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Outcomes of Cartilage Tympanoplasty in the Pediatric Population

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Abstract

Objective—To justify the successful use of a patient selection algorithm based on age for primary cartilage tympanoplasty.

Study Design—Case series with chart review.

Setting—Tertiary care pediatric hospital.

Subjects and Methods—A retrospective chart review of patients between ages 4 and 13 who underwent cartilage tympanoplasty for tympanic membrane perforations from August 2005 to November 2011 was performed. Demographics, complication data, and auditory outcomes were collected.

Results—Patients were subdivided into three age groups. Group 1 consisted of patients less than 7 years of age (n=43), group 2 ages 7 to 10 (n=40), and group 3 ages 10 to 13 (n=36). Mean follow up was 595 days (range=48-1742). Complication rates respective to the three groups were as follows: remnant perforation (6.97%, 5.00%, 2.78%), revision tympanoplasty (2.33%, 2.50%, 0%), and need for tympanostomy tubes (4.65%, 2.50%, 0%). Logistic regression models were used to evaluate complication rates between groups. No significant differences were found (remnant perforation, p=0.710, repeat tympanoplasty, p=0.998, tympanostomy tubes, p=0.875). No significance was found among audiological outcomes between the three groups.

Conclusion—These data suggest cartilage tympanoplasty can be performed effectively in young children when appropriate conditions exist.

Keywords

tympanoplasty; children; pediatric; cartilage; middle; ear; perforation; tympanic; membrane; repair; age; prognostic; factors

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INTRODUCTION

Pediatric tympanoplasty is a frequently performed procedure with varying reported success rates ranging between 35 and 94%. In general, tympanic membrane repair success in children is often perceived as lagging behind what is typically achieved in adults having similar underlying risk factors. Previously quoted reasons for the poorer success rate include: frequent upper respiratory tract infections, persistent otitis media and ongoing Eustachian tube dysfunction, and inconsistent postoperative care.¹

Graft choice in pediatric tympanoplasty (fascia versus cartilage) has not been examined to the extent that it has in the adult population where its use has been justified by excellent outcomes in numerous reports.² In 2003, Dornhoffer published a retrospective review of 1000 adult and pediatric patients that underwent cartilage tympanoplasty for all indications wherein a high perforation closure rate (96%) was noted with significantly improved hearing in all pathologies³—which was comparable to an similar earlier report⁴ that found cartilage to be no different than with fascia with respect to hearing outcomes. These findings were confirmed in a recent systemic review published by Mohamad et al. which aimed to elucidate the difference in efficacy of fascia grafts versus cartilage grafts concluded that cartilage tympanoplasty was associated with significantly better rates of tympanic membrane repair while resulting in hearing outcomes that were no different.² If one accepts these findings, the logical question follows as to why cartilage cannot reasonably be considered an acceptable default reconstruction material for most cases of tympanoplasty.

One possible source of hesitation in routinely using cartilage for pediatric tympanoplasty is the limited data available on the long-term outcomes and collective uncertainty regarding the appropriate timing of tympanoplasty relative to age. Among publications that have examined the significance of age as a prognostic value in pediatric tympanoplasty, the majority utilized fascia grafts for repair of the tympanic membrane and many lacked high numbers of pediatric patients. Thus, the purpose of this study is to explore long-term pediatric cartilage tympanoplasty outcomes with particular attention given to age. In doing so, we substantiate the hypothesis that, when patients are selected judiciously based on perceived underlying Eustachian tube maturity, outstanding hearing and perforation closure rates can be safely attained when cartilage is used as the standard default tympanoplasty grafting material in the pediatric population.

MATERIALS AND METHODS

Patients

All research was conducted at a tertiary care pediatric hospital after University of Arkansas for Medical Sciences institutional review board approval was obtained. A retrospective chart review was performed of all patients below the age of 13 who underwent type I cartilage tympanoplasty to repair a tympanic membrane perforation from August 2005 to November 2011 by the senior author as a single surgeon. Patients were subdivided into three age groups. Group 1 consisted of patients less than 7 years of age, group 2 ages 7 to 10, and group 3 ages 10 to 13. Exclusion criteria included patients who underwent prior cartilage tympanoplasty in the study ear, those with history of cholesteatoma, those undergoing

concomitant ossicular chain reconstruction, and those with atelectatic ears that did not have a perforation. The electronic and paper medical records of patients were reviewed and data were collected including: age, sex, type of graft utilized, complications, and follow-up visits. Several factors previously identified as possibly having an effect on outcome of tympanoplasty in the pediatric population were specifically reviewed. These included revision status, size of perforation >50%, and prior adenoidectomy.

Audiometric testing

Preoperative and postoperative audiometric measurements were reviewed including air and bone conduction threshold measurements. Pre- and postoperative pure tone average (PTA) air-bone gap (ABG) was calculated according to the 1995 American Academy of Otolaryngology—Head & Neck Surgery guidelines.⁵

Tympanoplasty

Decision about timing of tympanoplasty was undertaken according to the guidelines developed at our institution as set forth by Hartzell et al, namely: tympanoplasty is not considered until patients are at least 4 years of age. If the contralateral middle ear is found to be abnormal, adenoidectomy and nasal treatment are recommended, but tympanoplasty is delayed until age 7 (Figure 1).⁶

All patients underwent underlay cartilage tympanoplasty utilizing auricular cartilage grafts from the tragus or concha cymba. Specifically, if the perforation exceeded half of the tympanic membrane, a single large (8-9 mm diameter) circular composite perichondrium-cartilage island graft was utilized with perichondrium having been stripped off of the medial surface of the graft. If the perforation was small and limited to either the posterior or anterior portion of the tympanic membrane, either a single semicircular composite perichondrium-cartilage island graft or a palisade of small bare cartilage grafts subsequently covered with a piece of perichondrium was utilized (Figure 2). A postauricular or endaural approach was employed based on the surgeon's estimation of required visualization of the perforation.

Statistical Analysis

Differences among the three age groups (<7 yrs, 7-10 yrs, 10-13 yrs) were tested in terms of prognostic factors (revision, size of perforation, prior adenoidectomy) using Fisher's Exact tests. Logistic regression models were used to test the difference among the three age groups with respect to three complications: remnant perforation, need for revision tympanoplasty, and need for tympanostomy tubes.

A paired t-test was performed to test the difference between preoperative and postoperative pure tone average air-bone gaps. A repeated measure analysis of variance (ANOVA) model was used to test the difference between air bone gap measures across four frequencies (500, 1000, 2000, and 3000) among the three age groups. An alpha level of 0.05 was used to declare statistical significance for all statistical tests. SAS v9.3 (Cary, NC) was used for all statistical analyses.

RESULTS

A total of 119 patients (52 males and 67 females) met inclusion criteria and were included in the study. Group 1 consisted of 43 patients (mean age 5.5 years), group 2 of 40 patients (mean age 8.5 years), and group 3 of 36 patients (mean age 11.5 years). Mean follow up was 595 days for all subjects (range=48-1742) and 548, 735, and 575 in Groups 1,2, and 3 respectively.

Table 1 shows the possible negative prognostic factors in each group. No significant difference was found with Fisher's Exact tests between groups.

Functional outcome

Success rate, defined as graft take rate, for the three groups was 93.0%, 95.0%, and 97.2% for groups 1,2, and 3 respectively. Statistical analysis consisting of logistic regression models were used to test the difference among age groups with respect to remnant perforation, need for revision tympanoplasty, and need for tympanostomy tubes. Complications did not prove to be significantly different among the three comparison groups as portrayed in Table 2.

Audiologic outcome

The average preoperative PTA ABG across all groups was 20.67 dB and the average postoperative PTA ABG was 8.46 dB. The change between preoperative and postoperative hearing outcome was significant based on results of a paired t-test ($P<0.0001$).

Table 3 and 4 show preoperative and postoperative audiologic results for all patients included in the study by age group. A repeated measure ANOVA model was used to test the difference between air bone gap measures across four frequencies (500, 1000, 2000, and 3000) among the different age groups. This analysis showed no significance ($P=0.2559$) and confirms no difference between the audiologic outcomes after cartilage tympanoplasty among the different age groups.

DISCUSSION

Management of tympanic membrane perforations in the pediatric population is a common challenge and optimization of surgical technique for repair of these perforations is an ever-emerging field. As cartilage tympanoplasty is attaining widespread usage, questions linger regarding the ideal application of this technique in children such as determining what timing scheme is ideal. To the authors' knowledge, this is the largest report to date on pediatric cartilage tympanoplasty outcomes. At the authors' institution a specific previously published algorithm is followed that aims to stratify and select patients for surgery according to perceived underlying Eustachian tube maturity—although admittedly using age cut-offs for such a determination of maturity is imperfect. The current study sought to investigate the merit of this algorithm with the intent that its usage would have negated the effect of age-related risk factors in pediatric cartilage tympanoplasty. To this end, it is noted that no statistically significant difference was found between age groups with respect to either

tympanoplasty success rate or audiological outcomes—thereby seemingly providing support for our method of patient selection and surgical technique.

Age as a prognostic factor in pediatric cartilage tympanoplasty is controversial with seemingly contradictory results existing within the relevant medical literature. Vrabec et al performed a meta-analysis in order to determine whether technique or preoperative factors (including age) affect success in pediatric type I tympanoplasty and noted greater success with advancing age.⁷ Yet, similar to the findings in the current study, Yung et al (51 patients)⁸, Merenda et al (58 patients)⁹, and Umapathy and Decker (89 patients)¹⁰ all did not find age to impact cartilage tympanoplasty outcomes. It is unknown if our findings with respect to the impact of age would have differed if surgical timing had been made on a more random basis as opposed to the regimented timing algorithm outlined above.

The tympanic membrane repair success rate in this study was quite high with an average of 95.0% among the three groups with a mean follow up of greater than 1 1/2 years. This result compared favorably even to most of what has been published on adult tympanoplasty, thereby reaffirming the practice of using cartilage as the default tympanic membrane graft repair material in lieu of fascia at the authors' institution. As it is becoming more clear that the use of cartilage as a grafting material for tympanoplasty results in improved repair rates while avoiding significant impairment in hearing outcomes as compared to fascia², cartilage tympanoplasty appears to be becoming more common in children. Possible benefits of cartilage grafts over fascia that may account for improved outcomes include a relative tendency to rigidly fixate and avoid medial migration during the postoperative healing phase as well as a tendency to resist re-retraction when underlying Eustachian tube dysfunction is pervasive. Furthermore, it has been the authors' observation that, as compared to fascia, the bare medial surface of large cartilage grafts that have been stripped of perichondrium tend to be relatively resistant to adhesion formation within the middle ear cleft—in a manner similar to silastic.

In trying to delineate whether cartilage is preferable to fascia specifically in the pediatric population, a recent literature review by Nicholas et al. found only four studies examining results of pediatric cartilage tympanoplasty.¹¹ Success rates ranged from 71-100%. Two of these studies examined success of inlay butterfly cartilage tympanoplasty. Eavey examined this technique in 11 patients from the age of 6 to 19 and had a graft closure rate of 100%.¹² Couloigner et al. compared inlay cartilage grafting to an underlay fascia tympanoplasty technique in patients ranging from age 3 to 17 and noted no significant difference in outcomes between the two techniques.¹³ However, it should be noted that inlay butterfly grafting is a technique that is typically utilized for relatively small perforations. Gaslin et al. published their results of a new method of cartilage interleave tympanoplasty in 42 patients (ages 3 to 16) with a long-term success rate of 83.3%.¹⁴ Most recently, Ozbek et al. compared a cartilage palisade technique to fascia tympanoplasty in a retrospective study of 45 patients (ages 8 to 16) that found the cartilage repair rate (100%) to be statistically better than fascia (70.2%).¹⁵ In follow-up to their prior study, Ghanem et al. reviewed the use of butterfly cartilage inlay graft in patients with medium to large perforations and achieved a success rate of 90% with most patients experiencing an improvement in hearing postoperatively.¹⁶

Of the few postoperative perforations encountered in the current study, most (83.3%) occurred in areas where the cartilage graft was deficient (ie, at the edge of the graft or in the posterior quadrant when an anterior graft was performed). Eighty percent of these were small perforations that did not need to be repaired. Thus, the *de facto* cartilage tympanoplasty failure rate among our patients was in reality less than the 5% figure noted above.

Despite our enthusiasm for cartilage tympanoplasty, which has become the most frequently used tympanic membrane repair material in our practice for both adults and children, its use is not without negative consequences. First, if care is not taken when harvesting the graft, a donor-site cosmetic deformity may result. This is particularly true with respect to the tragus where preserving a residual lateral crescent of cartilage (ideally at least 2mm) is recommended. Second, assessment of the middle ear status by tympanometry is not useful following cartilage tympanoplasty due to the effects of its stiffness on tympanic membrane compliance. Third, opaque cartilage grafts render otoscopic view of the middle ear cleft impossible. Lastly, tympanic membrane intubation may be difficult following cartilage tympanoplasty. In our experience, a laser may be helpful in executing a myringotomy when tube placement is required. All of these potential negative consequences notwithstanding, it is the authors' impression that the upside of cartilage grafts is sufficient to justify their routine use in children. A prospective controlled study would be required to definitively establish this point, as the retrospective uncontrolled nature of the current study is an acknowledged weakness.

CONCLUSION

In summary, we note that the use of cartilage in pediatric type I tympanoplasty tympanoplasty for tympanic membrane perforation repair results in excellent outcomes that are comparable to the best-case outcomes that have been reported in the adult population. Furthermore, it appears that when pediatric cartilage tympanoplasty is timed according to perceived underlying Eustachian tube maturity, age does not impact the rate of tympanic membrane repair or hearing outcomes.

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Figure 1.
Algorithm for timing of tympanoplasty.

Figure 2.

A: sample cartilage perichondrium island graft with strip of cartilage removed to facilitate the malleus. B: example of cartilage palisade for reconstructing entire tympanic membrane.

Table 1

Possible Negative Prognostic factors

	Group 1 (<7 yrs)	Group 2 (7-10 yrs)	Group 3 (10-13 yrs)	<i>P</i>
Revision	2.33%	12.50%	5.88%	0.1859
Size of perforation > 50%	48.80%	32.50%	38.89%	0.3187
Prior adenoidectomy	41.86%	50.00%	61.11%	0.2256

Table 2

Complications

	Group 1 (<7 yrs)	Group 2 (7-10 yrs)	Group 3 (10-13 yrs)	<i>P</i>
Remnant perforation	6.97%	5.00%	2.78%	0.7099
Revision tympanoplasty	2.33%	2.50%	0.00%	0.9980
Tubes	4.65%	2.50%	0.00%	0.8747

Table 3

Preoperative ABG PTA

ABG PTA	<10dB	<20dB	<30dB	<40dB	<50dB
Group 1 (<7 yrs)	6 (17.6%)	16 (47.1%)	27 (79.4%)	33 (97.0%)	34 (100.0%)
Group 2 (7-10 yrs)	4 (10.5%)	22 (57.9%)	32 (84.2%)	37 (97.4%)	38 (100.0%)
Group 3 (10-13 yrs)	7 (20.6%)	21 (61.8%)	32 (94.1%)	33 (97.1%)	33 (97.1%)

Abbreviations: ABG, air-bone gap; PTA, pure tone average

Table 4

Postoperative ABG PTA

ABG PTA	<10dB	<20dB	<30dB	<40dB	<50dB
Group 1 (<7 yrs)	24 (63.2%)	35 (92.1%)	38 (100.0%)	-	-
Group 2 (7-10 yrs)	27 (69.2%)	28 (97.4%)	39 (100.0%)	-	
Group 3 (10-13 yrs)	24 (70.6%)	30 (88.2%)	33 (97.1%)	34 (100.0%)	-

Abbreviations: ABG, air-bone gap; PTA, pure tone average