Comparison between Endoscopic and Microscopic Stapes Surgery

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Abstract

Objectives: To investigate whether endoscopic stapes surgery is safer and less invasive than conventional stapes surgery using an operating microscope.

Study Design: Retrospective study.

Methods: The subjects were 15 patients (15 ears) who underwent endoscopic stapes surgery for otosclerosis. Another 15 patients (15 ears) in whom microscopic stapes surgery was performed by the same surgeon were assigned to the control group. The procedures for endoscopic surgery were fundamentally the same as those for microscopic surgery, unless there was no anterior or posterior auricular skin incision. The two surgical techniques were compared with respect to the operating time, postoperative hearing, complications, postoperative pain, and the extent of drilling at the posterior superior part of the external auditory canal.

Results: There were no differences of operating time or postoperative hearing between the endoscopic and microscopic groups. There was very little postoperative pain in the endoscopic group. Postoperative dizziness was mild in all patients who received endoscopic surgery. Drilling at the posterior superior part of the external auditory canal was less extensive in the endoscopic group than in the microscopic group.

Conclusion: Transcanal fully endoscopic stapedectomy is a feasible and safe technique for surgical management of hearing loss associated with otosclerosis.

Key Words: Endoscope – Stapedectomy – Otosclerosis – Microscope.

Introduction

STAPEDECTOMIES and stapedotomies are currently done in most centers in the world under the microscope [1-3]. Surgical microscopes provide a good quality amplified image in a straight line. However, such limitation inherent to the equipment limits visual field when we make exclusively transcanal access in the narrowest segment of the external ear canal. In winding canals, this may represent an even greater limitation, requiring other access pathways to the middle ear, behind the ear or modified trans-canal approaches [3,4]. Even with extended access to the middle ear, one of the important steps in performing stapes surgeries under the microscope is to partially remove the bone wall of the most medial segment of the external acoustic meatus. This important step in this surgery enables a better exposure of the incus-stapes joint, the oval window niche, pyramidal eminence and other important structures in this procedure. Nonetheless, such step requires exposure, manipulation and, in some cases, irreversible trauma of the chorda tympani nerve in order to have the best visualization of the oval window niche. Another important point to be considered during stapes surgery under the microscope is the visualization of the stapes supra-structure. Most of the times, when using a trans-canal approach under the microscope; the surgeon is unable to see the stapes anterior crus, forcing the surgeon do blindly fracture such structure. Although endoscopes were introduced in ear surgeries over 15 years ago, their role have been rather limited in the treatment of middle ear inflammatory disorders and otosclerosis [1-5]. There are many reasons for this, such as the belief of a limited and marginal role endoscopes play in middle ear surgery, instrument limitation, and a potentially long learning curve in order to get used to single-handed work and the lack of a stereoscopic view [2,3]. There already are some reports concerning the use of endoscopes in ear surgeries, including stapes surgery; however, the all discuss the use of otological endoscopes, 3mm in diameter and 10cm in length. Due to its limited diameter, these endoscopes have a very restricted visual field, differently from the regular endoscopes used in sinonasal surgeries [2-4]. Sinonasal scopes with 4mm in diameter and 18cm in length, with wide-angle lens and different angles, allow for an amplified image which can be
quickly modified by advancing or pulling the instrument back [2]. And, differently from the shorter otologic endoscopes, these longer instruments provide a larger field for working with one’s hands, since the hand holding the endoscope does not interfere with the other hand holding the surgical instruments. Since the introduction of stapes surgery by Shea in 1956, numerous modifications of the classical stapes operation have been described in medical literature. However although endoscope-assisted stapedotomy was first described by Poe in 2000 [6], there are only a few published articles in the literature regarding the endoscopic stapedectomy [7].

The goals of the present study are:
A- To assess the possibility of using 4mm and 18cm endoscopes in fully endoscopic stapes surgeries.
B- To show the preliminary results, assessing the possible pros and cons of using these instruments.

Material and Methods

The study was done at Hearing and Speech Institute, Imbaba from Jun. 2012 to Jun. 2015.

Ethical considerations:

Institutional ethical clearance was taken prior to conduction of this study. The patients were explained that there were chances of failure of this new technique. Patients not agreeing after explanation were not operated endoscopically and thus excluded from the study. An informed written consent was taken from all the patients who agreed to undergo operation by this new technique.

Patients selection:

Inclusion criteria: Hearing impairment (without any history of middle ear infection), normal otoscopic findings, pure tone audiometry showing conductive hearing loss with an AB gap=30 dB, normal bone-conduction threshold at 500,1000, 1500 and 2000 Hertz (Hz), stapedius reflex absent, and normal temporal bone CT Scan

Exclusion criteria: Patients not fulfilling one of the inclusion criteria or requiring a revision surgery or surgery on the only hearing ear.

All surgical procedures were digitally recorded. Some anatomical situations were assessed in the post-operative from the surgery videos, as follows:
A- Oval window niche exposure.
B- Need to manipulate the chorda tympani nerve.
C- Visibility of the stapes crura (especially the anterior crus).

Instruments:

For endoscopic surgery, a high definition monitor and a camera head manufactured by Karl Storz were used together with a 4-mm, wide-range, 18cm rigid Sino-nasal endoscope with 0 degrees of angulation. Standard ear surgery instruments were used, as well as tailor-made slightly curved suction tubes, gouges, and round knives. The monitor was positioned in front of the surgeon, Fig. (1). an operating microscope was also set out before the operation so that the endoscopic procedure could be immediately switched to microscopic surgery if necessary.

Parameters investigated:

The parameters investigated were the operating time, postoperative hearing, intraoperative and postoperative complications, postoperative pain, postoperative dizziness, and extent of drilling at the poster superior part of the external auditory canal. Hearing was assessed at 2 to 7 months after surgery in the endoscopic group and at 6 months to 1 year after surgery in the microscopic group. As intraoperative and postoperative complications, the incidence of floating footplate, facial paralysis, and chorda tympani injury were compared between the two groups. In the endoscopic group each patient was questioned about the severity of postoperative pain at approximately 6 hours after surgery. The severity was recorded using three grades almost no pain, mild pain requiring no analgesics, and pain requiring analgesics. The severity of postoperative dizziness was compared as well as the duration of dizziness (number of days).

Surgical technique:

In both groups, all patients underwent stapes surgery under general anesthesia. The external auditory canal was infiltrated with 1% lignocaine containing 1/200,000 epinephrine. There were no differences of the surgical procedures between the two groups. Briefly, a relatively large tympanomeatal flap was created in the poster superior part of the external auditory canal. Then, while preserving the chorda tympani, the bone wall in the poster superior part of the external auditory canal was removed by curette until the pyramidal eminence and the horizontal part of the facial nerve came into view, Fig. (2). After mobility of the stapes was confirmed, the distance from the footplate to the long limb of the incus was measured. In all the cases we used a Teflon prosthesis (0.6mm in diameter and 6mm in length), which was made from the length measured between the footplate and the
medial surface of the incus's long process. After this measurement, which is usually 4.5mm, we cut the prosthesis using the surgical ruler (scaled in millimeters) and the #1 1 scalpel blade. At this step, the endoscope was positioned outside of the surgical field. After cutting, the endoscope was repositioned in the surgical field, and a small, 0.6mm in diameter, hole was punched in the posterior portion of the stapes footplate, with a small 0.6mm tip perforating instrument. The prosthesis was placed in this hole and fit along the long process of the incus subsequently, the incudostapedial joint was removed using a pick, the stapedius tendon was severed, and the superstructure of the stapes was removed. We avoided frequent suctions, especially after opening the footplate, in order to avoid post-op complications, such as vertigo and cochlear damage. The malleus was palpated in order to rule out head fixation and make sure the entire ossicular chain moves all the way to the prosthesis, Fig. (3). In order to seal the footplate, we used small pieces of dry Gelfoam®, placed with the micro scissors. Following that, the tympanic-meatal flap was repositioned and we then inserted Gelfoam® dressing in the external acoustic meatus, without ointments or creams.

Results

There were 30 patients in the study group between July 2011 and June 2014 divided into two group each consist from 15 patients, Group A done by microscope, Group B done by endoscope. Male/female ratio was 17/13. The mean age of the patients was 37±10 (range 22-45) years. The mean follow-up period was 13 months (range 4-27 months).

Surgical procedure:

Stapedectomy performed using endoscope and microscope was compared. The operating surgeon was the same person. 15 cases of endoscopic stapedectomy were used for comparison with microscope used stapedectomy. Comparison was made actually during each step of the procedure. All these cases were performed under general anesthesia. All these surgeries were performed via endomeatal approach.

Elevation of tympanomeatal flap:

Microscope: Elevation of tympanomeatal flap was easy. In one patient who had a large posterior bony overhang elevation was found difficult. Angulation of objective had to be changed for visualizing the area.

Endoscope: Elevation of tympanomeatal flap was fairly simple. Image resolution was excellent. With minimal manipulation of endoscope the entire area of tympanic membrane could be clearly seen. Bony overhang area could be clearly seen without any problem.

Handling chorda tympani nerve:

Too short chorda tympani [8] will cause problems during curretage because of inadequate operating angle. It should hence be mobilised adequately by dissecting the mucosal fold covering it. In patients with a short chorda tympani nerve curretting the bony overhang would free up some more of the nerve. Overzealous curretage could cause permanent problems like postero superior retraction pockets. This is where the use of endoscope helps. Endoscopic stapedectomy vitates the necessity of excessive mobilisation of chorda tympani nerve. The angle of the chorda being sufficient for the procedure to be completed successfully. This could be a problem if microscope is used.

Removal of bony overhang:

Microscope:

Ideally adequate amount of bone from the posterosuperior portion of posterior canal wall should
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be removed. The amount of bone removal should be just enough to expose the pyramid, and entire suprastructure of stapes. If the chorda tympani nerve is short, the angle which is available for curettage is reduced. This could cause injury to the nerve while operating with a microscope. Too liberal removal of bony overhang can cause retraction pocket/small perforation of ear drum in that area. While using the microscope the angle of objective had to be changed two/three times for adequate visualization of suprastructure of stapes.

**Endoscope:**

When endoscope is used the amount of bony overhang to be removed need not be too aggressive. By just tilting the endoscope the suprastructure of the foot plate can be easily visualized. Endoscope offered the best help during this stage of the entire procedure. Stages of cutting the stapedial tendon, dislocation of incudo stapedial joint and fracture of the crura can easily be performed both under microscopic/endoscopic vision with ease.

**Fenestration of foot plate and insertion of prosthesis:**

This step is the most crucial and difficult part of the entire surgery. When microscope is used both hands of the surgeon are free and facilitate better insertion technique. With more and more otolaryngologists adept at doing endoscopic sinus surgeries, they easily adapt to one hand technique which needs to be followed if endoscope is used.

**Operating time:**

When the operating time was compared between the microscopic group (15 ears) and the endoscopic group (15 ears), the mean operating time was 50.1 and 63.0 minutes, respectively, showing no significant difference between the two groups (t-test).

**Postoperative hearing:**

In the microscopic group, the mean ABG (500, 1000, 1500 and 2000Hz) preoperatively was 41.5±5.2dB. Three months after surgery, the mean ABG (with postop BC) at frequencies 500, 1000, 1500 and 2000Hz was 10.1±3.6dB and the mean ABG (with preop BC) was 10.3±3.5dB. The difference between the preoperative mean ABG and the postoperative mean ABG (with preop and postop BC) was found to be statistically significant (p<0.05). The mean change in average preoperative and postoperative BC is 0.1±0.7dB, with 93.3% having better BC postoperatively and 6.3% worse. In the endoscopic group, preoperative and postoperative average Air Conduction thresholds (AC) were 39.0±6.2dB and 11.5±5.9dB respectively (p=0.000).

**Postoperative complications:**

Intraoperative complication was observed in 1 patient. Malleus was detached from incus accidentally in one patient. Malleus was reattached to incus by using bone cement. Although, ossicular system was reconstructed in this patient, average postoperative ABG was improved to 18dB compared with preoperative 33dB average ABG. In the endoscopic group none of the patients developed postoperative dysgeusia due to chorda tympani injury. In the microscopic group the chorda tympani was not severed in any of the patients. However, transient abnormal taste sensation that was presumably due to intraoperative chorda tympani traction occurred in four of the 15 patients.

**Postoperative pain:**

When asked about the severity of postoperative pain, it was respectively rated as “almost no pain” or as “mild pain requiring no analgesics” in 14 and one of the 15 patients from the endoscopic group. Thus, there was little postoperative pain in the endoscopic group. Four patients underwent bilateral surgery, with a microscopic procedure for one ear and endoscopic surgery for the other. All of them answered that they had suffered from irritating pain for 2 to 3 days after microscopic surgery, which was performed via an incision at the anterior border of the ear but had no pain after endoscopic surgery.

**Postoperative dizziness:**

Postoperative dizziness was mild in all patients who received endoscopic surgery. The duration of dizziness after endoscopic surgery was 1 day (the day of surgery) in 12 patients and 2 days (until the next day) in three patients. It was not 3 days or more in any patient. Yet the duration of dizziness after microscopic surgery was 1 day in 13 patients, 2 days in one patient, and 3 days in one patient.

**Discussion**

Ear surgery is usually performed with both hands under an operating microscope. However, endoscopes have been used for observation and
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Treatment of conditions in the tympanic sinus and periossicular areas because these areas may be hard to visualize completely under the microscope [3,9-11]. Particularly for the treatment of cholesteatoma, we have actively employed an endoscope combined with a microscope to minimize drilling, thereby preserving both hearing and the facial nerve [12]. However, this is “endoscopy-assisted surgery” in which the operating microscope plays the leading role. Thanks to various innovations in endoscopes and instruments, reports have been published in recent years about pure “endoscopic ear surgery” in which all procedures are performed with an endoscope [5,13-15]. Yet, few reports from Western countries have been published concerning stapes surgery that is entirely performed by endoscopy, presumably because stapes surgery is usually done by the endaural approach and there is less need for endoscopic procedures [7]. Endoscopic stapes surgery has the following advantages: (1) A good view of the operating field can be obtained easily by endoscopy in patients for whom microscopic surgery via the endaural approach is difficult because they often have a narrow and curved external auditory canal. Microscopic stapes surgery is performed at some institutions, but its advantages are limited because the otoscope has to be held with the left hand; thus, surgical manipulation can only be done with one hand. In addition, during endoscopy very fine structures can be observed if the endoscope is brought close enough, while overall relations can be accurately assessed if it is pulled back slightly. (2) Endoscopic surgery is better for education. Since the monitor can be viewed by both the surgeon and assistants, the surgical anatomy and procedure can be understood more easily. (3) It is noteworthy that there was no auricular numbness and little pain after endoscopic surgery. This emphasizes the usefulness of endoscopic surgery that is performed via an endaural incision, as was also suggested by the impressions of patients who underwent surgery by different methods on each ear. (4) Drilling at the posterosuperior part of the external auditory canal can be minimized by performing endoscopic surgery. This may also be related to better postoperative wound healing. Nogueira [7] minimized the extent of drilling by using a 30-degree endoscope and completed surgery without drilling in some cases. We performed minimal drilling to allow treatment with a 0-degree endoscope. We also planned for endoscopic surgery if unexpected adverse events occurred. Endoscopic stapes surgery also has some disadvantages: (1) Manipulation with one hand is problematic. However, bleeding is limited and aspiration should be minimized after fenestration during stapes surgery, so there is little need to use an aspiration tube held by the left hand and surgery can be completed with the right hand alone. (2) Stereoscopic vision cannot be obtained because the monitor is two-dimensional. Stereoscopic vision is generally considered to be necessary for perceiving subtle differences of depth when cutting the stapedial limb or tightening the wire. However, by performing this procedure several times, a surgeon can become accustomed to the manipulations required and the lack of stereoscopic vision eventually becomes unimportant. (3) Appropriate measures should be taken to prepare for unexpected complications during endoscopic surgery. The most common problem may be a floating footplate. However, its incidence is probably not different between microscopic and endoscopic surgery because there are no procedural differences between the two techniques. To avoid a floating footplate fenestration is performed first at our institution and then the superstructure of the stapes is removed after inserting the wire piston. Therefore, even if floating footplate occurs, it will probably only be partial (limited to the anterior or posterior half of the footplate). If a floating footplate occurs despite such preventive measures, it is necessary to perform total stapedectomy. This can be done endoscopically, but it may be performed more safely and securely under the operating microscope. Although we have never encountered a floating footplate that required total stapedectomy, keeping such a risk in mind, we are always ready to immediately switch to the operating microscope and are also ready to close the oval window by using gelatin sponge soaked in physiological saline. If continuation of endoscopic surgery is considered difficult because of complications, we should switch to the operating microscope without hesitation to ensure safety. Comparison of the operating time showed no difference between endoscopic surgery and conventional surgery under the operating microscope. Considering that endoscopic surgery was introduced recently before the present study, the operating time will become shorter with improvement of the surgical technique in the future. Postoperative hearing was satisfactory in both groups, showing no difference between the two surgical methods. In the endoscopic surgery group, postoperative dizziness did not persist for 3 days or more in any of the patients and was mild in all patients. This was presumably because the procedure for the fenestration of the stapedial footplate was gentler. In the present series, intraoperative complication was observed in 1 patient. Malleus was detached from incus accidentally in one patient.
Malleus was reattached to incus by using bone cement. Although, ossicular system was reconstructed in this patient, average postoperative ABG was improved to 18dB compared with preoperative 33dB average ABG. In the endoscopic group none of the patients developed postoperative dysgeusia due to chorda tympani injury. In the microscopic group the chorda tympani was not severed in any of the patients. However, transient abnormal taste sensation that was presumably due to intraoperative chorda tympani traction occurred in four of the 15 patients. No other complications occurred. The chorda tympani were preserved in all patients, and there were no cases of dysgeusia. With endoscopic surgery there are no blind spots, even if there is an overhanging posterior wall of the external auditory canal, and the chorda tympani can easily be identified. Therefore, endoscopic stapes surgery may be superior for surgical intervention on the chorda tympani. In the present study endoscopic surgery was found to be safe based on the incidence of complications, although we investigated a limited number of patients. However, stapes surgery is difficult and complications can lead to serious sensorineural hearing impairment. With endoscopic stapes surgery, handling of an endoscope is required, so the operation is done with one hand. Therefore, it should not be performed by surgeons without adequate experience of both ear surgery and endoscopic surgery at other sites, such as endoscopic intranasal surgery.

First endoscopic stapedectomy procedure was published by Poe in 2000 and several papers were published since that time [5,7,16,18]. These early publications have promising results. Nogueira et al. [7] published early results of 15 endoscopic stapedectomy procedures in 2011. They reported improvement of hearing threshold in 14 of 15 patients. Sarkar et al. [17] published their results of endoscopic stapedectomy surgeries in 2013. They have 32 patients. They reported that they shifted to microscopic surgery in 2 patients due to perilymph gusher. This is a good example for showing the limitation of endoscopic stapedectomy surgery. Every surgeon should recognize and keep in mind that; endoscope does not replace the need for microscope in surgery. Therefore microscope should be available in the operating room in every endoscopic ear surgery. Surgeons should not hesitate to shift the microscopic surgery when needed.

Migirov and Volf [16] reported another advantage of endoscopic stapedectomy. Their study focused to preservation of Chorda Tympani Nerve (CTN) during the stapedectomy. They achieved to preserve CTN in all 8 endoscopic stapedectomy procedures. This is really important because chorda tympani damage may occur in 30% of cases in conventional microscopic stapedectomy procedure. It is more common if the bony canal in the posterior quadrant is removed using a drill rather than a curette [19]. Unfortunately, our study didn't focus on CTN preservation. Our observation is that; possibility of anatomical preservation of CTN is much higher in endoscopic stapedectomy comparing with microscopic surgery.

Recently, Kojima et al., compared endoscopic versus microscopic stapedectomy procedure [18]. Their study group involved 15 years in endoscopic stapedectomy group and 41 years in microscopic stapedectomy group. They reported that there were no differences of operating time or postoperative hearing between the endoscopic and microscopic groups. There was very little postoperative pain in the endoscopic group. Postoperative dizziness was mild in all patients who underwent endoscopic surgery. Drilling at the posteriorsecondary part of the external auditory canal was less extensive in the endoscopic group than in the microscopic group. They concluded that endoscopic surgery is particularly suitable for stapedial disease. Endoscopic stapes surgery can even be done in patients with a curved and narrow external auditory canal. Over the last 20 years, the number of stapes operations performed has decreased steadily. Possible reasons for the reduction could be the fluoridation of water supplies and improvement of the quality of hearing aids. Yung et al., investigated the learning curve in stapes surgery and its implication to training. They reported that only 900 stapedectomies were performed in England and Wales in year 2000 [20]. In their study, it took at least 60 to 80 cases for two different authors to reach a landmark point in their learning curves. Therefore as the number of practicing otolaryngologists steadily increases, it is inevitable that fewer cases of otosclerosis present to each surgeon. Endoscopic stapedectomy procedure can also facilitate the learning curve of surgical technique and anatomy for trainees. Since both the surgeon and assistants can view the monitor, the surgical anatomy and procedure can be understood more easily [18]. Although no SNHL was reported by previous limited number of endoscopic stapedectomy reports, we observed 2 SNHL in our series. Hopefully these are not total hearing loss. SNHL is the scariest complication of otosclerosis surgery. The cause is usually unknown and the incidence ranges from 0.6% to 3% in microscopic surgery [19]. The most common cause of permanent hearing loss is surgical trauma. We couldn't identify any reason for the occurrence of SNHL in these 2 patients. There was no recognized surgical trauma.
We can speculate that heating effect of light source could be a possible cause for inner ear trauma. Kozin et al., [20] demonstrated the heating effect of light source during the endoscopic procedures experimentally previously. Several authors also mentioned this potential side effect in their publications. However, there is no clinical evidence to support this potential harmful side effect [21]. Otosclerosis surgery is somewhat different from the other endoscopic middle ear surgeries. Frenestration of the oval window results with the direct exposure of inner ear structures to heating effect of light source. Therefore exposure time can be a determining factor for the development of SNHL. We can advise that; light source power should be adjusted to the lowest settings that allow adequate visualization. In addition, surgeon should remove the endoscope from ear frequently and should clean the tip of the endoscope with antifog solution, which will help in cooling the endoscope [22].

We have also one complication during the intraoperative period. Malleus-incus detachment was occurred in this patient accidentally. Although we reattached the malleus to incus by using bone cement, 18dB ABG was remained in this patient. Endoscopic ear surgery has a monocular vision; therefore adaptation to depth sensation requires experience. We have accomplished to finalize all surgeries endoscopically. But operating microscope was in the operating room and was ready to use when needed in all cases.

Conclusion:
Endoscopic surgery is particularly suitable for stapedial disease. Endoscopic stapes surgery can even be done in patients with a curved and narrow external auditory canal. Endoscopic surgery is also suitable for education: The surgical anatomy can be understood easily and both the surgeon and assistants can observe the procedure on the same monitor. However, it should only be performed by experienced surgeons because one-handed manipulation is required and Stereoscopic vision is not available.

References
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