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Original Research Article

Evaluation of the Effectiveness of Different Surgical Techniques for Ossicular Reconstruction

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Abstract

Background: Ossicular chain disruption is a common cause of conductive hearing loss, often resulting from chronic otitis media, trauma, or iatrogenic injury. Surgical reconstruction of the ossicles is essential for restoring sound conduction and improving hearing. Various techniques and materials—ranging from synthetic prostheses like Partial Ossicular Replacement Prosthesis (PORP) and Total Ossicular Replacement Prosthesis (TORP) to autologous grafts such as cartilage—are used based on the extent of damage and intraoperative findings.

Objective: This study aimed to evaluate and compare the effectiveness of different surgical techniques used in ossicular reconstruction in terms of hearing outcomes and postoperative complications.

Methodology: A prospective observational study was conducted at Patna Medical College & Hospital from 10Th January 2023 to 10th January 2025. A total of 30 patients with conductive hearing loss due to ossicular chain damage were included. Patients were grouped based on the reconstruction technique: Group A (PORP), Group B (TORP), and Group C (cartilage/autograft). Pre- and post-operative hearing was assessed using pure tone audiometry (PTA), and follow-up was done at 1, 3, and 6 months.

Results: PORP showed the greatest mean improvement in air-bone gap (19.2 dB), followed by cartilage/autograft (17.7 dB) and TORP (14.3 dB). The PORP group had the highest success rate (90%) and lowest complication rate.

Conclusion: PORP was found to be the most effective ossicular reconstruction technique in this study. Cartilage grafts offer a viable alternative where synthetic prostheses are limited. TORP, while essential in certain cases, carries a higher risk of complications.

Keywords: Ossicular Reconstruction, PORP, TORP, Cartilage Graft, Conductive Hearing Loss, Middle Ear Surgery, Audiological Outcome, Prosthesis.

Introduction

Hearing, one of the most basic senses, affects social functioning, communication, and quality of life [1]. The inner ear and middle ear tympanic membrane, which conducts sound, are mechanically connected by the ossicular chain [2]. The ossicular chain consists of the malleus, incus, and stapes. Sound waves go from the tympanic membrane to the oval window of the cochlea via a complicated bone network [3].

The malleus articulates with the incus, stapes, and tympanic membrane. The stapes footplate-ovular window interaction sends sound waves into the cochlear fluids for processing [4]. This technique optimises sound energy conversion from air to fluid medium, ensuring auditory efficiency. Ossicles must be movable and anatomically right for effective hearing. Several pathologic conditions can harm or destroy the ossicular chain. Chronic otitis media (COM), especially squamous COM, which often causes cholesteatoma, is a primary cause of ossicular chain injury [5]. Cholesteatoma enzymatic activity, persistent inflammation, and infections can degrade the incus and other ossicular bones over time. Traumatic injury from an accident or surgery can also produce ossicular discontinuity. Ossicles can be blocked by tumours, congenital abnormalities, or vascular necrosis.

Ossicular erosion and conductive hearing loss are frequent in poor nations like India due to recurrent otitis media [6]. Since in the sound conduction pathway hole causes considerable hearing loss, Surgery is the best option once non-invasive treatments fail. Ossiculoplasty, which repairs the ossicular chain, improves hearing and sound conduction. It is crucial for treating ossicular erosion or discontinuity. Ossiculoplasty restores

hearing physically and functionally [7]. Over time, several surgical procedures and materials have been developed to achieve this. Depending on the middle ear mucosa, infection, eustachian tube function, and stapes superstructure availability, several treatments may work. Optimally performed middle ear surgery, ossiculoplasty can enhance hearing, morbidity, and quality of life [8,9].

Ossicular reconstruction uses many surgical methods and prosthetic materials, each with its own indications and outcomes [10]. PORP is used when the stapes superstructure is intact and moveable. PORPs connect the stapes head to the remaining malleus (tympanic membrane). TORP is suitable when the stapes superstructure is absent and the prosthesis must adhere directly to the footplate. In low-resource conditions, sculpted incus and cartilage transplants are used because they are affordable and biocompatible. Titanium prostheses are popular because they transmit sound well, are light, and are biocompatible [11,12]. Cartilage interposition stabilises and hides prostheses. The optimum technique depends on intraoperative findings, surgeon experience, and patient characteristics. Each method has pros and cons.

we can use many tools and resources, but there's no guarantee of improved results. Research shows that ossicular repair success rates vary widely due to prosthesis design, surgeon skill, and patient pathology. PORP's stability may aid people with intact stapes, while those with extensive ossicular damage need TORP. Autografts minimise the potential of a foreign body reaction, but their size, form, and availability can be troublesome. Titanium prostheses cost more but perform better. Due to the large range of possible results, it is vital to compare surgical approaches methodically to discover the optimal ones for clinical application. Surgery success depends on prosthesis stability, extrusion speed, and hearing improvement. Long-term follow-up must assess these aspects.

Clinical practice requires evaluation of the most successful, safest, cost-effective, and user-friendly ossicular restoration approach, especially in tertiary care hospitals like Patna Medical College & Hospital. Due to the high prevalence of chronic otitis media in India and its significant influence on hearing loss, comparing surgical options is important and suitable. This research could improve surgical decision-making, patient outcomes, and ENT surgeon practice in similar clinical settings.

We compare the efficacy of ossicular restoration surgeries in conductive hearing loss patients. PORP, TORP, and cartilage autografts are being tested. Patients' hearing improvement will be assessed using pure tone audiometry measurements before and after surgery, complications, and long-term results. A comprehensive approach to this research should strengthen the data base for ossiculoplasty best practices and enhance middle ear disease treatment.

Materials and Methods

Study Design and Setting: The prospective observational study was conducted at Patna Medical College & Hospital in Bihar, India, in its Otorhinolaryngology Department. Research ran from January 2023 to January 2025. The Institutional Ethics Committee approved the study before it began. After getting informed consent from patient they were included in study.

Sample Size and Participant Selection: In the study, 30 adults were scheduled for ossicular reconstructive surgery for conductive hearing loss caused by chain disintegration. Patients were successively selected using eligibility criteria.

Inclusion and Exclusion Criteria

Inclusion criteria were as follows:

- Adult patients (aged 18 years and above)
- Documented conductive hearing loss with ossicular chain damage confirmed on otoscopic, radiologic, and intraoperative evaluation
- Willingness to undergo surgical treatment and comply with follow-up protocol

Exclusion criteria included:

- Patients with congenital middle ear anomalies
- Cases with mixed or sensorineural hearing loss
- Patients with systemic illnesses contraindicating surgery
- Revision ossiculoplasty cases

Grouping Based on Surgical Technique

Patients were divided into three groups based on the ossicular reconstruction technique employed during surgery:

- **Group A**: Partial Ossicular Replacement Prosthesis (**PORP**)
- **Group B**: Total Ossicular Replacement Prosthesis (**TORP**)
- **Group C**: **Cartilage or autograft** ossiculoplasty (using patient's own cartilage or incus)

The choice of technique was made intraoperatively based on the extent of ossicular damage and availability of structures, particularly the stapes superstructure.

Data Collection and Follow-up: The medical history and physical results of each patient were properly noted. An audiologist employed pure tone audiometry (PTA) before surgery and one, three, and six months afterward to assess hearing. The

main effect was the air-bone gap (ABG) closing in decibels (dB).

Intraoperative findings included middle ear mucosa, stapes superstructure, and prosthesis. We recorded any issues such prosthesis displacement or extrusion, infection, or hearing loss during postoperative follow-up appointments.

Statistical Analysis: Data analysis was done with SPSS (25.0). Demographics and hearing outcomes were summarised using descriptive statistics. ANOVA or chi-square were used to compare the three groups, and a p-value sub 0.05 indicated statistical significance.

Results

Demographic Profile of Study Participants: A total of 30 patients undergoing ossicular reconstruction were included in the study, with 10 patients in each group (Group A – PORP, Group B – TORP, Group C – cartilage/autograft). The mean age of participants was 36.8 ± 9.5 years, with a range of 19 to 56 years. There were 17 males (56.7%) and 13 females (43.3%), and no significant difference in demographic distribution was noted among the groups ($p > 0.05$).

Table 1: Demographic Characteristics of Patients

Parameter	Group A (PORP)	Group B (TORP)	Group C (Cartilage/Autograft)	Total
Number of patients	10	10	10	30
Mean Age (years)	34.6 ± 7.1	38.3 ± 8.7	37.5 ± 10.2	36.8 ± 9.5
Male	6	5	6	17 (56.7%)
Female	4	5	4	13 (43.3%)

Preoperative and Postoperative Hearing Assessment:
All patients underwent pure tone audiometry (PTA) before and after surgery. The primary outcome was air-bone gap (ABG) closure, measured in decibels (dB). A paired t-test showed statistically significant improvement in ABG within each group postoperatively ($p < 0.001$). Mean ABG improvement was highest in Group A (PORP), followed by Group C (cartilage/autograft), and lowest in Group B (TORP).

Table 2: Pre-op vs. Post-op Hearing Outcomes (ABG in dB)

Group	Pre-op ABG (Mean ± SD)	Post-op ABG (Mean ± SD)	Mean Improvement	p-value
Group A (PORP)	33.4 ± 4.5	14.2 ± 3.9	19.2	<0.001 **
Group B (TORP)	35.1 ± 5.2	20.8 ± 4.7	14.3	<0.001 **
Group C (Cartilage)	34.6 ± 4.8	16.9 ± 4.2	17.7	<0.001 **

Significant at $p < 0.05$

Complications by Group: Postoperative complications were relatively few and varied by group. The most common complication was prosthesis displacement**,** seen predominantly in the TORP group. One case of extrusion and one of persistent otorrhea were observed in Group B.

Table 3: Postoperative Complications

Complication	Group A (PORP)	Group B (TORP)	Group C (Cartilage)
Prosthesis displacement	0	2	1
Extrusion	0	1	0
Otorrhea (persistent)	1	1	0
Total Complications	1	4	1

Surgical Success Rate: Success was defined as postoperative ABG ≤ 20 dB at 6 months. The success rate was 90% in Group A, 60% in Group B, and 80% in Group C. One-way ANOVA showed a statistically significant difference in hearing outcomes among the three groups ($p = 0.041$).

Discussion

This prospective observational study examined and compared ossicular chain repair surgeries for patients with conductive hearing loss. The PORP group improved hearing the most, as indicated by air-bone gap (ABG) closing, compared to the TORP and cartilage or autograft ossiculoplasty groups.

The other two groups were tight. The TORP group had the most complications and the least hearing threshold improvement. Ossicular restoration helps restore hearing because all three groups had significant ABG improvements after surgery. The groups' results differed significantly ($p = 0.041$), suggesting that the surgical method determines the intervention's success. While problems were rare,

they were more common in the TORP group and usually involved prosthesis displacement or extrusion. This is likely because to the extensive repair needed without the incus or stapes superstructure.

Comparison with Existing Studies: This study confirms previous findings. [13] Found that PORP reconstructions closed postoperative ABG better than TORP when the stapes superstructure was intact. A meta-analysis by [14] indicated that PORP had a success rate of 70–90%, compared to 50–70% for TORP, due to better prosthesis anchoring and stability. Cartilage and autograft ossiculoplasties work in underdeveloped nations when synthetic prostheses are scarce. Our data confirm that autograft/cartilage reconstruction is inexpensive, reliable, and complication-free.

Our complication profile matches prior studies that demonstrate TORP procedures increase prosthesis instability risk. This is presumably due to no stapes superstructure support. Two of ten TORP instances had prosthesis displacement in our investigation, but none in PORP [15]. Middle ear surgery risks anatomical incompatibility or postoperative infection; one TORP extrusion case may imply this.

Best Performing Technique: This study indicated that PORP ossicular repair was best for hearing restoration and patient prognosis. This group had a 19.2 dB mean ABG improvement over TORP (14.3 dB) and cartilage/autograft (17.7 dB). In the PORP group, the success rate (defined as ABG $\leq$ 20 dB at 6 months post-op) was 90%, much higher than previous procedures. PORP experienced the fewest issues, aside for a medication-responsive mild chronic otorrhea. In cases with full ossicular discontinuity, TORP is necessary, although its lower success rate (60%) and additional problems (n=4) make it riskier. With an 80% success rate, cartilage/autograft ossiculoplasty proves native tissue regeneration is safe and effective when resources are short.

Surgical Ease, Prosthesis Availability, and Patient Outcomes: Stable and easy to place, the stapes superstructure makes PORP treatments easier for surgeons. Anchoring the prosthesis to the footplate and aligning it make TORP operations harder. This complexity may have contributed to the TORP group's increased complication rate. Patna Medical College & Hospital needs resources. PORP and TORP prostheses, especially titanium ones, are expensive and unavailable to most patients. In this case, patient incus or tragal cartilage autografts are effective. Suitable for low-resource settings, these biocompatible materials are easily accessible during surgery and cost nothing more. Expert sculpting is needed for autografts, which may last longer. In this study, objective audiological findings matched patient satisfaction. Some TORP patients worried about hearing loss or postoperative pain, although cartilage and PORP patients reported better hearing and quality of life.

Limitations of the Study: This study has several limitations, but it provides vital information. First, the small sample size of 30 patients limits statistical power. A larger sample may improve generalisability and comparability. Second, because it only included one tertiary care center's surgical and postoperative treatment preferences, institutional bias may have biassed the results. Six months is enough for early evaluation, but it may not capture prosthesis stability or late effects such extrusion or recurrent otitis media. Long-term hearing restoration effects need further longitudinal study with extended follow backs. Even if surgical grouping was based on intraoperative observations, lack of randomisation increases selection bias. Surgeons' unconscious choice of procedure based on case severity may have affected results.

Strengths of the Study: The study's strengths make it not entirely terrible. This prospective Indian hospital study compares three ossicular repair techniques. Both synthetic and autologous materials were employed, reflecting clinical variance, making the findings relevant to resource-constrained institutions.

Standardised audiometric tests (PTA) at postoperative intervals provide credible and quantifiable hearing improvement data. Careful documentation of intraoperative observations, complications, and patient-reported outcomes improves analysis. The study concludes that ossiculoplasty requires tailored surgical planning. The best approach depends on individual patient's anatomy, prosthesis availability, and surgeon expertise, not a universal strategy.

Conclusion

This prospective observational study at Patna Medical College & Hospital compared total osseointegration (TORP), vestibular osteotomy (PORP), and cartilage/autograft ossicular reconstruction methods for patients with conductive hearing loss caused by ossicular chain damage. Patients' hearing improved dramatically with all three procedures. PORP closed the mean air-bone gap (ABG) the most, had the highest success rate, and had the lowest complication rate when the stapes superstructure was intact. Cartilage/autograft ossiculoplasty also performed well in resource-poor areas without synthetic prostheses. Despite its necessity in complete ossicular erosion, TORP increased difficulties and lowered audiological success. This research supports the premise that surgeons should consider intraoperative outcomes, prosthesis availability, and patient history when choosing an ossicular

reconstruction technique. This highlights ossiculoplasty surgical training and high-quality prostheses. New ossicular chain repair materials and methods need larger, multicentric randomised trials with long-term follow-up to compare their efficacy and hearing durability.

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