The application of a 70° endoscope in performing transcanal middle ear surgery

Kuan-Chung Ting[a,b,c], Tzong-Yang Tu[a,b,c,*]

[a]Department of Otolaryngology-Head and Neck Surgery, Taipei Veterans General Hospital, Taipei, Taiwan, ROC; [b]Department of Otorhinolaryngology, National Yang Ming Chiao Tung University, Taipei, Taiwan, ROC; [c]Institute of Clinical Medicine, National Yang Ming Chiao Tung University, Taipei, Taiwan, ROC

Abstract

Background: Endoscopes increase the expediency of transcanal middle ear surgery. However, the application of a 70° endoscope is limited and seldom discussed, mainly because of its large angle. We introduce our experiences with the 70° endoscope in transcanal middle ear surgery.

Methods: This is a retrospective chart review of 127 patients with chronic otitis media who underwent middle ear surgery performed by the senior author in 2016 at a tertiary referral center. The types of eardrum perforation were classified as central, inferior, posterior, or anterior according to the main location of the hole. The demographics, surgical pictures, and operative records were reviewed.

Results: In 15 ears of the 127 patients, the ossicles were recognized directly by a microscope. In another 112 ears, the ossicles could not be identified under a microscope. Without elevating the tympanomeatal flap, the ossicles could be recognized in 72 of these 112 ears with endoscopes, especially the 70° endoscope. In 35 of these 112 ears, an incision to extend the drum perforation or creation of a small tympanomeatal flap in the posterior-superior canal was made to observe the ossicles. However, 5 of these 112 ears were still noted to have a narrow and/or curved ear canal and preoperatively needed to undergo endaural incisions. Among the other 122 patients who first underwent attempted transcanal surgery, 15 ears changed to endaural incisions. The drum perforations were repaired directly through the perforation in 107 ears via the transcanal route. One year after surgery, the air-bone gap closure was 16.0 ± 11.8 dB, and the graft take rate was 91.3%.

Conclusion: With the help of a 70° endoscope, we can use the transcanal transperforation route to evaluate and reconstruct drum perforations and ossicular chains in appropriate patients. Hence, normal tissue injuries to the ear canal can be minimized.

Keywords: EES; Endoscopic ear surgery; 70° endoscope; Middle ear surgery

1. INTRODUCTION

Since endoscopes were introduced to facilitate the performance of various middle ear (ME) surgeries, the 0°, 30°, and 45° endoscopes have been the most commonly employed worldwide.[1–6] The 70° endoscope seemed to be reserved for use in paranasal sinus surgery and have seldomly been mentioned by otologic endoscopic enthusiasts.[7–9] Otologic endoscopists are accustomed to elevating and creating a tympanomeatal flap (TMF) from the posterior ear canal wall to enter the ME and observe the ossicles.[1–3,5,6,10,11] However, to minimize normal tissue injuries and shorten the operation time, the authors prefer to inspect the ME, especially the integrity and mobility of the ossicles, with all degrees of endoscopes, including the 70° endoscope, and then reconstruct the perforation and ossicles directly through the perforation, if possible. We present our experiences with the 70° endoscope during the endoscopic chronic otitis media (COM) surgery.

2. METHODS

2.1. Study population

We retrospectively reviewed the medical records of patients who underwent COM surgery at the Taipei Veterans General Hospital in Taiwan from January 1 to December 31, 2016. Images of the surgical field were routinely taken via a microscope and endoscopes (0°, 30°, 45°, and 70°) during surgery. The size and location of the perforation and the condition of the ossicles were recorded. The graft type, graft take rates, and postoperative air-bone gap closure rates were documented. The report was approved by the Institutional Review Board (IRB No. 2019-04-001AC) of the Taipei Veterans General Hospital.

2.2. Measures

The eardrum is traditionally divided into four quadrants (posterosuperior, anterosuperior, posteroinferior, and anteroinferior) by one line along the malleus handle and another line that crosses the umbo at right angles.[12] According to the main location of the eardrum hole, we used these two lines to classify the eardrum perforations as central, inferior, posterior, or anterior.

*Address correspondence. Dr. Tzong-Yang Tu, Department of Otolaryngology-Head and Neck Surgery, Taipei Veterans General Hospital, 201, Section 2, Shi-Pai Road, Taipei 112, Taiwan, ROC. E-mail address: tytu@vghtpe.gov.tw (T.-Y. Tu).

Conflict of interest: The authors declare that they have no conflicts of interest related to the subject matter or materials discussed in this article.

Journal of Chinese Medical Association. (2021) 84: 309-313.

Received August 29, 2020; accepted October 28, 2020.

doi: 10.1097/JCMA.0000000000000481.

The four different types of endoscope applied were 0°, 30°, 45°, and 70° angled rigid endoscopes with an outer diameter of 2.7 mm (Karl Storz, Tuttlingen, Germany). A relatively new light-emitting diode (LED) light source was used with 50% output settings (Karl Storz). An ear speculum is always used to guide the direction and to protect canal wall when using a 70° endoscope.

2.3. Statistical analysis

Quantitative data were summarized as the mean ± standard deviation (SD) and categorical variables as percentages. IBM SPSS software version 23 (IBM Corp., Armonk, NY, USA) was used for the statistic analysis.

3. RESULTS

A total of 127 patients with COM were operated on by the senior author from January 1 to December 31, 2016. In 15 ears, the ossicles were recognized directly by a microscope. In 112 ears, the integrity and mobility of the ossicles could not be clearly evaluated under a microscope. Hence, the ossicles could only be observed with endoscopes. Without elevating a TMF, the ossicles could be clearly seen in 72 of these 112 ears with the help of endoscopes, especially the 70° endoscope. Among these ears, ossiculoplasties were performed in 20 ears. In 35 of these 112 ears, incisions to extend the drum perforation or creation of small triangular TMFs in the posterior-superior ear canal were made to observe the condition of the patients' ossicles. Ossiculoplasties were performed in 12 of these cases. However, 5 of these 112 ears were still noted to have narrow and/or curved external auditory canals (EACs) and decided preoperatively to undergo endaural incisions to enlarge the EAC to repair the drum perforation or ossicular chain. Among the other 122 patients who were first underwent attempted transcanal surgery, 15 ears changed to endaural incisions, mainly because of difficult ossiculoplasties during surgery. Accordingly, 20 of the 127 ears finally underwent endaural incisions. Fifteen of these 20 ears underwent ossiculoplasties. The drum perforations were repaired directly through the perforation in 107 ears via the transcanal route (Table).

When the drum perforation was located in the posterior or central portion, the stapes might be recognized through the drum perforation with a 45° endoscope. However, in some cases, the whole incudostapedial (IS) joint and the long process of the incus were barely identifiable. In this situation, we used a 70° endoscope to assess these structures. When the perforations were in the inferior part of the drum or the EAC was not straight enough, not only was the IS joint and incus long process not visible but also the stapes was usually not visible with a 45° endoscope through the perforation. In contrast, a 70° endoscope could easily visualize the incus long process, IS joint and whole stapes in these less-than-optimal conditions (Figs. 1–3). If the perforations were in the anterior part and the ossicles could not be examined even by a 70° endoscope through the perforation, we raised a small triangular TMF to evaluate the ossicles with a 45° or a 70° endoscope. The visibility of the ossicles and other ME structures with 45° and 70° endoscopes are shown in Fig. 4 as a comparison. After the integrity and mobility of the ossicular chain was ensured, the drum could be repaired directly through the perforation with dermis/subcutaneous/perichondrium tissue harvested from anywhere in the body. The authors preferred harvesting these tissues from the postauricular, conchal or tragal areas because of easy accessibility with the same surgical field. When the IS joint was eroded or fixed and had poor mobility, the ossiculoplasty method depended on the position of the perforation. In the posterior and central perforations, the ossiculoplasty can be performed with the help of a 45°endoscope, directly through the perforation. In the anterior or inferior perforations, the ossicles can still be repaired with a 45° endoscope after the elevation of a TMF or creation of an incision to extend drum perforation, in most cases (Fig. 5). One year after surgery, the air-bone gap closure was 16.01 ± 12.38 dB, and the graft take rate was 91.3%.

Table

Demographic and clinical characteristics of the patients

Perforation area	No. of patients
Total	127 (100%)
Sex	
Male	55 (43%)
Female	72 (57%)
Ossicles identified, preoperative	
Microscope	15 (11.8%)
Posterior	15
Anterior	0
Central	0
Inferior	0
Endoscopes through the perforation	72 (56.7%)
Posterior	18
Anterior	0
Central	29
Inferior	25
Endoscopes with a small TMF	35 (27.6%)
Posterior	0
Anterior	13
Central	11
Inferior	11
Endaural incision	5 (3.9%)
Posterior	1
Anterior	0
Central	3
Inferior	1

TMF = tympanomeatal flap.

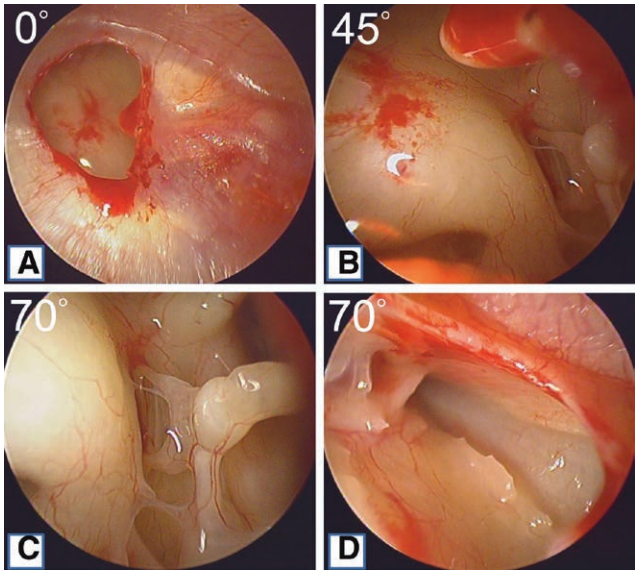

Fig. 1 The perforation is in the inferior part of the drum. A, Only the promontory is seen via the perforated drum with a 0° endoscope. B, Just the stapes and stapedial tendon can be seen with a 45° endoscope. C and D, The incus long process, incudostapedial joint, whole stapes and the orifice of the Eustachian tube can be evaluated with a 70° endoscope.

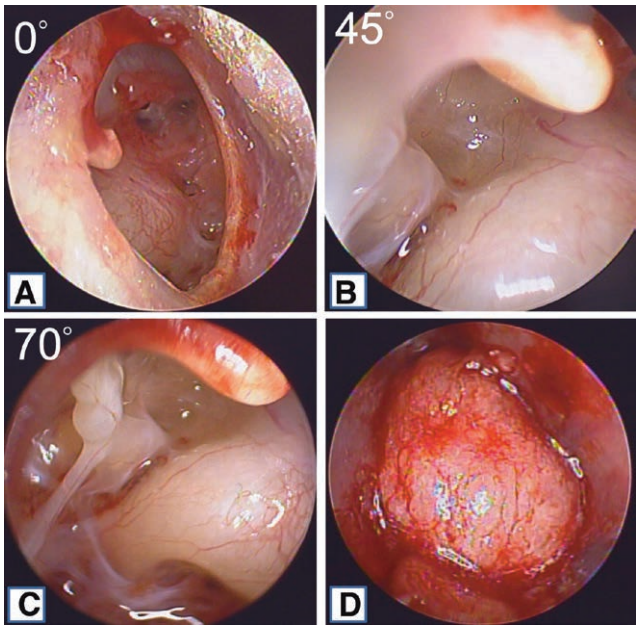

Fig. 2 This is a central and near total perforation in a patient with a curved and narrow external auditory canal. A, The ossicles cannot be seen with a 0° endoscope. B, Only part of the stapedial arch is observed with a 45° endoscope. C, The long process, incudostapedial joint and whole stapes are clearly shown with a 70° endoscope. D, A graft is underlaid directly through the transcanal and transperforation route without elevation of a tympanomeatal flap.

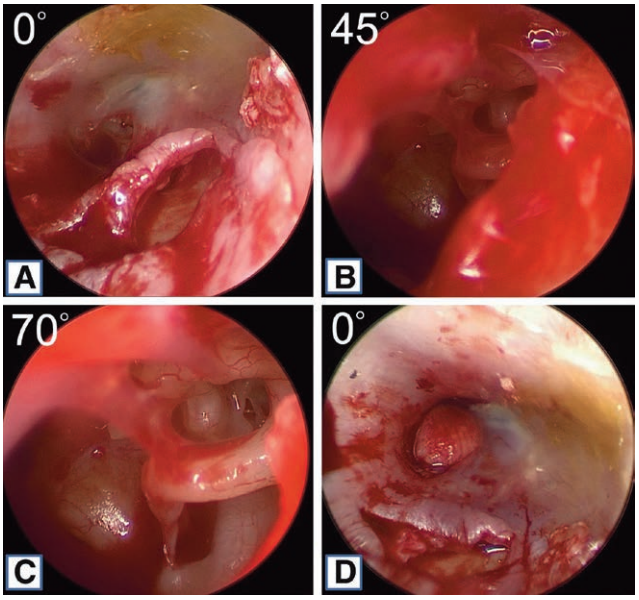

Fig. 4 The perforation is in the anterior part of the drum. The ossicles cannot be seen with endoscopes. A, A tympanomeatal flap (TMP) is raised. The 45° (B) and 70° (C) endoscopes are used to check the ossicles, and the 70° endoscope more clearly revealed the long process of the incus, facial nerve and whole stapes than the 45° endoscope. D, A graft is underlaid directly through the perforation. The TMF is replaced.

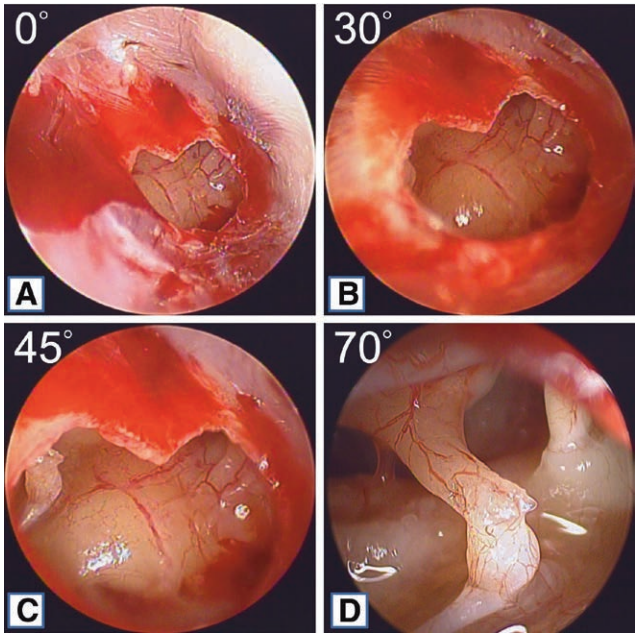

Fig. 3 The perforation is in the inferior part of the drum. The 0° (A), 30° (B), and 45° (C) endoscopes demonstrate only a limited part of the ossicular chain. D, An extension of the drum perforation through a small incision and a 70° endoscope further shows the cochleariform process, tensor tympani tendon, facial nerve, long process of incus, and whole stapes.

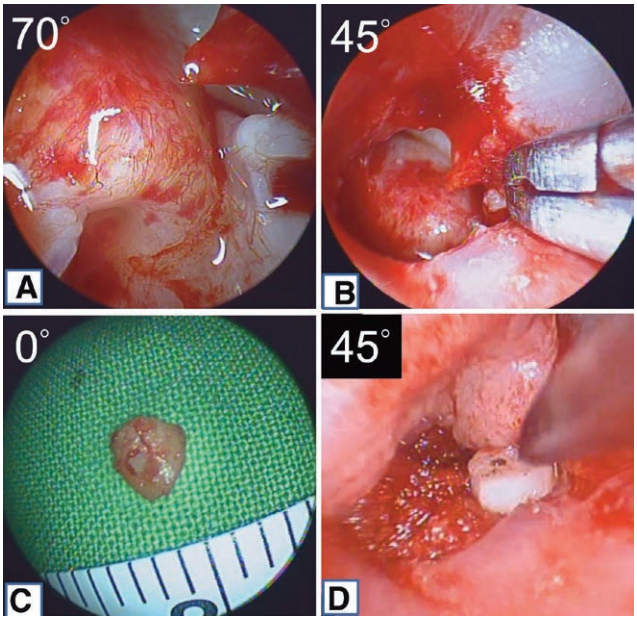

Fig. 5 Transcanal transperforation drum repair and ossiculoplasty. A, A 70° endoscope reveals the incudostapedial (IS) joint and that the long process of the incus is wrapped in the granulation tissue. The mobility of the incus long process is limited. B, With a 45° endoscope, the IS joint is separated and the long process of the incus is amputated and removed. C, A piece of conchal cartilage is harvested and sculpted to be interposed between the graft and stapes head. D, Ossiculoplasty with conchal cartilage is completed.

4. DISCUSSION

Microscopic surgery has been the traditional method for ME surgery for decades, but endoscopic ear surgery has gained importance and popularity worldwide in recent years.[9] Microscopes offer excellent surgical visualization, along with enabling binocular stereovision and two-handed surgery.[13,14] However, the surgeon's view and instrumental manipulation of ME structures may be impeded by a narrowing or protruding EAC due to the straight vision of microscopes.[13] In contrast, endoscopes provide a wide-angle view with magnification. The angled lens offers all-around vision of the ME cavity, particularly the anterior epitympanum, retrotympanum, hypotympanum, and the Eustachian tube orifice can all be visualized well. The disadvantages of endoscopes are that the device only permits single-handed surgery and lacks three-dimensionality.[14] In a literature review, the 0°, 30° and 45° endoscopes were mentioned for endoscopic ear surgery in most reports; however, there was no specific discussion about the role of a 70° endoscopes in ME surgery.[2–4,9,13–15] The possible reasons are that most otologists observe and reconstruct the ossicular chains with a 30° and/or a 45° endoscope after the elevation of a TMF from the canal wall, and the 70° endoscope may cause trauma to the EAC and ME structures when the surgeon is not used to manipulating such a large-angled endoscope. Conventionally, the TMF is raised from the EAC when an endoscope is used to observe the ME structures and to repair the drum and ossicles.[5,10] However, in our opinion, surgeons familiar with the operation of a 70° endoscope can obtain a better view of the ossicles and other ME structures with this scope than with a 45° endoscope. In this study, we reported our experiences with using endoscopes of 0°, 30°, 45°, and 70°, especially the 70° endoscope, to perform transcanal transperforation COM surgery in appropriate patients.

In our study, the types of eardrum perforations were classified into four categories according to the ease of visualization and accessibility of ME structure, especially the ossicles, with endoscopes. Depending on the location of the perforation, we used the malleus handle to divide the perforations in the upper part of drum into anterior and posterior perforations. If the drum perforation was beyond an imaginary perpendicular line crossing the umbo, then we categorized it as an inferior perforation. Otherwise, the perforations out of the boundaries of these two lines were defined as central perforations. In our experiences, if the drum perforations were located in the posterior or central part of the drum, a transcanal transperforation drum repair and even ossicular chain reconstruction may be performed directly through the perforation with endoscopes of different degrees, including the 70° endoscope, without any incisions in the EAC in appropriate ears. When the eardrum perforation was located in the inferior part of the drum, the 70° endoscope is an ideal tool to examine the ME structures, especially the ossicles. When the IS joint was eroded, ossiculoplasty could be performed with the help of a 45° endoscope directly through the perforation in most ears, after a small extension was made to the drum perforations. If the perforation was situated in the anterior part, we could still repair the drum through the perforation, but a small triangular TMF in the posterior-superior EAC might be needed to examine and/or reconstruct the ossicular chain with the help of a 45° endoscope. Accordingly, except for anterior perforations, we could use this transcanal transperforation method to assess the ossicles with a 70° endoscope and perform ossiculoplasty by interpositioning a piece of conchal cartilage between the stapes and the drum with a 45° endoscope because cartilage interpositioning is much easier with a 45° endoscope than with a 70° endoscope. In this way, our surgical techniques can minimize normal tissue injuries to the EAC and ME and avoid the need to check for bleeders in the EAC. Therefore, this surgery can be performed under local anesthesia in most patients.

The choice of endoscope is an important issue. The diameters of 2.7, 3, and 4 mm are commonly used for endoscopic ear surgery. The image quality increases with larger diameters; however, large diameters might decrease the working space in the EAC. When using a larger-diameter endoscope, the instruments may crowd the EAC, and the large-angled endoscope can frequently become contaminated by blood. This situation is particularly prone to happen to Asian patients with narrow EACs. In addition, the EAC may be easily injured by surgeons who are not familiar with manipulating such a large-angled endoscope, because only the canal wall can be seen when a 70° endoscope is advanced in the EAC. Canal trauma may cause edematous swelling and further restrict the approach through the canal. The choice of a narrow-diameter endoscope, such as those with an outer diameter of 2.7 mm, can prevent these potential shortcomings. Moreover, the use of an ear speculum may be of assistance in guiding the endoscopes and protecting the canal wall for surgeons not yet completely familiar with surgical procedures with a 70° endoscope.

Thermal injuries are another special consideration. When extending the tip of the endoscope into the ME, theoretically, local heat transmission from the tip might be harmful to some sensitive ME structures, such as the oval/round windows, ossicles, E tube orifice, and dehiscent facial nerves.[16] This potential risk does exist if the operator places a large-angled endoscope in the ME for too long or an inexperienced surgeon uses a high-output light source. To avoid this kind of shortcoming, the type of light source should be the first consideration. A Xenon light source produces a higher temperature than a halogen light source after the first minute according to a guinea pig study.[17] Using a high-intensity xenon light source may result in much more thermal tissue injuries than using newer LED light sources.[16] The duration and depth that the tip of the endoscope stayed in the ME is the second consideration. In a human temporal bone model of endoscopic ME surgery, a rapid temperature elevation up to 46°C within 1 mm from the tip of endoscope was observed within 30 to 124 seconds.[18] The temperature decreased rapidly after turning off the light source or using suction. A more comprehensive study using a 4-mm endoscope with a xenon light source and 100% output was compared to a 0° endoscope with either a 2.7- or 4-mm diameter coupled to an LED source at 40% output. The former led to a high temperature of 44.1°C, while the latter led to a temperature below 31°C.[19] To avoid possible thermal tissue damage, we suggest frequently cooling the tip of the endoscope with suction or irrigation, not staying in the ME in one position for a prolonged period, using cooler light sources, such as LED systems, with a submaximal light intensity (<50% output setting) and a 2.7-mm diameter endoscope, and preventing the endoscope tip from contacting any structures.

Since endoscopes have been employed for ME surgeries, the condition of the ME structures, such as the epitympanum, posterior mesotympanum, and hypotympanum, has been more realized via endoscopes than via microscopes after TMF elevation.[20] In this report, we introduced our experiences in performing transcanal transperforation COM surgery with the assistance of angled endoscopes, especially the 70° endoscope. We can use this method to assess and reconstruct the ossicles without the TMF elevation in appropriate cases. In the future, a comparison of the operation time, postoperative pain level, hospital stay duration, and postoperative air-bone gap closure rate of this method to those of endoscopic ear surgery with TMF elevation would be worthwhile.

In conclusion, the 70° endoscope is a useful and efficient tool for performing ME surgery. We can use the transcanal transperforation route to assess and reconstruct drum perforations and ossicular chains in continuity in most posterior and central perforations. A small TMF is still needed for anterior perforations. With the help of a 70° endoscope, normal tissue injuries to the ear canal, such as TMF creation, can be avoided during transcanal ME surgery.

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