Transcanal totally endoscopic stapes surgery: step-by-step procedure

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Received 16 December 2016
Accepted 27 December 2016

The Egyptian Journal of Otolaryngology
2017, 33:477–483

Objectives
The purpose of the present work was to evaluate the role of otoendoscopy in performing stapedotomy in clinically otosclerotic patients.

Patients and methods
Twenty patients presenting with clinically diagnosed otosclerosis were randomly selected from the outpatient ENT clinic in a tertiary referral Institutional Hospital. All patients were subjected to transcanal totally endoscopic stapes surgery (TTESS) from early 2013 to the fall of 2014.

Methods
This prospective study demonstrated the detailed technique of TTESS using mainly 0° lens of 14 cm length rigid endoscope for elevating the tympanomeatal flap, handling the chorda tympani nerve, curettage of posterior bony canal wall, visualization of oval window niche structures, creation of stapedotomy, and accurate prosthesis insertion. Postoperative audiogram was performed after 2 months. Assessment of postoperative complications, especially change in taste sensation, was carried out.

Results
The chorda tympani nerve was preserved in all cases. Two cases had change in taste sensation that was improved within 6 months postoperatively. There was a significant improvement in hearing. The preoperative air-bone gap mean value was 40.30±6.38, and the postoperative mean value was 7.15±4.27 (P=0.001), with complete closure of air-bone gap in four cases. No facial paralysis or tympanic membrane perforation was encountered during the follow-up period.

Conclusion
Transcanal totally endoscopic stapes surgery is a feasible and safe technique for the surgical management of conductive hearing loss associated with otosclerosis, which is recommended in bilateral and revision cases.

Keywords:
endoscopic, microscopic, otosclerosis, stapes surgery

Egypt J Otolaryngol 33:477–483

1012-5574

Introduction

Otosclerosis is a disease of the otic capsule that clinically presents with conductive hearing loss (CHL), especially when the middle ear ossicles are involved [1]. It is considered one of the most frequent causes of CHL in adults that can be perfectly surgically managed [2]. Worldwide, operative microscopic stapes surgery still has the upper hand in solving this issue as it permits bimanual working and adequate handling of middle tissue structures. Surgical microscopes provide amplified good quality images but in a straight line, which limits visual field, especially when the surgeons operate through a narrow portion of the external auditory canal (EAC) using an exclusive transcanal approach [3]. Some anatomical obstacles hinder the visual field of the surgical microscope, such as posterior bulging of the bony EAC and overhanging scutum limiting adequate access to the oval window niche (OWN) structure, and make the procedure quite difficult. Thus, drilling or overcurettage of the scutum and posterosuperior EAC to visualize the OWN area might lead to irreversible trauma to the chorda tympani nerve (CTN). In case of winding of the external canal, the limited visual field of the microscope is even much greater and might require other access pathways to the middle ear [3,4].

Although middle ear endoscopy was introduced over 15 years ago, their role in the treatment of middle ear inflammatory diseases and otosclerosis was limited [3–7].

There are several possible reasons for the limited role of endoscopy, including a potentially long learning curve through the initial stages of adapting newer techniques for a single-handed work [2,3]. In patients with excessive bony overhang, it would be difficult to access the middle ear cavity using operating microscope. Using endoscope, authors were able to circumvent these difficulties [8]. Advantages of using endoscope include the following: excellent exposure, visualization of the entire middle ear cavity with ease, and excellent crystal clear images. All steps of stapedectomy could easily be performed using endoscope. However, the main disadvantage is that it is a single-handed surgery with the nondominant hand holding the endoscope [9]. The purpose of the present work was to evaluate the role of otoendoscopy in performing stapedotomy in clinical otosclerotic patients.

Patients and methods

The research was conducted in accordance with Helsinki declaration. After approval from the local institutional ethical committee, 20 patients presenting with clinical otosclerosis were selected from the outpatient clinic of Otolaryngology department of a tertiary referral hospital throughout the period from early 2013 to the fall of 2014. Informed consent was taken from each patient before his/her participation.

Inclusion criteria were as follows: clinically diagnosed otosclerosis with normal otoscopy, audiometry showing CHL with an air-bone gap (ABG) of at least 25 decibels (dB), type A tympanometry, speech discrimination score greater than 60%, and absent stapedial reflex.

Exclusion criteria were as follows: repeated history of middle ear infections, tympanic membrane perforation, stenotic or severely winding bony EAC, ABG of less than 25 dB, poor speech discrimination, preoperative subjective change in taste sensation, evidence of active disease (Schwartz sign), and refusal to undergo the procedure.

Operative equipment and instrumentation for endoscopic stapes surgery:

(1) Photodocumentation tower and monitor mounted on a mobile video-cart. The video monitor is placed on the upper shelf in the surgeon's direct line of vision. All surgical procedures were digitally recorded.
(2) The optic equipment used consisted of 0° and 30°rigid Karl Storz Hopkins rod telescopes with an outside diameter of 3 mm and a working length of 14 cm.
(3) Three-chip HD camera.
(4) Cold light source and fiber optic light cable.
(5) Standard instruments used in conventional middle ear surgery.

Operative procedures

Anesthesia

(1) The procedure was carried out under hypotensive general anesthesia.
(2) Local canal infiltration of xylocaine epinephrine (1 : 100 000) was performed before the surgical procedure.

Surgical steps

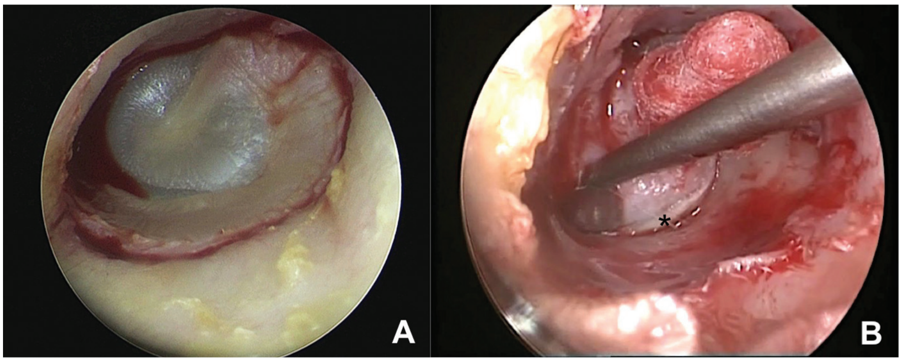
(1) The tympanomeatal flap was created under endoscopic guidance (0° or 30° lens) as an inverted U-shaped flap, in which two vertical incisions were made at 6 and 12 o'clock positions and the horizontal incision was performed at a distance of about 1–1.5 cm from the tympanic membrane. The flap was elevated with a round Rosen knife and the tympanic annulus was entirely dissected before opening the middle ear cavity (Fig. 1a and b).
(2) After raising the flap, the middle ear structures were visualized with either 0° or 30° rigid endoscope. Ossicular chain fixation was checked by palpating the malleus (Fig. 2a and b).
(3) Handling the CTN: Endoscopic stapedotomy usually spares excessive mobilization of the CTN because the angle of the CTN is sufficient for the procedure to be completed successfully. In some cases, we were in need to manipulate the CTN (displaced upward or downward) when it was present in front of the visual field, preventing adequate assessment of the OWN. In all situations the CTN was not cut.
(4) Posterosuperior bony EAC and scutum overhang were removed to visualize the OWN structures: the pyramid, stapes suprastructures, stapedius tendon, the facial nerve, and footplate of stapes. With the aid of endoscope the amount of bone overhang to be removed of the posterior canal wall was minimal (Fig. 2c and d).
(5) A control hole was drilled in the footplate of the stapes using a 0.5 mm straight perforator.
(6) Incudostapedial joint was separated with a 1 mm round knife followed by a sharp cut of the stapedial tendon using a straight microscissor (Fig. 3a).
(7) The stapes suprastructure was carefully outfractured under direct endoscopic view and

removed, leaving the footplate control hole fully exposed (Fig. 3b and c).

(8) A 0.6 mm manual microdrill or a powered low-speed microdrill was used to create the stapedotomy to fit the prosthesis (Fig. 3d).

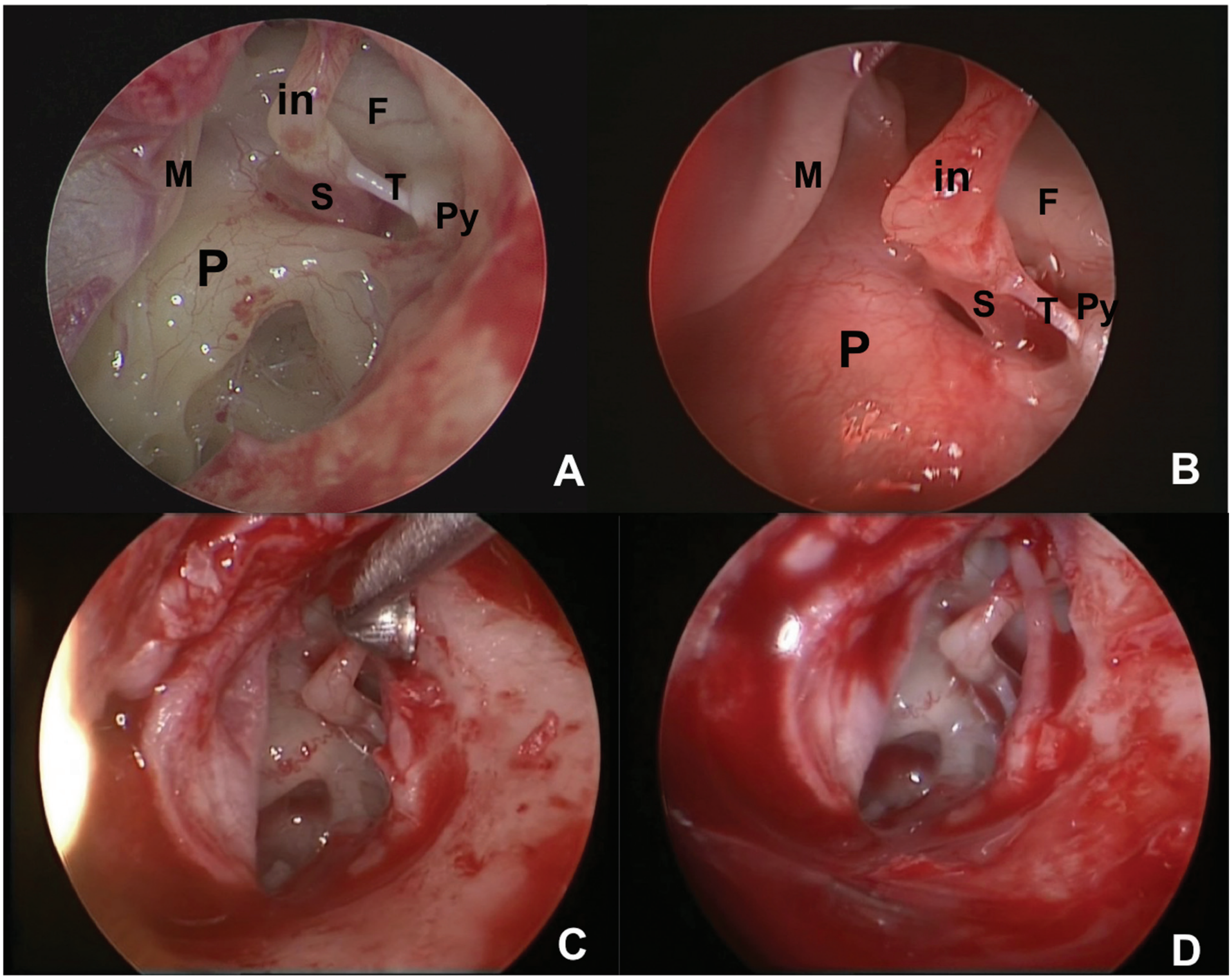
(9) Under endoscopic guidance with a 0° lens the whole Teflon prosthesis (4.5 mm×0.6 mm) was introduced into the fenestrated footplate and hanged over the long process of incus after opening its fitting point (Fig. 4).

Figure 1



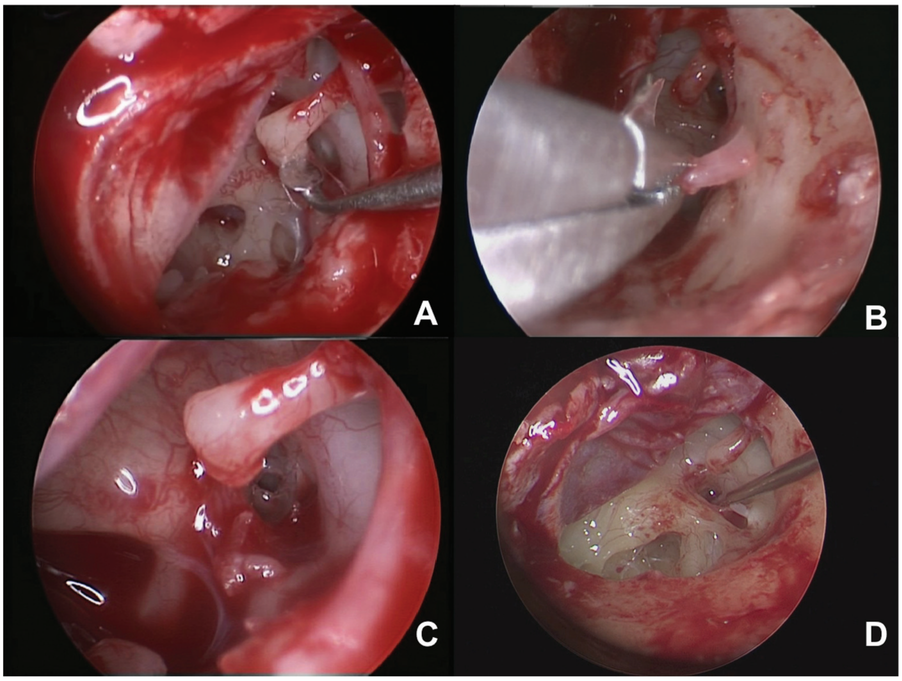
Endoscopic picture of the left ear: (a) Creation of U-shaped tympanomeatal flap. (b) Dissection of the entire tympanic annulus (*).

Figure 2



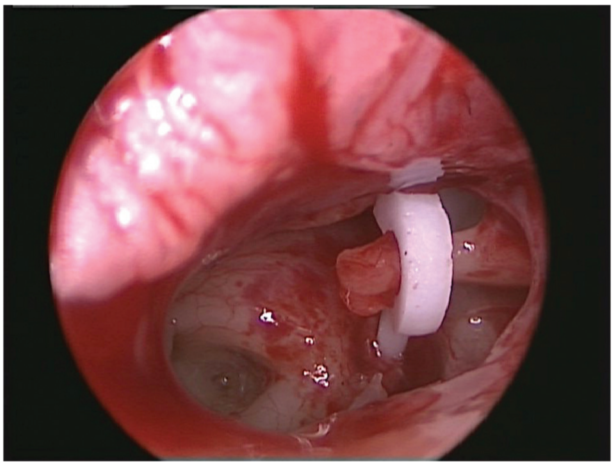
Endoscopic picture of middle ear structures: (a) with 0° lens directed to view the middle cavity from below upwards; (b) with 30° lens; (c) minimal curettage of posterosuperior external auditory canal; (d) chorda tympani nerve is freed and displaced upward. F, facial nerve; in, incus; M, malleus; P, promontory; Py, pyramid; S, stapes; T, stapedial tendon.

Figure 3



(a) Incudostapeial joint separation with 1 mm round Knife. (b) Removal of stapes suprastructures. (c) Control hole. (d) Creation of stapedotomy.

Figure 4



Whole teflon prosthesis insertion.

(10) We avoided frequent suctions, especially after opening the footplate, to avoid postoperative complications such as vertigo and cochlear damage.
(11) The malleus was palpated to ensure that the entire ossicular chain moves all the way to the prosthesis.
(12) We used either fat or blood clot to seal the footplate around the prosthesis, if needed.
(13) The tympanomeatal flap was repositioned and Gelfoam dressing soaked with antibiotic solution was placed in the external acoustic meatus, without ointments or creams.

Time of the surgical procedure

It was calculated from the time of incision to repositioning of the tympanomeatal flap in minutes.

Postoperative follow-up included the following:

(1) Weekly cleaning of the ear canal and assessment of flap healing for the first 4 weeks postoperatively.
(2) Assessment of any postoperative complications such as vertigo, tinnitus, facial palsy, and change for taste sensation.
(3) Pure-tone audiometry after 2 months.

Results

Totally endoscopic stapes surgery was performed in all 20 patients, four men and 16 women; their ages ranged from 26 to 50 years with a mean age of 33.90±6.95 years.

On analyzing the surgical endoscopic view of the OWN structures (stapes footplate, facial nerve, and pyramidal eminence) using 0° lens, we achieved ideal exposure of OWN in 10 cases without manipulating the CTN or curettage of the posterior bony canal wall. In eight (40%) patients, minimal curettage of the posterior bony canal wall and upward displacement of the CTN were performed to achieve optimal exposure of OWN structures. In the last two cases, the OWN was hardly exposed and marked curettage of the posterior bony canal wall and scutum with overstretching and downward displacement of the CTN were carried out to reach the target area to continue the surgical procedure.

We had two cases with narrow OWN up to 0.8 mm, which did not interfere with prosthesis insertion, wherein in one case (revision case) the OWN was 0.6 mm on computed tomography scan and required manual drilling of overhanging promontory covering the footplate of stapes.

There were no intraoperative complications as regards perilymphatic gusher or injury to facial nerve or excessive suction over the footplate after performing the stapedotomy. The range of the operative time was 30–70 min with a mean of 48.25 min.

Two patients who had marked manipulation of the CTN had postoperative change in taste sensation and tongue numbness, which improved within 6 months.

There was no postoperative tympanic membrane perforation, vertigo, increasing tinnitus, or facial paralysis.

As regards the audiometric data we noticed the following: the preoperative ABG ranged between 28 and 48 with a mean of 40.30±6.38, and the postoperative ABG ranged between 0 and 13 with a mean of 7.15±4.27. There was a statistically significant improvement between preoperative and postoperative ABG (P=0.001). The postoperative ABG showed complete closure in four (20%) cases, up to 10 in 12 (60%) cases, and more than 10 to less than 20 dB in four (20%) cases.

As regards hearing and the technique used, stapedotomy technique was carried out in 18 cases, of which only two cases had complete closure of postoperative ABG; the postoperative ABG was 10 dB or less in 12 cases and more than 10 to less than 20 dB in four cases. However, the two cases that underwent posterior partial stapedotomy had complete closure of their ABG.

Discussion

The era of modern stapes surgery began in 1956, when Shea successfully removed stapes and reconstructed the ossicular chain with Teflon prosthesis [10]. Since then, many modifications of the surgical procedure were described in the literature, but all surgeons carried it out through binocular microscope.

With the advancement of optical engineering, there was a revolution to use endoscopy in otology not only in diagnostic process as in the past decades but also for intervention treating procedures [11,12]. At the present time, middle ear endoscopy introduced new anatomical and physiological concepts of tympanic cavity aeration and mastoid air cell system to understand the disease and its surgical management [13–15]. Therefore, its use for chronic inflammatory diseases is rising as it provides better access and visualization of middle ear recesses in which the cholesteatoma is hidden, with reduced chances of a residual disease.

Few articles described fully endoscopic stapedotomy as the sole procedure for treating otosclerosis without operative microscopic assistance. In the current work we used rigid otoendoscope of 14 cm length and 3 mm width (0° and 30° lens). It provided excellent manipulation within the EAC and easy advancement toward the tympanic cavity with perfectly focused images, and this is in agreement with a previously published work by Migirov and Wolf[16]. Other surgeons preferred the use of sinonasal rigid endoscope of 18 cm length and 4 mm width as it is available in most peripheral hospitals and provides wide field images and better instrument handling [2,17].

In totally transcanal endoscopic stapes surgery, the surgeon holds the endoscope with the nondominant hand, which is more or less similar to holding the ear speculum in microscopic surgery. We agreed with Naik *et al.* [17] that the head of the microscope is usually tilted repeatedly to adjust the operative field, but the endoscope is easily manipulated and good images are achieved.

Following the surgical steps, the U-shaped tympanomeatal flap was easily designed at a dist ance not less than 1 cm from the tympanic membrane. This was planned to circumvent any later retraction pocket following overcurettage of the posterior canal wall and scutum. With the aid of the wide angle 0° otoendoscopes, the entire tympanic annulus was adequately visualized and elevated even if there was posterior bony canal bulging hindering the tympanic membrane visualization, and this is considered as an advantage over the classical operative microscope that has a narrow field of vision, thus decreasing the incidence of tympanic membrane perforation. In most cases undergoing stapes surgery under the microscope, the posterior bony wall of the EAC is partially removed, and this might imply some degree of CTN manipulation, or even totally damaging it. Handling the CTN in endoscopic stapes surgery depended on its length and degree of scutum and posterosuperior bony canal overhang, hindering the accessibility to OWN area. In 50% of our cases the CTN was not mobilized as there was no bony overhang to interfere the procedure; 40% (eight cases) had mild overhang that needed minimal curettage and upward displacement of the CTN instead of downward mobilization in classical microscopic surgery. For the last two cases the OWN structures were hardly seen, and hence aggressive bone curettage was performed and the CTN was dissected and mobilized from the back of the neck of malleus to be displaced downward. Under microscopic magnification the stapedial suprastructures are hardly seen, especially the anterior crus, which occasionally outfractured blindly with a high risk for stapes dislocation. In contrast, endoscopy provides better visualization of the whole stapes when the surgeon either uses 30° endoscope or tilting the 3 mm 0° endoscope at the lower part of the tympanic cavity to look upward toward the stapedial suprastructures. We punctured the footplate using 0.5 mm perforator to perform a control hole before the removal of stapedial suprastructures to avoid intraoperative complications such as fracture and floating footplate. Unfortunately, in two cases the footplate was fractured and posterior partial stapedectomy was performed. Stapedotomy was carried out using manual or low-powered microdrills with no difficulty to be performed under endoscopic guidance. Whole teflon prosthesis (4.5 mm×0.6 mm) was preferred because it is tough and resists bending if multiple insertions are needed.

On examining the audiometric results 2 months postoperatively, there was a statistically significant improvement between the preoperative (40.30±6.38) and the postoperative ABG mean value (7.15±4.27) (P=0.001). Complete closure of the ABG was achieved in four cases, two of which underwent posterior partial stapedectomy. Twelve (60%) patients showed ABG of up to 10 dB, whereas four patients had residual mild CHL less than 20 dB. These results were quite similar to that in the literature [17]. However, the audiometric results of Kojima *et al.* [18] stated that he obtained better audiometric results of the studied endoscopic group over the microscopic one, but he did not achieve complete closure in any case of the endoscopic group.

In fact, it was not in all cases that we had to curette the posterior wall of the external acoustic meatus with no or minimal manipulation of the CTN, which seems to be one of the advantages of the endoscopic technique when compared with the microscopic approach. Fifty percent of the cases did not require manipulation of the CTN; in 40% (eight cases) the CTN was mobilized upward after minimal curettage of the scutum and posterior bony wall. These 18 patients had no disturbance in taste sensation in the postoperative period. The last two cases in which the CTN was displaced downward after aggressive curettage of bony overhang developed numbness and metallic taste that resolved within 6 months. We did not face any tympanic membrane perforation or posterior superior retraction pockets due to the well-designed and adequately elevated tympanomeatal flap.

In our series we faced two cases (one of them was a revision case) with narrow OWN of 0.8 mm or less, which forced us to widen the OWN using a manual drill and perform partial stapedectomy in one of them; this did not affect improvement of the postoperative hearing. The revision case had 0.6 mm-sized OWN on preoperative computed tomography scan and prosthesis was not fitted properly. There was overhanging promontory that made the footplate of the stapes hardly seen. The overhang was drilled out and the prosthesis was inserted correctly.

There were no intraoperative facial nerve abnormalities or frozen attic and we did not face perilymphatic gusher or dislocated ossicles. The range of the operative time was 30–70 min with a mean of 48.25 min, which is quite comparable to that reported in the literature of average 31 min [17] and of 53 min [18], respectively.

No postoperative complications such as facial paralysis, severe tinnitus, sensory neural hearing loss, and persistent vertigo were encountered during the follow-up period, except temporary change in taste sensation in two cases that improved within 6 months of follow-up.

Safety tips as recommended in previous publications are as follows [2,17]: avoid accidental endoscopic movements that might endanger the ossicles or the facial nerve; avoid repeated trauma to the tympanomeatal flap in favor to decrease bleeding; and dip the tip of the endoscope in saline-soaked gauze frequently to avoid thermal injury to middle ear structures.

Otorhinolaryngologists must try to work and learn to handle both types of instruments, endoscopes and microscopes, to better understand and treat ear diseases, to increase the patient’s benefits.

Conclusion

Transcanal totally endoscopic stapes surgery is a feasible and safe technique for the surgical management of CHL associated with otosclerosis. It provides crystal clear images that could be used in teaching purpose. The wide field of vision allows better handling of tympanomeatal flap to avoid tympanic membrane perforation. There is minimal or no manipulation of the CTN, and hence it is recommended in bilateral otosclerotic patients and in revision cases. The disadvantages of this procedure are the need to increase the learning curve and lack of stereoscopic vision.

Acknowledgements

The authors acknowledge all medical and paramedical staff members of ORL H&N and Anesthesia departments who participated and helped in fulfilling this work.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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