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INDIVIDUALIZED TYMPANOPLASTY TECHNIQUES: INTEGRATING INTRAOPERATIVE JUDGMENT AND PATIENT-SPECIFIC ANATOMY

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ABSTRACT

Background: Tympanoplasty, though traditionally categorized into standardized types (I - VI), often requires a patient-centered tailored approach based on anatomical, pathological, and audiological variations. The paradigm in surgical practice is shifting toward individualized decision-making, reflecting its growing importance in optimizing clinical results. **Objective:** To explore the surgeon's perspective on tailoring tympanoplasty techniques based on patient-specific variables and to assess the outcomes of such individualized surgical strategies. **Methods:** A prospective observational study was conducted over two years involving 34 tympanoplasty cases. Surgical plans were individualized based on middle ear status, ossicular integrity, Eustachian tube function, prior surgeries, and patient-specific needs. Data on surgical approach, graft material, ossiculoplasty decisions, and the use of endoscopy were recorded. Outcomes were evaluated in terms of graft uptake and hearing improvement.. **Results:** A tailored surgical approach resulted in complete graft success rate (100%) and significant auditory improvement across all types of tympanoplasty.While temporalis fascia was the graft material used in most cases, cartilage grafts were selectively utilized in ears susceptible to retraction. The tailored surgical decision-making by the surgeon led to better outcomes, with fewer complications and greater patient-reported satisfaction than protocol-driven approaches. **Conclusion:** An individualized approach to tympanoplasty guided by intraoperative findings, patient-specific factors, and addressing all relevant aspects of the middle ear cleft when indicated, yields superior outcomes compared to type-based surgical algorithms.This highlights the critical role of surgical judgment and adaptability in middle ear reconstruction.

KEYWORDS

Tympanoplasty, individualized surgery, patient-specific approach, surgeon perspective, middle ear reconstruction, hearing outcomes

INTRODUCTION

Tympanoplasty, the surgical restoration of the tympanic membrane, is one of the most frequently performed procedures in otologic surgery. Since the foundational work of Wullstein and Zollner in the mid-20th century, the principles of tympanoplasty have evolved from standardized techniques toward more nuanced, tailored approaches [1,2]. While the goals remain consistent—achieving a dry ear, restoring sound conduction, and maintaining middle ear aeration and volume —the pathway to these outcomes must often be customized based on individual patient characteristics.

The classic Wullstein classification of tympanoplasty types was revolutionary in its time. However, with advancements in microsurgical techniques, imaging, audiological assessment, and a deeper understanding of middle ear pathophysiology, tympanoplasty requires a more dynamic and patient-centered framework [3]. A surgeon must weigh factors such as perforation size and location, middle ear mucosa condition, Eustachian tube function, ossicular chain status, anatomical variations, deep canal involvement, ingrowing epithelium , osteitis and comorbidities [4].

Pediatric patients, for instance, often exhibit immature Eustachian tube function, leading to lower graft uptake and higher rates of reperforation. In these cases, cartilage tympanoplasty offers increased structural rigidity and resistance to retraction, making it a preferred option [5]. In contrast, adult patients with isolated central perforations and good Eustachian function may do well with traditional temporalis fascia underlay techniques, yielding excellent hearing outcomes [6].

The status of the contralateral ear and baseline hearing thresholds also play an essential role in surgical decision-making. Anterior or subtotal perforations may require overlay grafting techniques to ensure complete closure [7]. The integration of endoscopic ear surgery has further improved visualization and accessibility, especially in cases with narrow external auditory canals or anterior overhang [8].

Thus, the individualized approach to tympanoplasty represents a paradigm shift—from standardization to surgical personalization—emphasizing precision, adaptability, and patient-specific optimization [9].

MATERIALS AND METHODS

Study Design And Setting

A prospective observational study was conducted in the Department of Otolaryngology at a tertiary care hospital, over a 2 year period. Institutional Ethics Committee approval was obtained, and informed consent was secured from all patients (or guardians for pediatric cases).

Patient Selection

Inclusion Criteria:

- Patients aged 7–60 years diagnosed with chronic suppurative otitis media (CSOM), mucosal type and squamosal type . .
- Willingness to undergo tympanoplasty and regular follow- ups

Exclusion Criteria:

- Otomycosis at the time of surgery.
- Patients lost to follow-up.

Preoperative Evaluation

Each patient underwent clinical evaluation including otoscopy, microscopy, and endoscopic ear examination to assess perforation size, location, middle ear status, and canal anatomy. Pure tone audiometry (PTA) was performed preoperatively to assess the air-bone

gap (ABG). CT temporal bone was done in selected cases with suspected ossicular pathology or anatomical variations.

Surgical Planning And Technique

Surgical Technique Was Individualized Based On:

- **Graft Material:** Temporalis fascia, tragal cartilage, or conchal cartilage grafts.
- **Approach:** Postauricular (microscopic) or transcanal , depending on canal anatomy and perforation characteristics.
- **Technique:** Underlay with 360 degree intact skin tube technique

Decision-Making Algorithm Included:

- Anterior/subtotal perforations → cartilage augmentation ± underlay technique
- Pediatric or poor Eustachian function → cartilage grafting.
- Well-ventilated middle ears → fascia with underlay.

All procedures were performed by single experienced surgeon under local or general anesthesia.

Objective Assessment

Primary Objective:

- Graft uptake at 1 month (intact vs. residual perforation).
- Hearing improvement assessed via mean air-bone gap (ABG) closure at **1 months**, **3 months**, **6 months, 1 year**, and **2 years**.

Secondary Objective:

- Intraoperative and postoperative complications.
- Correlation between individualized surgical technique and clinical/audiological outcomes.

Sample Size

This pilot observational study estimated the sample size using the formula for a single proportion.

Assumptions:

- Graft success rate (p) = 100%
- Confidence level = 95% (Z = 1.96)
- Margin of error (d) = 10%

The calculated minimum sample size was 34.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics (version XX).

- **Continuous Variables:** Mean ± SD or Median (IQR)
- **Categorical Variables:** Frequencies and percentages
- **Primary Outcomes:** Expressed with 95% CI
- **Tests:** Chi-square or Fisher's exact for categorical; t-test or Mann-Whitney U for continuous variables
- $p < 0.05$ was considered statistically significant

Due to small sample size, emphasis was placed on trends and feasibility rather than hypothesis testing.

RESULTS

Patient Demographics And Clinical Profile

A total of **34 patients** (20 males, 14 females) underwent individualized tympanoplasty procedures over the study period. The mean age was **29.1 ± 11.8 years** (range: 7–60 years).

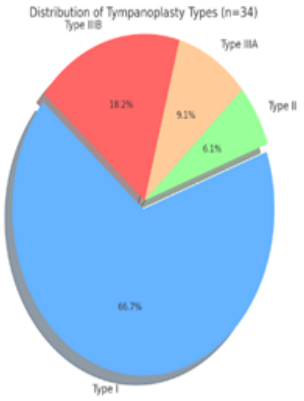
- **Pediatric cases (<18 years)**: 3 patients (8.8%)
- **Mucosal CSOM**: 24 patients (70.6%)
- **Squamosal CSOM**: 10 patients (29.4%)
- The predominant symptom was **persistent ear discharge with hearing loss**.
- Preoperative mean air-bone gap (ABG): **27.4 ± 6.2 dB**

Surgical Details

- **Surgical Approach**:
- **Postauricular (microscopic):** 32 cases (94%)
- **Transcanal (microscopic) :** 2 cases (5.88%)

- **Graft Materials**:
- **Temporalis fascia:** 30 cases (88.2%)
- **Cartilage grafts (tragal or conchal):** 4 cases (11.7%)

- **Tympanoplasty Types:**
- **Type I:** 22 cases (64.7%)
- **Type II:** 2 cases (5.9%)
- **Type IIIA:** 3 cases (8.8%)
- **Type IIIB:** 6 cases (17.6%)



Primary Outcomes

Graft Uptake

- **Graft Success Rate At 1 Month: 100% (34/34)**

All patients achieved complete graft uptake without residual perforation and maintained graft integrity during the follow-up period.

Hearing Outcomes (ABG Closure)

Progressive improvement in hearing was noted at each follow-up interval:

Follow-up Time	Mean ABG (dB)	Mean ABG Closure (dB)
Pre-op	27.4 ± 6.2	—
1 month	18.1 ± 5.9	9.3 ± 3.1
3 months	14.4 ± 5.3	13.0 ± 4.1
6 months	12.0 ± 4.1	15.4 ± 4.6
1 year	10.6 ± 3.7	16.8 ± 4.4
2 years	9.4 ± 3.1	18.0 ± 4.9

- Significant **ABG closure ($p < 0.001$)** was seen across all tympanoplasty types.
- **Best audiological outcomes** were observed in Type I and II tympanoplasties using temporalis fascia.
- Cartilage grafts used in pediatric and subtotal perforations also yielded **excellent hearing improvement** with no structural compromise.

Secondary Outcomes

- **Intraoperative/early complications**: None
- **Minor Postoperative Complications**:

Myringits, tinnitus and epithelial pearl was seen in 3 patients (8.8%) – resolved with conservative management.

- **No cases** of graft failure, lateralization, reperforation, sensorineural loss, or cholesteatoma during 2-year follow-up.

Surgical Individualization And Outcomes

- All patients received tailored surgical techniques based on their anatomical and functional middle ear profile.
- Cartilage grafts performed equally well in terms of **graft uptake and hearing results**.
- Sliced cartilages used for augmentation of the temporalis fascia graft (0.5mm thickness)
- **Customized decision-making** led to **excellent outcomes** in terms of graft success, hearing gain, and patient satisfaction.

DISCUSSION

This study reinforces the clinical value of an individualized, patient-specific approach to tympanoplasty, with excellent outcomes observed in both graft uptake and hearing restoration. All 34 patients achieved complete graft uptake (100%) at 1 month, with no reperforation, lateralization, or graft failure over a 2-year follow-up, aligning favorably with literature reporting success rates of 85–95% (5,10).

Hearing outcomes showed progressive and statistically significant improvement, with mean air-bone gap (ABG) improving from 27.4 ± 6.2 dB preoperatively to 9.4 ± 3.1 dB at 2 years, reflecting a mean ABG closure of 18.0 ± 4.9 dB ($p < 0.001$), which is in line with previous studies indicating favorable hearing gains following successful tympanoplasty (4,12). Temporalis fascia, used in 88.2% of

patients—especially in Type I and II tympanoplasties—showed superior hearing results, consistent with findings from Saliba et al. (13), who highlighted the fascia's favorable acoustic properties and long-term reliability. Cartilage grafts, selected in 11.2% of cases—particularly in subtotal perforations and pediatric ears—performed equally well in terms of graft integration and hearing, echoing results from Dornhoffer (7), Zahnert et al. (14), and Mohamad et al. (15), who emphasized cartilage's resistance to retraction and infection without compromising auditory outcomes.

The tailored surgical technique, guided by middle ear status, ossicular chain integrity, and perforation characteristics, allowed for optimal intraoperative decision-making. Notably, the absence of major complications, along with only minor self-limiting postoperative issues (myrinigitis, epithelial pearl, tinnitus 8.8%), demonstrates the safety of this individualized strategy. These findings align with the evolving surgical philosophy advocated by Albera et al. (16) and Dornhoffer (7), which favors adaptability over type-based classifications, highlighting that intraoperative customization based on real-time pathology enhances both anatomical and functional outcomes in tympanoplasty.

The most significant advantage was the surgeon's refined ability to interpret intraoperative findings and adjust surgical parameters including graft type, approach, and ossicular management, ensuring optimal anatomical and functional outcomes. This adaptability, guided by preoperative imaging and intraoperative judgement, led to **fewer complications (only 8.8%)** managed conservatively and avoided rigid adherence to a one-size-fits-all protocol.

While this study supports the shift from traditional, type-based tympanoplasty algorithms toward a **personalized surgical philosophy**, it also highlights the **need for surgeon expertise** in weighing multiple variables simultaneously—a skill that improves with experience and ongoing refinement of technique.

Limitations

This was a **single-center pilot study** with a **small sample size**, limiting the generalizability of the findings. Longer follow-up is needed to evaluate long-term graft stability and sustained hearing gains. Further, randomized comparative studies between individualized and protocol-driven tympanoplasty could more definitively quantify the benefits of this approach.

CONCLUSION

An individualized approach to tympanoplasty—rooted in the surgeon's expertise, clinical judgment, and meticulous anatomical assessment—has been shown to consistently yield excellent outcomes in both graft uptake and hearing restoration, even in complex or challenging middle ear pathologies. By moving beyond the confines of traditional classification systems, this paradigm advances the concept of tailored, precision otologic surgery centered on individual patient anatomy and pathology.

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