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Original Article

Endoscopic vs Microscopic Approach in Stapes Surgery: Advantages in the Middle Ear Structures Visualization and Trainee's Point of View

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OBJECTIVE: Comparing the endoscopic and microscopic approaches in stapes surgery, and establishing the surgical approach that allows better results in terms of visualization of the middle ear structures and aids assistant's training.

MATERIALS and METHODS: Twenty-one residents from the first to the fifth year of training in Otolaryngology were enrolled in this prospective study. A questionnaire specifically designed to investigate the understanding of middle ear anatomy, the surgical steps, and a personal opinion about endoscopic stapes surgery was submitted to each resident.

RESULTS: Statistical differences between the endoscopic and microscopic approaches were evident about identification of stapes and long process of the incus (p=0.03) and stapes footplate and the oval window (p=0.03). No substantial difference between the two surgical approaches emerged regarding the visualization of the tympanic membrane and the other middle ear structures (p>0.5). A substantial difference in favor of the endoscopic approach emerged regarding the identification of the hole creation in the footplate of the stapes.

CONCLUSION: Endoscopic stapes surgery could favor an easier understanding of the surgical technique for assistants in training with little knowledge of the anatomy and surgical steps.

KEYWORDS: Surgical education, stapes surgery, otosclerosis, endoscopic stapes surgery, middle ear

INTRODUCTION

Today endoscopic surgery is becoming more frequently used in middle ear surgery. This surgical technique is suitable for chronic otitis media, malformations of the auditory ossicles, traumatic damage to the ossicles, cholesteatomatous otitis media, otoslcerosis, and other diseases [1-6]. Similarly, the number of papers reporting the advantages of endoscopic middle ear visualization has also been increasing in the last years [6-9]. Despite improvements, especially in terms of lighting and magnification, microscopes have defined lines of sight and are constrained by the anatomy of the external auditory canal leading to areas within the surgical field that are difficult, if not impossible, to visualize [9-12]. With endoscopes, the line of sight can be moved closer to the surgical field, allowing more complete surveillance. In addition, endoscopes allow visualization around structures, which is not possible with a conventional microscope and is greatly augmented with angled endoscopes [6, 13-16]. Accordingly, an increasing number of ear-surgeons nowadays considers otosclerosis to be a suitable disease for endoscopic stapes surgery due to the fact that the endoscopic approach offers excellent visualization of middle ear structures and recesses, mainly the oval window niche, stapes anterior crus, and its suprastructure [5, 6, 17-19]. However, few comparative studies between endoscope and microscope regarding visualization and resolution of middle ear structures in stapes surgery have been reported [5, 6, 20].

During the last year, we observed that in our university center resident assistants were especially interested in endoscopic stapes surgery. They explained this interest by the observation that the endoscopic approach offered an advanced visualization of the surgical field and middle ear structures, with a better understanding of middle ear anatomy and surgical steps achieved by expert surgeons.

Is it therefore possible that the endoscopic approach could have a superior value in the surgical education of assistants in training?

To answer at this question, we issued to a group of trainee residents a questionnaire specifically designed to compare the endoscopic and microscopic approaches in stapes surgery. The aim of this study was to evaluate the following: 1) the advances offered

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by the endoscope in terms of visualization of the middle ear structures and recesses; 2) the surgical approach of the two that allows better results in terms of assistant's training in stapes surgery.

MATERIALS and METHODS

Twenty-one resident from the first to the fifth year of training in Otolaryngology were enrolled in this prospective study. Medical students, interns, and consultants were excluded from the study. Exclusive endoscopic stapes surgery was introduced in our Institute 2 years ago and similar audiological results have been reported for the two approaches [6].

Forty patients with the diagnosis of otosclerosis were surgical treated; 20 patients underwent an exclusive endoscopic stapes surgery and the other 20 patients underwent exclusive microscopic surgery.

Each of the residents attended at two stapedotomies, the first performed by an exclusive microscopic approach and the second, immediately after in the same daily operative session, performed by an exclusive endoscopic approach. The two patients assigned to each resident, one of whom underwent a microscopic and the other an endoscopic stapes surgery, were preoperatively selected on the basis of gender, age, size of external auditory canal, and angulation of the tympanic membrane to minimize possible middle ear differences that could have influenced the trainee's level of understanding. In this way, each assistant could compare the same surgical procedure performed in two different patients (with similar characteristics) using two different approaches (microscopic or exclusive endoscopic).

Both procedures were performed by the same surgeon (G.M.) in order to exclude the influence of varying surgical abilities of multiple surgeons on the trainee's opinion.

Specific questionnaires structured to evaluate the understanding of middle ear anatomy and surgical steps of stapes surgery were submitted to each assistant at the end of the microscopic stapes surgery and the at the end of the endoscopic stapes surgery.

A third questionnaire specifically designed to compare the endoscopic and microscopic approach in stapes surgery was submitted to each of the assistants just after the end of the operative session.

This research study was performed in accordance with the principles of the Declaration of Helsinki and approved by our local Ethics Committee. An informed consent of patients and resident assistants was taken. The study was performed in accordance with all the guidelines for experimental investigation with human subjects required by our Institute

Instruments

For endoscopic stapes surgery, rigid endoscopes angled at 0° and 30° angles with a length of 14 cm and an outer diameter of 3 mm and 4 mm (Olympus, Germany) were used, connected to a camera head (Stroz, Germany) and a high-definition monitor. The monitor was positioned in front of the surgeon and his assistant. Standard stapes surgery instruments were used.

For microscopic surgery, a high-performance surgical microscope (Leica M525 F50) was used, connected to the same high-definition monitor.

Surgical Procedures

Reversal stapes surgery as proposed by Fisch [21] was performed in all surgical procedures both endoscopic and microscopic. According to his method, dislocation of the incus, luxation, and fracture of the footplate are avoided by performing the footplate hole and fixing the prosthesis to the incus before removing the stapes superstructure [21-23].

All surgical procedures were performed under general anesthesia. Stapes surgery steps were the same as those proposed by Fisch [21] and reported in our previous study regarding endoscopic stapes surgery [6].

In both groups, the external auditory canal was infiltrated with anesthetic (1% lidocaine), and in the microscopic group, an endaural skin incision was made. Otherwise, there were no differences in the surgical procedures between the two groups.

Questionnaire

All the questions were written by the same surgeon (G.M.), who has experience in both endoscopic and microscopic surgery. Each questionnaire was filled in anonymously by the assistants and the results analyzed by another author (G.I.) using the blinded method.

Part I of the questionnaire (Table 1) was structured to evaluate the understanding of middle ear anatomy and surgical steps of stapes surgery as described by Fisch [21]. For each question, residents were asked to answer whether they had achieved total, partial, or no understanding. "Partial" corresponded to an uncertain or not total identification of the middle ear structures. Part II (Table 2), on the other hand, was designed to indicate the advantages and disadvantages of each surgical technique for inexpert surgeons. In this case, the assistants were asked to answer as follows: yes, no, or I do not know.

An initially descriptive analysis of part I and II of the questionnaire was carried out. Data regarding the level of understanding of middle ear anatomy and surgical steps (part I of the questionnaire) were also analyzed in the form of a point-scale questionnaire. When assistants reported a "total" understanding, a score of 2 points was assigned to the question, to a reply of "partial" or "no" understanding, a score of 1 points and 0 point was assigned, respectively. The response score for the understanding of middle ear anatomy and surgical steps of stapes surgery ranged between 0 and 8 points and 0 and 14 points, respectively. For the comparison of the questionnaire data between endoscopic and microscopic approaches, the Student's t test were used (SAS, JMP8 version - SAS Institute, Cary, NC). The chi-square test was employed to compare the two surgical approaches regarding the different surgical steps. A p value of <0.05 was taken as the threshold of statistical significance.

RESULTS

Characteristics of the Study Group

The residents who participated in the study were 12 women and 9 men. Five assistants (23.8%) were in their first year of training. The other four assistants (19%) were in their second, third, fourth, and fifth year of training. Previous endoscopic ear surgery experience was reported as <10 cases in 33.3% of participants, 10 to 30 cases in 50%, and >30 cases in 16.7%.

Table 1. Questionnaire for residents in training (Part I). Understanding of middle ear anatomy and surgical steps of stapes surgery

Part I	Endoscopic approach			Microscopic approach			
Identification of middle ear structures	**No**	**Partial**	**Total**	**No**	**Partial**	**Total**	**p**
Have you identified the tympanic membrane?	-	-	21 (100%)	0	0	21 (100%)	-
Have you identified the stapes and the long limb of the incus and the incudostapedial joint?	-	-	21 (100%)	0	4 (19%)	17 (80.9%)	0.03
Have you identified the footplate of stapes and the oval window?	0	6 (28.5%)	15 (71.4%)	1 (4.7%)	12 (57.1%)	8 (38%)	0.03
Have you identified the other middle ear anatomical structures? (promontory, facial nerve, and tendon of the stapedius muscle)	0	13 (61.9%)	8 (38%)	3 (14.2%)	9 (42.8%)	9 (42.8%)	0.75
Understanding of the surgical steps	**No**	**Partial**	**Total**	**No**	**Partial**	**Total**	
Creation of the tympanomeatal flap	-	-	21 (100%)	-	-	21 (100%)	-
Access to the middle ear and preservation of the chorda tympani	-	-	21 (100%)	-	-	21 (100%)	-
Curettage of the bone wall in the posterosuperior part of the external auditory canal (if necessary)	-	-	21 (100%)	-	-	21 (100%)	-
Confirmation of stapes hypomobility, measurement of the distance from the footplate to the long limb of the incus and small hole creation in the footplate of stapes using 0.4 mm, 0.5mm, and 0.6 mm perforators, respectively, one after the other.	-	3 (14.3%)	18 (85.7%)	-	9 (42.8%)	12 (57.1%)	0.04
Insertion of a 0.4-mm self-crimping superelastic nitinol prosthesis in the footplate hole, and fixation of the self-crimping band-shaped loop to the long limb of the incus	-	2 (9.5%)	19 (90.5%)	-	6 (28.5%)	15 (71.4%)	0.1
Removal of the incudostapedial joint using a pick, severance of the stapedius tendon, and removal of the stapes superstructure	-	2 (9.5%)	19 (90.5%)	1 (4.7%)	4 (19%)	16 (76.1%)	0.2
Repositioning of the tympanic membrane and tympanomeatal flap to its original position	-	-	21 (100%)	-	-	21 (100%)	-

Significant information marked in bold. p value has been calculated between "total" identification and overall "partial" and "no" identification of the two different surgical approaches.

Table 2. Endoscopic vs microscopic approach, trainee's point of view

Number of questions		Yes	No	I do not know
1	Did you identify the middle ear structures better in the endoscopic approach that in microscopic approach?	20 (95.2%)	1 (4.8%)	-
2	Do you think that the endoscope provides a better magnification and view of the entire surgical field?	20 (95.2%)	-	1 (4.8%)
3	Did you identify the different surgical steps and technique better in the endoscopic approach that in microscopic approach?	18 (85.7%)	2 (9.5%)	1 (4.8%)
4	Do you think that the endoscope is better than the microscope for education purposes?	21 (100%)	-	-
5	Do you think that endoscopic surgery is more difficult to perform than microscopic surgery?	9 (42.8%)	4 (19%)	8 (38%)
6	Do you think that the one-handed surgery of endoscopy is a disadvantage compared to the microscopic approach?	15 (71.4%)	5 (23.8%)	1 (4.8%)
7	Do you think that the operative times could influence the choice of the surgical approach?	13 (61.9%)	4 (19%)	4 (19%)
8	Do you think that the learning curve of endoscopic surgery is longer and more difficult than microscopic surgery?	4 (19%)	10 (47.6%)	7 (33.3%)
9	Considering the advantages and disadvantages of endoscopy would you choose this surgical approach in your training?	18 (85.7%)	1 (4.8%)	2 (9.5%)

Understanding of Middle Ear Anatomy and Surgical Steps of Stapes Surgery

The differences between endoscopic and microscopic approach in terms of understanding of middle ear structures in stapes surgery are shown in Table 1.

All residents totally recognized the stapes, long process of the incus, and incudostapedial joint through the endoscopic approach, while 80.9% reported a "total" identification of these middle ear structures during the microscopic approach. According to these data, a "total" identification of the stapes footplate and the oval window was

Table 3. Understanding of middle ear anatomy and surgical steps of stapes surgery; Point-scale questionnaire

Questionnaire part I	Endoscopic approach Score of response (average value)	Microscopic approach Score of response (average value)	Statistical difference Between microscopic and endoscopic approach p
Middle ear structures visualization (range 0–8 points)	7.1 Range 6–8 points SD 0.79	6.2 Range 4–8 points SD 1.40	0.009
Stapes surgery: surgical steps (range 0–14 points)	13.6 Range 12–14 points SD 0.86	12.8 Range 11–14 points SD 1.39	0.039
Total score of questionnaire part I (range 0–22 points)	20.7 Range 17–22 points SD 1.62	19 Range 15–22 points SD 2.5	0.017

SD: standard deviation

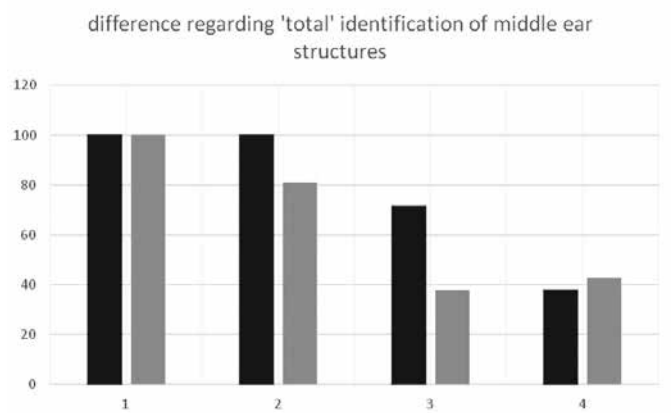

Figure 1. Black column: identification during endoscopic approach. Grey column: identification during microscopic approach. 1, identification of the tympanic membrane; 2, identification of the stapes and the long limb of the incus; 3, identification of the footplate of stapes and the oval window; and 4, identification of the other middle ear anatomical structures.

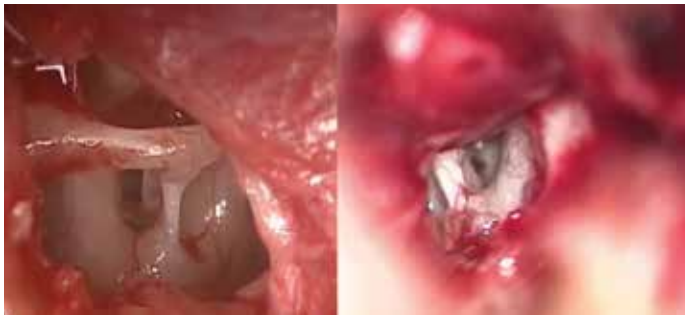

Figure 2. Different views at the operative monitor between endoscopic and microscopic approach.

achieved by 71.4% of residents during the endoscopic approach, whereas only 38% of them reported a "total" identification of these structures in the microscopic approach. Statistical differences between the endoscopic and microscopic approaches were evident with regard to the identification of stapes and long process of the incus (p=0.03) and stapes footplate and the oval window (p=0.03).

No significant difference between the two surgical approaches emerged regarding the visualization of the tympanic membrane and the other middle ear structures (p>0.5 or not calculable) (Figure 1).

Regarding the surgical steps of stapedotomy as described by Fisch [21] (Table 2), significant differences in favor of the endoscopic approach emerged regarding the "total" identification of the hole creation in the footplate of the stapes (85.7% vs 57.1%, p=0.04). Regarding the insertion of a 0.4-mm self-crimping superelastic nitinol prosthesis in the footplate hole, despite a different percentage of identification between the two approaches (90.5% vs 71.4%), no statistical difference was present (p=0.01).

Point-Scale Questionnaire

Comparative data between the endoscopic and microscopic approaches using the point-scale questionnaire are reported in Table 3. A statistical difference between the microscopic and endoscopic approaches was observed both in the grade of identification of the middle ear structures (p=0.009) and in the level of understanding of the surgical steps (p=0.039).

Interesting data emerged by analyzing the questionnaire score obtained by residents at different years of training. Statistical differences in the total questionnaire score between the microscopic and endoscopic approaches were present in the first, second, and third year of training (p<0.05). The residents in their last two year of training did not describe significant differences between endoscopy and microscopy in the investigated parameters (p>0.05).

These data confirm that it is easier for less experienced surgeons or trainees to recognize the anatomical structures and surgical steps using an endoscopic view.

Endoscopic vs Microscopic Approach, Trainee's Point of View

Table 2 shows the advantages and disadvantages of endoscopy compared with the microscopic approach, according to the trainee's point of view.

It was interesting to note that 20 of 21 residents (95.2%) reported that endoscopy offers the best visualization of middle ear structures and recesses, as well as the surgical field, when compared with the microscopic approach. According to this finding, 100% of assistants considered the endoscopic approach to be better for educational purposes.

These two aspects should not be underestimated in young surgeons in training who could have greater difficulty in identifying anatomi-

cal structures and understanding some surgical steps performed by experienced surgeons.

Finally, another interesting finding was that despite the fact that 71.4% of residents considered the one-hand surgery of the endoscopic approach a disadvantage compared with microscopic surgery, 85.7% of them reported that they would choose this approach for their training program.

DISCUSSION

Stapes surgery takes place on a very fragile anatomical region where there is a risk of injury to the tympanic membrane, chorda tympani, incus, and facial nerve [24-28]. A sensorineural hearing loss is also possible in the event of incorrect surgical procedures. These possible complications, the microscopic field, and the complex anatomy of the middle ear are a cause of concern and indecision for young inexperienced surgeons [29-30].

The residency-training program should provide a long period of instruction during which the trainee acquires adequate surgical skills and anatomical knowledge to carefully perform stapes surgery [29-32]. Therefore, achieving surgical competency in this kind of surgery represents a challenge to both the trainee and trainer.

Over the last year, we observed that in our university center, resident assistants were especially interested in endoscopic stapes surgery. They explained that the reason for this interest arose from the observation that the endoscopic approach offered advanced visualization of the surgical field and middle ear structures, with a better understanding of middle ear anatomy and surgical steps performed by expert surgeons. Different views at the operative monitor between endoscopic and microscopic approach are shown in Figure 2. The advantages of the endoscope in viewing the surgical field view, compared with the microscopic view, have been reported in retrospective studies that showed reduced residual cholesteatoma disease rates after endoscopic tympanoplasty due to better visualization of hidden middle ear areas [9, 15, 33-35]. Karchier et al. [33] analyzed the visualization of the specific anatomical area of the tympanic cavity via posterior tympanotomy. Endoscopes with both 30° and 45° angulation, provided excellent visualization of the tympanic cavity recesses, mainly due to their proximity and magnification. Visualization of the footplate, sinus tympani, and Prussak's space was significantly better using an endoscope in comparison to that using a microscope. Bennett et al. [9], using a three-dimensional model developed from temporal bone scans, showed that angled scopes permit visualization of a more extensive surface area of all sub-regions of the middle ear than microscopes.

To the best of our knowledge, few studies have analyzed the advantages for the visualization of middle ear structures during stapes surgery and how this advantage could be of help in stapes surgery [5, 6, 20].

In a recent retrospective study, we analyzed the surgical outcomes of endoscopic stapes surgery, comparing the results with a conventional stapes surgery under microscopic approach [6]. We found that audiological outcomes achieved by endoscopic surgery are similar to the results obtained by a microscopic approach but that the endoscopic approach is able to provide an excellent visualization of the oval window niche, stapes anterior crus, and its supra-structures in comparison to the microscopic approach.

In this subsequent study, by assessing the opinions of trainee surgeons, the authors attempted to confirm the advantages of the endoscope in comparison to the microscope for visualizing particular anatomical areas of the middle ear during stapes surgery. We chose stapes surgery because in patients suffering from otosclerosis there are no pathological changes in middle ear anatomy, that might be present in cholesteatomas or chronic middle ear infections. This makes it easier for trainee assistants to learn the anatomy and identify middle ear structures properly.

Ninety-five percent of the residents reported better visualization of the middle ear structures and recesses in endoscopic view, mainly the long process of the incus, stapes crus and footplate, stapes supra-structure, and oval window niche (Table 2, questions 1). A greater magnification of the entire surgical field in the endoscopic approach was also reported by the same percentage of assistants (95.2%) (Table 2, question 2).

According to these data, our study demonstrates the advantages of endoscopic stapes surgery for visualizing middle ear structures and surgical field when compared to the microscopic view.

The main limitation of this study could be that the group of trainees enrolled and tested were inexpert surgeons who have less anatomical knowledge and less training in the identification of the middle ear structures. Probably, testing a group of senior surgeons would have obtained different results without a significant difference between the two approaches in terms of visualization of the surgical field and middle ear structures. However, it should be remembered that the choice of assistants in training was made in concordance with the main purpose of this paper that was to evaluate the educational aspects offered by a better view of the middle ear structures in stapes surgery.

In our opinion, endoscopic surgery is better for education purposes of assistants in training because of the following reasons. First, the monitor can be viewed by both the surgeon and his assistants, making surgical anatomy and procedures more easily understood by trainee surgeons. Second, the endoscope located near to the middle ear structures allows a greater magnification without loss of resolution [7, 9, 17, 18, 20, 36]. This could be an important advantage to assistants in training who are inexperienced in recognition of middle ear structures. Third, the dynamic vision offered by endoscope movements could favor easier understanding of the surgical technique for assistants in training with little knowledge of the anatomy and surgical steps [6, 37].

These hypotheses were evaluated via the specifically designed questionnaires. The advantages in terms of visualization of middle ear structures have already been reported above. In this study, 85.7% of the residents reported a greater understanding of the surgical technique with a better identification of the different surgical steps during the endoscopic approach, compared with the microscopic surgery. Besides, it was interesting to note that 100% of the interviewed assistants, expressed the opinion that the endoscopic approach would be better than the microscopic approach for educational purposes.

Although endoscopes allow a better visualization, reduced residual rates, and less invasive approaches, some disadvantages exist. They

include one-handed surgery, the loss of binocular vision, a potentially long learning curve, difficult hemostasis, and the possibility of narrow external ear canals [6, 35, 36, 38-40].

All these possible disadvantages must be evaluated during stapes surgery, especially by inexperienced surgeons in training [6]. One-handed surgery and the initially long operative times were considered to be disadvantages in 71.4% and 61.9% of residents, respectively.

Besides, 42.8% of assistants reported that endoscopic surgery seems to be more difficult to perform than microscopic surgery. However, regarding this aspect, it should be noted that 38% of the assistants answered "I do not know" to this specific question (Table 2, question 5). Assistants subsequently motivated this answer, claiming to have had limited experience as first operator in endoscopic surgery and for this reason not being able to establish the effective difficulty of this approach in comparison to the more commonly performed microscopic surgery.

Finally, surprisingly 47.6% of assistants did not consider the learning curve of endoscopic surgery to be longer or more difficult than that of the microscopic surgery, and 85.7% of residents claimed that they would choose this surgical approach for their training program.

Residents approached this study and the endoscopic technique with enthusiasm. The questionnaire completed by the residents revealed the willingness of most of them to become more familiar with endoscopic stapes surgery and take time learning the new technique just as with microscopic stapes surgery. For this reason, in accordance with the report by Iannella and Magliulo [6], we believe that the endoscope only represents an alternative tool to the microscopic view in stapes surgery to achieve the same audiological and surgical results and that the choice of a microscopic or endoscopic approach should only depend on the surgeon's skills and personal experience.

CONCLUSION

The endoscope provided excellent visualization of the tympanic cavity structures and recesses, mainly due to their proximity and magnification; Endoscopic stapes surgery could favor an easier understanding of the surgical technique for assistants in training with little knowledge of the anatomy and surgical steps; and one-hundred percent of the interviewed assistants, expressed their opinion that endoscopic approach is better than the microscopic approach for educational purposes. We considered these aspects relevant for performing endoscopic stapes surgery in a university center.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Sapienza University of Rome.

Informed Consent: Written informed consent was obtained from patients and residents who participated in this study.

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