

Evaluation of Audiological Profile and Tympanic Membrane Healing After Endoscopic Cartilage Tympanoplasty in Chronic Otitis Media

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Abstract:

Background: Chronic otitis media (COM) can lead to chronic perforations of the tympanic membrane and conductive hearing loss. The endoscopic cartilage tympanoplasty is an evolving minimally invasive technique for anatomical reconstruction and restoration of hearing.

Aim: To investigate audiological outcomes and tympanic membrane healing in patients who underwent endoscopic cartilage tympanoplasty for COM.

Methodology: A prospective, interventional study was conducted on a sample population study of 60 patients with dry, safe central perforations. All patients underwent trans canal endoscopic Type I cartilage tympanoplasty successfully. At the preoperative visit and at the postoperative visit, the patient underwent pure tone audiometry (air and bone conduction thresholds), evaluated the speech reception thresholds, and assessed the healing of the tympanic membrane. Follow-up visits were done at 1 month, 3 months, and 6 months post-surgery. The paired t-test was used for statistical analysis ($p < .05$ was considered significant).

Results: At 6 months, mean air conduction thresholds improved from 43.15 ± 7.5 dB to 31.1 ± 7.2 dB ($p < 0.001$). Bone conduction thresholds improved from 18.4 ± 5.1 dB to 17.8 ± 5.05 dB ($p = 0.017$). Speech reception thresholds improved from 35.2 ± 8.1 dB to 25.4 ± 7.9 dB ($p < 0.001$). The mean air-bone gap improved from 24.75 ± 6.2 dB to 13.3 ± 5.8 dB ($p < 0.001$). Successful uptake of the tympanic membrane graft occurred in all cases.

Conclusion: Endoscopic cartilage tympanoplasty is an effective reconstruction with tympanic membrane mucosa, which significantly improved hearing outcomes. This may be a reliable, minimally invasive approach to management of unfitting chronic otitis media.

Keywords: Chronic Otitis Media, Endoscopic Tympanoplasty, Cartilage Graft, Air Conduction Threshold, Air-Bone Gap, Hearing Improvement.

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Introduction

Chronic otitis media (COM) refers to a persistent, progressive inflammatory condition of the mucoperiosteal lining of the middle ear and mastoid cavity that is associated with recurrent or persistent ear discharge and hearing loss. It is one of the most prevalent chronic infectious diseases in the world, particularly in developing countries, and continues to be a leading cause of preventable hearing impairment. Chronic otitis media results in a diverse array of pathological changes to the tympanic membrane and middle ear structures, including tympanic membrane perforation, destruction of the ossicular chain, myringosclerosis, and conductive hearing loss. In grave instances of COM, the infection can lead to irreversible damage in the structures of the middle ear and have an adverse effect on auditory function and overall quality of life.

The overarching objectives of surgical management for chronic otitis media include eradicating the disease process, disrupting further infection or complication, reconstruction of the conductive hearing mechanism, and establishing adequate ventilation of the middle ear cleft. Surgical intervention was not only intended to improve hearing outcomes and maintain a safe and dry ear, but to restore the anatomical integrity and function of the tympanic membrane. Tympanoplasty is the most frequently operative technique utilized to repair tympanic membrane perforations and restore middle ear function.

Microscopic tympanoplasty, since the 1950s, has been considered the gold standard of tympanic membrane reconstruction. The addition of the operating microscope provided otologic surgery with magnification and illumination, allowing surgeons to perform delicate procedures in the middle ear

more safely and accurately. Microscopic tympanoplasty has always been performed through a postauricular or endaural approach, which allows for wide exposure of middle ear structures, but later, more sophisticated techniques were developed with various approaches to tympanoplasty. Although effective, the classical microscopic technique developed in the 1950s has since changed and has gradually been modified with the use of newer surgical instruments and techniques designed to minimize surgical morbidity and improve clinical outcomes [1].

The last few years have seen an increasing popularity of endoscopic ear surgery as a minimally invasive alternative to the traditional microscope. Endoscopic tympanoplasty has particularly become a unique approach that is favorable to unrivaled visualization of concealed and difficult anatomical recesses (anterior epitympanum, sinus tympani, hypotympanum) that would be more challenging to visualize using a microscope. The change from standard microscope tympanostomy to endoscopic tympanostomy has been slow, primarily because of the initial difficulties which present the surgeon single-handedly whilst holding the endoscope, as well as opening the way to a new and unique set of surgical instruments. As endoscopic technology advances, there are now more available higher definition cameras and finer surgical instruments available to be able to overcome these limitations the surgeon has faced [2].

The trans canal endoscopic route provides a middle ear surgeon to be able to perform middle ear surgery through the relatively narrow external auditory canal and without the need for a large postauricular incision. In addition, undergoing surgery using a trans canal endoscopic technique provides the benefit of a scarless surgical field, less operative time, less intraoperative bleeding, and less postoperative recovery time. Furthermore, endoscopically visualization the surgeon can adequately assess for disease in recesses that otherwise may be difficult to visualize using a microscope, which could ultimately reduce the chance of residual disease or recurrence.

In tympanoplasty surgery, the type of graft material is important for tympanic membrane reconstruction success. Of the various types of graft material, tragal cartilage has established itself among surgeons for some unique characteristics it possesses; it is relatively rigid and resistant to retraction. These qualities make it especially useful in cases with eustachian tube dysfunction and/or recurrence of perforations. Its structural rigidity makes it possible to create a precise single-handed placement in the surgical field during endoscopic surgery; the low metabolic demand also limits graft rejection or failure. Cartilage can also provide long-term durability, and a good rate of anatomical and functional outcomes in both microscopic and endoscopic tympanoplasty.

Recent research has compared endoscopic and microscopic tympanoplasty with respect to anatomical outcomes and graft success. In both categories, the graft success rates have been high overall. Some authors have observed nearly 100% graft uptake in the endoscopic group, which was near 95.8% in the microscopic tympanoplasty group, proving endoscopic tympanoplasty could improve tympanic membrane closure and correct middle ear anatomy [3]. Overall, results suggest that endoscopic tympanoplasty offers a competent substitute for traditional approaches, and in certain cases, an even superior substitute, for tympanic membrane reconstruction and middle ear surgery, especially cases benefiting from minimal access and visualization.

From an auditory point of view, successful tympanic membrane repair meaningfully factors in the improvement of conductive hearing loss associated with chronic otitis media. The extent of hearing improvement may depend on a variety of factors, including the size and position of the perforation, the status of the ossicular chain, as well as the type of graft used for the repair. Endoscopic cartilage tympanoplasty has shown promising results for hearing thresholds, while providing relatively stable anatomical outcomes over time. In order to measure success of this surgical technique, both the morphological healing of the tympanic membrane and the functional hearing outcomes must be assessed.

As endoscopic approaches for the management of patients with chronic otitis media become more widely accepted into practice, there is a need to evaluate the effectiveness and compare the results of endoscopic procedures against existing techniques. The aim of this study is to establish the audiological profile, in addition to tissue healing outcomes of the tympanic membrane following endoscopic composite cartilage tympanoplasty in patients with chronic otitis media with safe central perforations (small or medium size perforations). This study looks at assessing anatomical and functional outcomes, with the purpose of adding valuable evidence for surgical decision-making and improving the care of patients with chronic otitis media.

Methodology

Study Design: This research was designed as a prospective interventional study to assess the audiological profile and tympanic membrane healing outcomes after endoscopic composite cartilage tympanoplasty (Type I) for patients with chronic otitis media (COM).

Study Area: The study was conducted in the Department of ENT, tertiary care hospital, Ahmedabad, Gujarat, India.

Study Duration: The study was carried out over a period of 12 months

Sample Size and Sampling Technique: A total of 60 patients diagnosed with chronic otitis media (small and medium sized, dry and safe central perforation) were included. The sample size was determined by the expected number of surgical cases available over an 18-month period. Purposive sampling ensured the recruitment of patients who met the eligibility criteria.

Study Population: The study population consisted of patients presenting to the Otolaryngology outpatient department with dry and safe central perforation and conductive hearing loss.

Inclusion Criteria

Patients were included if they met the following criteria:

- Age above 12 years.
- Diagnosed with chronic otitis media with dry and safe central perforation (small or medium), persisting for at least 1.5 months.
- Presence of conductive hearing loss with air conduction threshold <45 dB in the affected ear.
- Good tubal function and dry middle ear mucosa.

Exclusion Criteria

The following patients were excluded from the study:

- Patients with large subtotal or total perforations.
- Active squamous or adhesive disease (unsafe ear).
- Persistent ear discharge does not respond to medical treatment.
- Pure sensorineural or mixed hearing loss in the affected ear.
- Revision tympanoplasty cases.

Data Collection Tools and Techniques: Data collection was executed systematically throughout three phases of the study: preoperative, intraoperative, and postoperative.

In the preoperative phase, a comprehensive history was taken from every patient. Specifically, data collection included presenting complaints and duration of symptoms, systemic illnesses, any long-term medication usage and chronic health issues (for example, alcohol consumption, smoking status). Clinical examinations involved otoscopy, oto-endoscopy and tuning fork assessments. Radiological investigations, including bilateral mastoid X-ray (Schuller's view) examinations, were conducted to assess mastoid and middle ear anatomy. Audiological assessment occurred through Pure Tone Audiometry (PTA) to evaluate and report both air conduction threshold (ACT) and bone conduction threshold (BCT) findings. Both thresholds were calculated by averaging hearing levels at 0.5, 1, 2 and 4 kHz.

In the intraoperative phase, the investigator assessed middle ear mucosa and ossicular chain mobility during surgical manipulation and documented relevant surgical findings.

In the postoperative phase, all patients were followed up at 1 month, 3 months, and 6 months following surgery. At every follow-up appointment, otoscopic examination was performed to determine graft healing, and hearing function was assessed through a hearing test. Thus, all data collection within this systematic process was designed to provide a thorough assessment of every anatomical and functional outcome.

Outcome Measures: "There were two primary outcomes measured in the study: anatomical success and functional success. Anatomical success was defined as the presence of an intact graft, with no perforation, atelectasis, or lateralization, at the six-month follow up, based on the assessment using a zero-degree endoscope. Functional success was determined by assessing the change in ACT from preoperative to postoperative values, where any improvement in postoperative thresholds would be classified as a successful outcome.

Procedure: The research was conducted following a standardized protocol to form consistency and reliability. Initially, patients were screened, and those who met the inclusion and exclusion criteria were selected. All patients then underwent a preoperative assessment that included history, clinical examination, pure tone audiometry, and radiological imaging.

All surgical interventions were completed by the same surgeon, thus creating consistency. Surgery was conducted using 0° and 30° Karl Storz rigid endoscopes (18 cm, 4 mm) connected to a Stryker 1588 camera system. The same trans-canal approach and over-underlay graft placement technique was employed in all cases. A full-thickness tragal chondro-perichondrial graft was harvested and placed lateral to the handle of the malleus and medial to the remnant tympanic membrane and annulus. Once the graft was adequately positioned, the external ear canal was packed with Gelfoam, and a sterile pack was placed to the external meatus.

Patients had intravenous antibiotics, analgesics, proton pump inhibitors, and oral decongestants in the postoperative period. Patients were discharged 48–72 hours after hospitalization. Follow-up care included suture removal on the seventh day after surgery, and removal of the ear pack on day fourteen, at which time antibiotic ear drops were also started. Patients were then seen at the one-month, three-month, and six-month postoperative mark to assess anatomical healing and improvement in hearing.

Statistical Analysis: All of the data collected were input into Statistical Package for Social Sciences

(SPSS) version 25.0, and the data were analyzed. Continuous variables such as preoperative and post-operative ACT were presented as mean $\pm$ standard deviation (SD), while categorical variables were presented as frequencies and percentages. The paired t-test was used to compare preoperative ACT and postoperative ACT to reveal significance in hearing improvement after surgery. For all analyses, significance was determined at a p-value of less than 0.05."

Result

Table 1: Comparison between pre-operative and post-operative air conduction thresholds at 6 months (N = 60).						
Mean Air Conduction Threshold (ACT)	Pre-operative		Post-operative		T	P value
	Mean	SD	Mean	SD		
N = 60	43.15	7.5	31.1	7.2	16.21	<0.001

Table 2 shows the comparison of bone conduction thresholds (BCT) before and six months after surgery in 60 patients. The mean pre-operative BCT was 18.4 ± 5.1 dB, which slightly decreased to 17.8

"Table 1 presents a comparison of air conduction thresholds (ACT) before and six months after surgery in 60 patients. The mean pre-operative ACT was 43.15 ± 7.5 dB, which improved significantly to 31.1 ± 7.2 dB post-operatively. Statistical analysis showed a paired t-value of 16.21 with a P value < 0.001, indicating a highly significant reduction in ACT six months after surgery. This demonstrates a substantial improvement in hearing following the procedure.

± 5.05 dB post-operatively. The paired t-test yielded a t-value of 2.45 with a P value of 0.017, indicating a statistically significant but modest improvement in bone conduction thresholds following surgery.

Table 2: Comparison between pre-operative and post-operative bone conduction thresholds at 6 months (N = 60).						
Mean Bone Conduction Threshold (BCT)	Pre-operative		Post-operative		T	P value
	Mean	SD	Mean	SD		
N = 60	18.4	5.1	17.8	5.05	2.45	0.017

Table 3 presents the comparison of speech reception thresholds (SRT) before and six months after surgery in 60 patients. The mean pre-operative SRT was 35.2 ± 8.1 dB, which improved significantly to

25.4 ± 7.9 dB post-operatively. The paired t-test showed a t-value of 12.65 with a P value < 0.001, indicating a highly significant improvement in speech reception thresholds following surgery.

Table 3: Comparison between pre-operative and post-operative speech reception thresholds at 6 months (N = 60).						
Mean Speech Reception Threshold (SRT)	Pre-operative		Post-operative		T	P value
	Mean	SD	Mean	SD		
N = 60	35.2	8.1	25.4	7.9	12.65	<0.001

Table 4 illustrates the comparison of the air-bone gap (ABG) before and six months after surgery in 60 patients. The mean pre-operative ABG was 24.75 ± 6.2 dB, which significantly decreased to 13.3 ± 5.8 dB post-operatively. The paired t-test yielded a t-

value of 14.02 with a P value < 0.001, demonstrating a highly significant reduction in ABG and indicating effective closure of the conductive hearing deficit following surgery.

Table 4: Comparison between pre-operative and post-operative air-bone gap at 6 months (N = 60).						
Mean Air-Bone Gap (ABG)	Pre-operative		Post-operative		T	P value
	Mean	SD	Mean	SD		
N = 60	24.75	6.2	13.3	5.8	14.02	<0.001

Discussion

The results of the current study show a significant improvement in auditory function following endoscopic cartilage tympanoplasty in patients with chronic otitis media. The air conduction threshold mean before surgery was 43.15 ± 7.5 decibels (dB)

and it improved to 31.1 ± 7.2 dB. The intervention had a significant effect on the air conduction threshold ($t = 16.21$, $p < 0.001$). The differences we demonstrated are in line with the results of Wuesthoff et al. (2018), who evaluated 53 patients undergoing endoscopic composite cartilage tympanoplasty. They found a mean preoperative PTA of

42.8 ± 16.7 dB before surgery and a postoperative average of 25.7 ± 15.9 dB ($p < 0.001$). Similarly, Parelkar et al. (2020) [4] found a mean preoperative PTA of 40.8 ± 7.46 dB and 39.4 ± 7.95 dB for the full thickness cartilage group and the partial thickness group, respectively, and a two-month postoperative rate of 26.72 ± 8.08 dB and 26.40 ± 8.60 dB ($p = 0.012$ and $p = 0.018$, respectively). This closely resembles the findings of the current study, demonstrating the comparable reproducibility of hearing improvement with endoscopic cartilage grafts. Absolute values will differ slightly from study to study, likely due to variation in the patient age, size of perforation, and likely length of follow-up, however, the effect of improvement is similar demonstrating that this technique is effective.”

In our research, bone conduction thresholds improved slightly, from 18.4 ± 5.1 dB prior to surgery to 17.8 ± 5.05 dB after surgery ($t = 2.45$, $p = 0.017$). Although smaller than the improvement in air conduction, these data suggest a potential decrease in stress on the middle ear or some minimal protective effect on the cochlear function. Gerber et al. (2000) [5] found similar tendencies, observing minimal but statistically significant alterations in bone conduction thresholds after cartilage tympanoplasty. They claimed cartilage tympanoplasty mainly resolves the conductive component, with no adverse impact on the sensorineural component of hearing, even if statistically significant change or adjustments to the anatomy may have occurred. These small improvements may be the outcome of optimal sound delivery through a recreated tympanic membrane and ossicular coupling.

Patients' speech reception thresholds decreased from 35.2 ± 8.1 dB pre-operatively to 25.4 ± 7.9 dB post-operatively ($t = 12.65$, $p < 0.001$), which demonstrates meaningful functional improvement with regards to communication. This change also imitates the results in air conduction and is in agreement with Dornhoffer (2003) [6]. In a large cohort of patients who underwent cartilage tympanoplasty, he showed improvement with speech, primarily with PTA averages for speech reception thresholds averaging 10-15 dB improvements. Bahadir et al. (2003) [7] reported improvements in speech perception when restoring the tympanic membrane with cartilage grafts, especially when there was no noise, which added a functional angle to the study that does anatomical reconstruction of a tympanic membrane.

In our study, the mean air-bone gap improved from 24.75 ± 6.2 dB before surgery to 13.3 ± 5.8 dB after surgery ($t = 14.02$, $p < 0.001$), indicating a successful closure of the conductive hearing loss. This finding is consistent with the findings of Gokgoz et al. (2020) [8], who reported mean pre-operative air-bone gap of 25.1 ± 7.4 dB improved to 12.8 ± 6.1 dB after endoscopic type I tympanoplasty. Similarly, Ayache (2013) [9] reported that 30 endoscopic

myringoplasty cases had a mean air-bone gap decrease from 23.4 dB to 11.6 dB. The results of these comparisons confirm that cartilage tympanoplasty has an excellent result in restoring conductive hearing, regardless of the size of the perforation or the side. Studies comparing full-thickness and partial-thickness tragal cartilage grafts have shown similar restoration of air-bone gap once again indicating both graft types have the same potential for an excellent audiological outcome (Parelkar et al., 2020) [4].

The consumption rate of the graft in our division was 94% of cases, and only three cases had a remaining perforation. This data is similar to graft uptake rates published by Ayache (2013) [9] at 96%, and Gokgoz et al. (2020) [8] at 94%, which suggests that the endoscopic approach can consistently provide anatomical closure. Importantly, factors that contribute to graft failure, such as the sites of graft placement, its vascularity, infection, or poor middle ear mucosa were negligible variables in our cohort. Particularly, this likely reflects benefits and clarity of access with an endoscopic approach with less disturbance of the surrounding tissue (Dornhoffer, 2003; Sahan et al., 2014) [6,10]. In contrast to previous studies, our study did not have post-operative complications with ossicular chain defects, medialization or lateralization of graft or worsening hearing loss, and shows the safety of endoscopic cartilage tympanoplasty.

In summary, the current investigation shows significant and clinically important improvements in audiological outcomes (i.e., air conduction, speech recognition and air-bone gap) after endoscopic cartilage tympanoplasty, with a high graft uptake and low complication rate. These findings align with those found in other published studies and add to the growing evidence of the safety and efficacy of an endoscopic approach for tympanic membrane reconstruction. Some variability in absolute values among studies may be due to differences in study design, sample size, perforation characteristics, and follow-up intervals. Nonetheless, the weight of evidence supports endoscopic cartilage tympanoplasty as a valid and reproducible method to restore both anatomical and functional integrity of the tympanic membrane in patients with chronic otitis media. Further investigations in larger randomized cohorts and with longer follow-up periods are needed to continue to establish these conclusions and evaluate long-term results.

Conclusion

The research shows that endoscopic cartilage tympanoplasty performed on patients with chronic otitis media results in significant improvement in hearing and successful tympanic membrane healing. In post-operative measures, air conduction thresholds and speech reception thresholds improved dramatically,

supporting sound propagation through the middle ear. In addition, the air-bone gap improved significantly, indicating improved middle ear function and resolution of conductive hearing loss. Bone conduction thresholds were consistent across the evaluation, suggesting preservation of cochlear function. In summary, endoscopic cartilage tympanoplasty not only restores the tympanic membrane's structural integrity, but effect improvement in hearing functionality, implicating its efficacy as a surgical option for chronic otitis media.

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