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Original Research Article

EVALUATING THE ROLE OF ENDOSCOPIC EAR SURGERY IN CHOLESTEATOMA MANAGEMENT: A COMPARATIVE STUDY

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ABSTRACT

Background: Cholesteatoma is a destructive, expanding lesion of the middle ear characterized by keratinizing squamous epithelium, often leading to chronic infection, bone erosion, and potentially life-threatening complications if left untreated. Traditional surgical management involves microscopic approaches, primarily canal wall-down (CWD) and canal wall-up (CWU) mastoidectomy techniques. However, with advancements in technology, endoscopic ear surgery (EES) has emerged as a promising minimally invasive alternative, providing enhanced visualization of hidden recesses without extensive bone removal. This study was undertaken to compare the outcomes of endoscopic ear surgery with conventional microscopic techniques in the management of middle ear cholesteatoma, evaluating disease clearance, operative morbidity, and hearing outcomes. **Materials and Methods:** This prospective comparative study was conducted at a tertiary care center over a period of 12 months. A total of 80 patients diagnosed with acquired middle ear cholesteatoma were divided into two groups: Group A (n=40) underwent exclusive endoscopic ear surgery, while Group B (n=40) underwent conventional microscopic surgery. Preoperative evaluation included otoscopic examination, pure tone audiometry, and high-resolution computed tomography (HRCT) of the temporal bone. Surgical outcomes assessed included complete disease clearance, operative time, postoperative complications, graft uptake rates, and hearing improvement measured by air-bone gap (ABG) closure at 6 months postoperatively. **Result:** Disease clearance was comparable between the two groups, with complete eradication achieved in 95% of Group A and 92.5% of Group B patients. The mean operative time was slightly longer in the endoscopic group. However, Group A demonstrated superior visualization of hidden areas like the sinus tympani and facial recess, reducing the residual disease risk. Graft uptake rates were high and similar between groups (97.5% vs. 95.0%). Hearing outcomes were favorable in both groups, with mean ABG closure of 12.8 dB in the endoscopic group compared to 11.5 dB in the microscopic group ($p > 0.05$). Postoperative morbidity, including canal wall injury and delayed healing, was lower in the endoscopic group. **Conclusion:** Endoscopic ear surgery is a safe and effective alternative to conventional microscopic techniques for the management of cholesteatoma, offering excellent disease clearance, comparable hearing improvement, and reduced morbidity. Its ability to access hidden anatomical areas with minimal invasiveness supports its expanding role in modern otologic surgery. Careful patient selection and surgeon expertise are critical factors for optimizing outcomes.

INTRODUCTION

Cholesteatoma is a chronic, progressive lesion of the middle ear and mastoid characterized by the presence of keratinizing squamous epithelium within the tympanic cavity.[1] It is associated with bone erosion, chronic otorrhea, conductive hearing loss, and, if untreated, potentially serious complications such as facial nerve paralysis, labyrinthitis, and intracranial infections. The primary goal of surgical management

is complete eradication of the disease while preserving or improving hearing and maintaining the structural integrity of the ear.[2,3]

Traditionally, cholesteatoma has been managed using microscopic surgical techniques, mainly through canal wall-up (CWU) or canal wall-down (CWD) mastoidectomy approaches. While these techniques provide effective disease clearance, they involve significant bone removal, alteration of middle ear anatomy, and may result in large postoperative cavities requiring meticulous long-term care. Moreover, the limited microscopic line of sight can restrict visualization of hidden recesses such as the sinus tympani, facial recess, anterior epitympanic space, and hypotympanum, which are common sites for residual or recurrent disease.[4,5]

In recent years, endoscopic ear surgery (EES) has emerged as a minimally invasive alternative, offering a wide-angle, panoramic view of the middle ear structures. The use of rigid endoscopes provides enhanced access to difficult-to-visualize areas without the need for extensive bone removal. Endoscopes facilitate better assessment of disease extent, thorough cleaning of hidden pockets, and preservation of healthy structures. Furthermore, EES promotes the philosophy of "functional ear surgery," emphasizing disease clearance with minimal anatomical disruption and rapid postoperative recovery.[6,7]

Several studies have reported favorable outcomes with the use of endoscopic techniques in middle ear surgery, particularly in cholesteatoma cases limited to the middle ear cleft. Advantages include reduced operative morbidity, smaller external incisions, faster healing, and improved cosmetic results. However, EES is technically demanding, often requiring single-handed dissection and meticulous surgical technique to avoid complications.[8] The learning curve associated with endoscopic ear procedures is another factor influencing its widespread adoption.

Despite the promising benefits, debates continue regarding the comparative effectiveness of endoscopic versus conventional microscopic approaches in achieving long-term disease control and hearing restoration. Most comparative studies suggest similar rates of disease clearance, with some favoring endoscopic techniques for reducing residual disease in hidden anatomical areas.[9]

Given the evolving surgical landscape and the increasing emphasis on minimally invasive techniques, it is essential to objectively evaluate the role of endoscopic ear surgery in cholesteatoma management. The present prospective comparative study was undertaken to compare the outcomes of exclusive endoscopic ear surgery with traditional microscopic techniques in terms of disease clearance, hearing improvement, graft success rates, operative morbidity, and complication rates. This study aims to contribute further evidence to guide surgical decision-making and patient counseling in the management of acquired middle ear cholesteatoma.

MATERIALS AND METHODS

This prospective comparative study was conducted at the Department of Otorhinolaryngology of Government Medical College and Hospital Nagarkurnool over a period of 12 months, from April 2024 to March 2025. The study aimed to evaluate the effectiveness of endoscopic ear surgery compared to conventional microscopic surgery in the management of acquired middle ear cholesteatoma. Ethical approval was obtained from the Institutional Ethics Committee before commencement of the study. Written informed consent was obtained from all participants after detailed counseling regarding the surgical techniques, benefits, and potential risks involved.

A total of 80 patients diagnosed clinically and radiologically with acquired middle ear cholesteatoma were enrolled and randomized into two groups:

- **Group A (n=40):** Underwent exclusive endoscopic ear surgery (EES)
- **Group B (n=40):** Underwent conventional microscopic ear surgery (MES)

Inclusion criteria included patients aged between 18 and 60 years, with primary acquired cholesteatoma limited to the middle ear cleft or early mastoid extension, based on high-resolution computed tomography (HRCT) temporal bone findings. Exclusion criteria were patients with extensive cholesteatoma requiring canal wall-down mastoidectomy, revision cholesteatoma cases, congenital cholesteatoma, active intracranial complications, facial nerve palsy at presentation, and those unfit for surgery under general anesthesia.

All patients underwent detailed clinical evaluation, including otoscopic examination, tuning fork tests, and preoperative pure tone audiometry (PTA) to assess the degree of hearing loss. HRCT scans were obtained to evaluate disease extent and mastoid air cell involvement. Patients were counseled regarding the planned surgical procedure based on random allocation.

Surgical Technique

- In **Group A**, surgeries were performed exclusively using 0° and 30° rigid endoscopes (4 mm diameter, 18 cm length). Underlay tympanoplasty with cholesteatoma removal was performed through a transcanal or postauricular endoscopic approach. Special care was taken to clear hidden recesses like sinus tympani and facial recess using angled endoscopes and fine instruments.
- In **Group B**, conventional canal wall-up microscopic mastoidectomy with tympanoplasty was performed using a surgical microscope. Standard techniques for disease removal and middle ear reconstruction were employed.

In both groups, temporalis fascia grafts were used for tympanic membrane reconstruction. Ossicular chain

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reconstruction was done where required, using autologous ossicles or titanium prostheses.

Outcome-Measures

Primary outcome measures included

- Complete disease clearance as assessed by intraoperative findings and postoperative follow-up
- Hearing improvement measured by air-bone gap (ABG) closure on PTA at 6 months
- Graft uptake rates assessed at 6 months postoperatively

Secondary outcome measures included:

- Operative time (measured from incision to completion of closure)
- Postoperative complications such as infection, graft lateralization, sensorineural hearing loss, facial nerve injury
- Rate of residual or recurrent cholesteatoma during follow-up

All patients were followed up at 2 weeks, 1 month, 3 months, and 6 months postoperatively with otoscopic examination, PTA, and in selected cases, repeat HRCT if clinically indicated.

Statistical-Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0. Quantitative variables were expressed as mean ± standard deviation and compared using paired and unpaired t-tests. Categorical variables were expressed as percentages and analyzed using Chi-square test or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Thus, this structured methodology enabled a comprehensive comparison of clinical outcomes between endoscopic and microscopic techniques in the surgical management of middle ear cholesteatoma.

RESULTS

A total of 80 patients diagnosed with acquired middle ear cholesteatoma were included in the study and randomized equally into two groups: Group A (endoscopic ear surgery) and Group B (microscopic ear surgery). The outcomes were evaluated in terms of disease clearance, hearing improvement, graft uptake, operative time, and postoperative complications.

Table 1 shows the age and gender distribution of study participants. The demographic characteristics were comparable between the two groups

Table 1: Age and Gender Distribution

Age Group (years)	Group A (n=40)	Group B (n=40)	p-value
18–30	14	13	
31–40	15	16	
41–50	7	8	
>50	4	3	0.94

Table 2 shows the gender distribution of study participants. Both groups had a similar male-to-female ratio.

Table 2: Gender Distribution of Study Participants

Gender	Group A (n=40)	Group B (n=40)	p-value
Male	26	24	
Female	14	16	0.63

Table 3 shows the preoperative air-bone gap (ABG) distribution. Baseline hearing levels were comparable across both groups.

Table 3: Preoperative Air-Bone Gap (ABG) Distribution

Preoperative ABG Range (dB)	Group A (n=40)	Group B (n=40)	p-value
≤20 dB	6	7	
21–30 dB	18	16	
>30 dB	16	17	0.88

Table 4 shows the mean operative time between the two groups. Endoscopic surgeries had a slightly longer operative duration.

Table 4: Mean Operative Time

Group	Mean Operative Time (minutes)	p-value
Group A	102.3 ± 15.6	
Group B	91.7 ± 13.2	0.021

Table 5 shows the rate of complete disease clearance observed intraoperatively and during follow-up. Both groups showed comparable clearance rates.

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Table 5: Disease Clearance Rate

Outcome	Group A (n=40)	Group B (n=40)	p-value
Complete Clearance	38 (95.0%)	37 (92.5%)	
Residual Disease	2 (5.0%)	3 (7.5%)	0.64

Table 6 shows the graft uptake success rate at 6 months postoperatively. High graft uptake was achieved in both groups.

Table 6: Graft Uptake Rates

Graft Status	Group A (n=40)	Group B (n=40)	p-value
Successful Uptake	39 (97.5%)	38 (95.0%)	0.55
Graft Failure	1 (2.5%)	2 (5.0%)	

Table 7 shows the postoperative improvement in hearing assessed by reduction in ABG at 6 months. Both groups demonstrated significant hearing improvement.

Table 7: Postoperative ABG Improvement

Group	Mean Pre-op ABG (dB)	Mean Post-op ABG (dB)	Mean ABG Closure (dB)	p-value
Group A	28.5 ± 7.4	15.7 ± 6.2	12.8 ± 4.1	
Group B	29.1 ± 8.0	17.6 ± 5.8	11.5 ± 4.5	0.18

Table 8 shows the rate of postoperative complications. Endoscopic surgery was associated with fewer minor complications.

Table 8: Postoperative Complications

Complication Type	Group A (n=40)	Group B (n=40)	p-value
Infection	2 (5.0%)	4 (10.0%)	
Graft Lateralization	1 (2.5%)	3 (7.5%)	
Sensorineural Hearing Loss	0 (0%)	1 (2.5%)	
Facial Nerve Injury	0 (0%)	0 (0%)	0.49

Table 9 shows patient-reported postoperative recovery in terms of pain and healing. Faster recovery was noted in the endoscopic group.

Table 9: Postoperative Recovery

Recovery Parameter	Group A (n=40)	Group B (n=40)	p-value
Early Return to Normal Activities (<2 weeks)	32 (80.0%)	24 (60.0%)	0.048

Table 10 shows the exposure of key anatomical areas (sinus tympani, facial recess) achieved during surgery. Visualization was superior in the endoscopic group.

Table 10: Visualization of Hidden Recesses

Anatomical Exposure	Group A (n=40)	Group B (n=40)	p-value
Sinus Tympani	40 (100%)	32 (80.0%)	0.004
Facial Recess	38 (95.0%)	30 (75.0%)	0.014

Table 11 shows the rate of residual disease identified on follow-up endoscopy at 6 months. Residual disease was slightly lower in the endoscopic group.

Table 11: Residual Disease at 6-Month Follow-Up

Residual Disease Status	Group A (n=40)	Group B (n=40)	p-value
Present	2 (5.0%)	4 (10.0%)	0.40
Absent	38 (95.0%)	36 (90.0%)	

Table 12 shows revision surgery requirement among the study population. The need for revision was minimal and comparable between groups.

Table 12: Revision Surgery Rate

Revision Required	Group A (n=40)	Group B (n=40)	p-value
Yes	1 (2.5%)	2 (5.0%)	0.55
No	39 (97.5%)	38 (95.0%)	

Table 13 summarizes the overall success rate combining disease clearance, hearing improvement, and graft uptake.

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Table 13: Overall, Success Rate

Outcome Status	Group A (n=40)	Group B (n=40)	p-value
Successful Outcome	37 (92.5%)	36 (90.0%)	0.69
Unsuccessful/Partial	3 (7.5%)	4 (10.0%)	

In summary, endoscopic ear surgery demonstrated comparable disease clearance and hearing outcomes to conventional microscopic surgery, with additional advantages of superior anatomical visualization, reduced minor complication rates, and faster recovery times.

DISCUSSION

Cholesteatoma represents a potentially destructive pathology of the middle ear that necessitates surgical intervention to eradicate disease, prevent complications, and restore hearing. Traditionally, microscopic ear surgery has been the standard of care, providing magnification and illumination for detailed dissection.[10] However, the advent of endoscopic ear surgery (EES) has introduced a paradigm shift toward minimally invasive approaches that emphasize enhanced visualization and anatomical preservation.[11] The present study compared the outcomes of exclusive endoscopic surgery with conventional microscopic techniques in patients with acquired middle ear cholesteatoma.

The demographic profile of the patients in this study was comparable between the two groups, with no significant differences in age or gender distribution. Baseline preoperative air-bone gap (ABG) values were also similar, ensuring that both groups were equally matched in terms of disease severity and hearing loss prior to intervention. This homogeneity provided a reliable platform for outcome comparison.[12]

In terms of disease clearance, both groups achieved high eradication rates (95.0% in the endoscopic group vs. 92.5% in the microscopic group), indicating that endoscopic surgery is as effective as microscopic techniques in achieving complete cholesteatoma removal. The slightly higher clearance rate in the endoscopic group, although not statistically significant, can be attributed to the superior visualization of hidden recesses such as the sinus tympani and facial recess, which are traditionally difficult to access with the microscope. This finding aligns with observations from several clinical series, where the wide-angled endoscopic view allowed thorough disease clearance from anatomically challenging regions.[13]

Operative time was marginally longer in the endoscopic group, possibly reflecting the technical demands of single-handed surgery and the use of multiple angled instruments. However, the clinical benefit of enhanced disease clearance and minimally invasive tissue handling appears to outweigh the modest increase in surgical duration.[14]

Postoperative hearing outcomes were favorable in both groups, with significant ABG closure observed at 6 months. The mean ABG closure was slightly better in the endoscopic group, although the difference was not statistically significant. This indicates that EES does not compromise hearing outcomes and may offer additional benefits by minimizing trauma to the ossicular chain and surrounding structures during dissection.[15]

Graft uptake rates were high in both groups, demonstrating that the tympanic membrane reconstruction success was unaffected by the choice of surgical technique. Minor postoperative complications such as infection and graft lateralization were fewer in the endoscopic group, suggesting that the less invasive nature of EES contributes to faster healing and reduced morbidity. No cases of facial nerve injury or significant sensorineural hearing loss were reported in either group, reinforcing the safety of both surgical modalities when performed by skilled surgeons.[16]

Importantly, patients undergoing endoscopic surgery reported earlier return to normal activities compared to those who underwent microscopic surgery. This highlights one of the key patient-centered advantages of EES—reduced convalescence and improved postoperative quality of life.[17]

Visualization of critical anatomical areas was significantly superior in the endoscopic group. The ability to access and inspect the sinus tympani, facial recess, anterior epitympanic spaces, and hypotympanum without extensive bone drilling represents a major advancement in cholesteatoma surgery, potentially reducing the risk of residual disease and recurrence.[18]

The residual disease rate was lower in the endoscopic group, although not statistically significant. This emphasizes the importance of meticulous follow-up in all patients, regardless of the surgical approach, to detect and manage any recurrence promptly. The need for revision surgery was minimal and comparable between the groups.[19]

Overall, this study supports the growing evidence that endoscopic ear surgery offers equivalent, if not superior, outcomes to conventional microscopic surgery in selected cases of middle ear cholesteatoma. While EES demands a steep learning curve and technical expertise, its advantages in terms of minimally invasive access, better visualization, reduced morbidity, and excellent patient satisfaction make it an increasingly attractive option in modern otologic practice.

CONCLUSION

This prospective comparative study demonstrates that endoscopic ear surgery (EES) is a highly effective and safe modality for the management of acquired middle ear cholesteatoma. The outcomes in terms of disease clearance, hearing restoration, and

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graft uptake were comparable to conventional microscopic surgery. Additionally, endoscopic surgery offered distinct advantages including superior visualization of hidden anatomical recesses, reduced postoperative morbidity, faster recovery, and higher patient satisfaction.

Although the operative time was slightly longer with EES, the clinical benefits achieved through enhanced access to difficult-to-visualize areas and minimal tissue disruption justified this trade-off. The lower incidence of minor postoperative complications and the early return to normal activities further highlight the patient-centered advantages of the endoscopic approach.

Endoscopic ear surgery, when performed by skilled surgeons with appropriate case selection, can serve as an effective minimally invasive alternative to traditional microscopic techniques in cholesteatoma management. As surgical expertise and technological support for EES continue to evolve, its role is expected to expand further, redefining standards in otologic surgery.

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