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Factors influencing hearing outcomes in pediatric patients undergoing ossicular chain reconstruction☆

Nandini Govil, MD, MPH [a], Thomas M. Kaffenberger, BS [b], Amber D. Shaffer, PhD [c], David H. Chi, MD [a, c, *]

[a] Department of Otolaryngology, University of Pittsburgh Medical Center, Eye and Ear Institute, Suite 519, 203 Lothrop St, Pittsburgh, PA 15213, USA
[b] University of Pittsburgh School of Medicine, M240 Scaife Hall, 3550 Terrace St, Pittsburgh, PA 15261, USA
[c] Division of Pediatric Otolaryngology, Children's Hospital of Pittsburgh of UPMC, 4401 Penn Ave, Pittsburgh, PA 15224, USA

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ABSTRACT

Objective: Ossicular chain disruption in children leads to conductive hearing loss. Few studies have focused on factors influencing successful results in pediatric ossicular chain reconstruction (OCR). We aim to determine whether demographic or surgical factors affect hearing outcomes in pediatric OCR.
Methods: We conducted a retrospective chart review of 120 patients undergoing OCR at our institution, a tertiary care hospital, between 2003 and 2014, with median length of follow-up of 2.2 years (range 0.1 −9.3 years). Pediatric patients (<18 years old at time of surgical procedure) who had current procedural terminology (CPT) codes of OCR, and available pre- and post-operative audiograms were included in the study. Demographic information, surgical details, and pre- and post-operative pure-tone averages (PTA), speech reception thresholds (SRT), and air-bone gaps (ABG) were recorded from clinic notes, audiograms and operative reports. Differences between PTA, SRT and ABG pre- and post-operatively, as well as demographic and surgical factors, were evaluated using Wilcoxon rank-sum tests. Factors influencing revision were evaluated using Log-rank tests.
Results: A total of 120 patients (123 ears) were included. 35.8% of cases were revised, most commonly due to displaced prostheses. 28.5% of surgeries resulted in normal hearing (PTA ≤25 dB) post-operatively. Post-operative SRT and ABG were significantly better in patients with partial ossicular replacement prosthesis (PORP) compared with those with total ossicular replacement prosthesis (TORP) ($p = 0.016$, 0.027). Titanium prostheses resulted in better post-operative PTA and larger changes in PTA compared with all other materials ($p = 0.034$, $p = 0.038$).
Conclusions: In our experience, children with titanium prostheses had better hearing outcomes than those with other materials, and children with PORP had better hearing outcomes than those with TORP.

1. Introduction

Ossicular chain (OC) disruption occurs in children due to several etiologies including genetic disorders, chronic suppurative otitis media, cholesteatoma, and trauma [1]. Discontinuity leads to conductive hearing loss, which can negatively impact the social and educational development of children. Surgical ossicular chain reconstruction (OCR) re-establishes the vibratory forces needed to properly conduct sound from the tympanic membrane to the cochlea. Although there is a need for expeditious and safe OCR in children, there are few studies examining which surgical techniques lead to consistently positive hearing results [1–3].

Due to the lack of large evidence-based studies focusing on OCR in the pediatric population, pre-operative counseling is limited. Often, surgeons utilize statistics from studies looking at outcomes in both adults and children. Most of the studies in children have focused on the results of tympanoplasty or looked exclusively at the results of OCR in children after cholesteatoma surgery [4–6]. Therefore, counseling a patient with a different pathology, such as a traumatic OC disruption, is challenging. Additionally, intra-operative decision-making about type of prosthesis, material of prosthesis, and surgical technique are often based on anecdotal or

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* Corresponding author. UPMC Department of Otolaryngology, 4401 Penn Ave, Pittsburgh, PA 15224, USA.
E-mail address: david.chi@chp.edu (D.H. Chi).

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learned experience. Finally, there is sparse literature on what factors influence revision rates and prosthesis extrusion, and how to improve long-term outcomes for children.

In this study, we assess the influence of demographic factors, etiology of OC disruption, type and material of prosthesis, and surgical technique on hearing outcomes in children undergoing OCR in a tertiary care hospital setting.

2. Material and methods

Electronic medical records (EMR) of patients undergoing OCR at Children's Hospital of Pittsburgh of UPMC between 2003 and 2014 were reviewed in compliance with IRB# PRO15010042 (University of Pittsburgh Institutional Review Board). Each patient's chart and operative note, and 120 patients who met inclusion criteria of having available pre- and post-operative audiograms with available hearing outcome data were included.

Patients' demographics, including age, birth history, family medical history, and past medical and surgical history, were recorded. For each affected ear, four-frequency air conduction pure-tone averages (PTA), speech reception threshold (SRT), and the air-bone gap (ABG) at 0.5, 1, 2, and 3 kHz were calculated and recorded from audiograms. When PTA or ABG at 3 kHz frequency was not available, it was calculated as the average of values at 2 and 4 kHz. Severity of hearing loss was determined based on the PTA of the operative ear (0–25 Normal; 26–40 Mild; 41–70 Moderate; 71–90 Severe; >90 Profound) [7]. Patients who underwent bilateral OCRs had data recorded separately for each ear. Data such as indication for OCR, type and material of prosthesis, presence or absence of cartilage graft, and type of mastoidectomy were noted. The difference between pre-operative and post-operative PTA, SRT, and ABG were used to assess improvement of hearing following OCR. For all patients, the pre-operative audiogram immediately preceding the first OCR was compared to the post-operative audiogram immediately following the same OCR. OCR complications were recorded as well as reasons for revisions. Follow up duration was determined from patients' initial surgery date to most recent audiogram date.

Indications for reconstruction were classified as acquired cholesteatoma, eustachian tube dysfunction (ETD), syndromic ETD, congenital cholesteatoma, congenital malformations of the ossicular chain, and temporal bone fracture. ETD patients had histories of erosion and disruption of the ossicular chain due to chronic or recurrent otitis media without retraction pocket cholesteatoma. Syndromic ETD included Pierre-Robin sequence and genetic syndromes associated with ETD such as Stickler, Noonan, Crouzon, Down's, Treacher Collins, Branchiootorenal, CHARGE, and Turner syndromes. Congenital malformations of the ossicular chain included patients with microtia and isolated idiopathic middle ear malformations.

Various materials were used for reconstruction. These included cartilage, titanium, hydroxyapatite (HA) alone or in combination with polyethylene or titanium, incus interposition grafts, and bone cement. Cartilage was grouped together with incus interposition grafts as autologous grafts.

Age, hearing measures, and number of revision surgeries were not normally distributed. Therefore, they are presented as median (range). Changes in hearing levels were evaluated using the Wilcoxon signed-rank test. The proportions of patients with hearing loss before and after OCR were compared using McNemar's test. The effects of age, family and medical history, indication for reconstruction, material used, PORP vs. TORP, cartilage graft, and surgeon were assessed using linear regression, Wilcoxon rank-sum or Kruskal-Wallis tests. Log-rank, Cox proportional hazards, logistic, and linear regression were used to assess associations between each of these variables and length of follow-up and the need for revision OCR surgeries. Statistical comparisons were conducted using Stata (StataCorp LP, College Station, TX).

3. Results

3.1. Demographics

Demographic characteristics are outlined in Table 1. A total of 120 patients were included in this study. Medical history included OM in 79.2% of patients, cleft palate in 5.0% of patients, and prematurity in 5.8% of patients.

3.2. Surgical details

Surgical details are shown in Table 2. The left ear was affected in 63/120, and the right ear was affected in 54/120 patients. The remaining 3/120 (2.5%) patients underwent bilateral OCR with each ear addressed at separate times, for a total of 123 ears. The most common reason for abnormality of the OC was acquired cholesteatoma in 64.2% of patients. More cases used TORP than PORP. Cartilage graft was used to bolster 89 (88.1%) of these 101 prostheses. Eight different attending surgeons performed the surgeries. The presence of trainees (residents and fellows) in the cases was not included since this information was inconsistently documented in the operative reports.

3.3. Hearing outcomes

Hearing outcomes are shown in Table 3. Overall, OCR significantly improved PTA, SRT, and ABG. Bone conduction was measured in 120/123 cases pre-operatively and 110/123 cases post-operatively, providing 108 paired ABG comparisons. Thirty-five patients (28.5%) had normal hearing (PTA $\leq$25 dB) after OCR. Patients who underwent revision surgery had more hearing loss compared to other patients, even after OCR surgery.

Pre- and post-operative ABG are shown in 10 dB bins in Fig. 1. Following OCR, significantly more patients had ABG 11–20 dB ($p = 0.008$) and fewer patients had ABG >30 dB ($p < 0.001$). It was not possible to include a scattergram with PTA and word recognition scores (WRS) because our audiologists do not obtain WRS in our pediatric population [8].

3.4. Etiology

Hearing outcomes were stratified by etiology. Patients with temporal bone fracture had impressive improvements in PTA and SRT (23 and 25 dB, respectively), but there were no significant differences in hearing measures based on etiology.

Table 1
Demographic information.

Number of Patients (n)	120
Sex, n (%)	
Male	74 (61.7%)
Female	46 (38.3%)
Family History, n (%)	
Hearing Loss	9 (7.5%)
Otitis Media	22 (18.3%)
Medical History, n (%)	
Otitis Media	95 (79.2%)
Cleft Palate	6 (5.0%)
Prematurity	7 (5.8%)