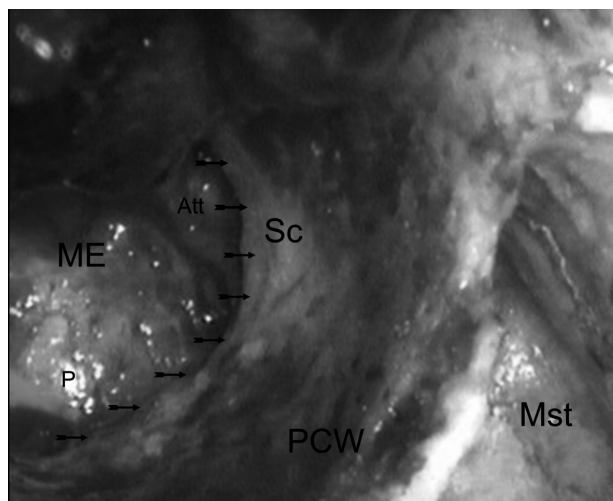


Figure 5. Left ear intact canal wall mastoidectomy. Arrows point to the internal part of the scutum which is the critical zone that should be respected and preserved not to jeopardize the bony-soft tissue interrelation. Sc= Scutum; ME= middle ear; P= promontory; PCW= posterior canal wall; Att= attic; Mst= mastoid cavity.

The mean duration of follow-up was 28.2 (\pm 8.7) months with a minimum follow-up duration of 1 year. It is needless to say that long-term follow-up is very important for discussing the recurrence rate of

cholesteatoma. The rate of de-novo recurrence increases with follow-up time. In this study, though follow-up to date is relatively short, further observation and second look procedures are planned to assess long-term results. Out of the 212 CWU cases, 93 second-look endoscopic explorations (43.9%) were performed. We agree with Youssef and Poe^[17] and McKennan^[19] that the use of the limited endoscopic exploration significantly decreased morbidity of the second-look procedure, enhanced visualization and reduced operative time. Eight recurrences (8.6%) were identified: 5 cases showed one or more tiny recurrent cholesteatoma pearls, and 3 cases showed a larger open cholesteatoma recurrence extending into the aditus and mastoid. All recurrent cholesteatoma pearls were endoscopically removed. As for the 3 cases with extensive cholesteatoma recurrence, they were approached widely again using microscope and endoscope interchangeably trying to achieve complete eradication of the pathology. One case was changed to CWD technique because of extensive pathology with marked bone erosion. Then ossicular reconstruction was attempted and the patients were instructed about the importance of thorough postoperative follow up. As for the CWD group, out of the 82 operated cases, 3 cases (3.7%) showed recurrent cholesteatoma pearls. The origin of the recurrence was in the ST in 2 cases while 1 case showed a tiny pearl in the anterior epitympanic recess. The 3 cases were reoperated and recurrences were endoscopically dissected and removed directly through the open cavity. It is to be noted that on returning to the operative reports of the primary surgery of these 3 cases, difficult dissection and the possibility of residual pathology was underlined and hence planned for strict follow up.

Although it appears that CWD yielded lower rate of cholesteatoma recurrence, this was only because not all cases of CWU underwent a second look procedure. Out of the 212 CWU cases, only 93 cases (43.9%) were subjected to second look operation. Our selection criteria for choosing cases with CWU for revision surgery were based on clinical and radiologic results as well as the operative report described from the primary

surgery. In case of doubtful quality of excision despite using endoscope, detailed operative findings were marked in the patient file. Therefore, close clinical as well as CT scan surveillance of a secondarily progressive suspicious opacity or a newly discovered rounded opacity indicative of a residual lesion pushed the surgeon to perform second look procedure. Cases that didn't get second look surgery were clinically free with undoubtful CT scan and satisfactory postoperative results therefore practically considered free from recurrence. This selection made our recurrence rate biased towards the CWD group. From our study, it became obvious that neither the operating microscope nor the endoscopes could surely identify to the 100% small areas of squamous epithelium in the middle ear cavity; but sure, the use of endoscopes did significantly reduce the rate of residual cholesteatoma. Although endoscopy cannot be viewed as a replacement for conventional mastoid surgery, it does offer the surgeon a less invasive option. We agree with Tarabichi that endoscopes have many proven advantages over the microscope.^[20] There was neither morbidity nor complication secondary to the use of endoscopes in the current study, however the risk of damage to the ossicular chain should not be underestimated.^[6]

Conclusion

The ability of endoscopes to peer into the recesses of middle ear and mastoid cavity proved without doubt its usefulness. The use of endoscope achieved significant higher degree of control over the disease and dramatically reduced the incidence of cholesteatoma recurrence particularly in those hidden recesses such as the sinus tympani. The use of oto-endoscopy has made functional endoscopic ear surgery our new current standard approach. Further observation and second look procedures are planned to assess longer-term results and confirm the efficacy of endoscopy as an adjunct in cholesteatoma surgery.

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