Meta-analysis of Pediatric Tympanoplasty

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Objective: To determine which preoperative conditions or surgical techniques may influence the success of tympanoplasty in the pediatric population.

Data Sources: A MEDLINE search of the English-language literature from 1966 to May 1997 was conducted using the search terms pediatric or child and tympanoplasty or myringoplasty.

Study Selection: Articles that provided age-specific data on tympanoplasty or myringoplasty were included. Of the original 651 studies retrieved, 30 were accepted for inclusion. The principal reason for exclusion was inability to separate adult and pediatric results in series that combined both patient populations.

Data Extraction: Success was defined as an intact tympanic membrane for the purpose of this review. Data were tabulated by consensus of 2 reviewers.

Data Synthesis: The effect of surgical technique, prior adenoidectomy, presence of active infection, size of perforation, status of the contralateral ear, age, and eustachian tube function on healing of the tympanic membrane after surgery was assessed. Only those studies providing data on a given parameter of interest could be included when comparing each variable. Weighted means were compared and subjected to sensitivity analysis. Simple linear regression analysis was used to assess the effect of age on outcome.

Conclusions: Greater success in healing of the tympanic membrane following tympanoplasty in children is seen with advancing age. None of the other parameters studied was shown to be a significant predictor of success. Guidelines for reporting results of tympanoplasty are presented.


OTOLOGIC SURGERY in children is regarded by many as being less successful than in adult patients. The higher incidence of otitis media in the pediatric population is often implicated as the reason for poorer results. This leads to disparate opinions concerning the appropriate indications for tympanoplasty in children. Most would agree that the ear with cholesteatoma or some other middle ear tumor warrants surgery. The chronically draining ear that is resistant to medical therapy also requires surgery. However, the management of patients with persistent perforation of the tympanic membrane (TM), with or without intermittent otorrhea, incites considerable controversy. Some advocate early surgery to correct anatomic defects and improve hearing. Others maintain elective surgery should be deferred until the peak incidence of acute otitis media has passed.

The opinions on both sides of the debate are formed through personal experience or review of available literature. Numerous attempts have been made to define factors that predict success or failure in elective cases. Factors that have received attention include age, surgical technique, status of the contralateral ear, presence of adenoids, presence of active infection, size of the perforation, and function of the eustachian tube. In each instance, there are some that find the presence of a given factor adversely affects outcome and those that find no difference.

An example of the debate is seen in articles discussing the child's age at the time of operation. Some advocate surgery at any age, while others advise postponing intervention in elective cases until a given age is attained. Even the age at which surgery becomes advisable varies considerably. MacDonald et al recommend avoiding surgery before age 7 years, Koch et al suggest waiting to age 8 years, Shih et al favor age 10 years, and Raine and Singh prefer age 12 years. The age limits have frequently been based on statistical analysis of a small series of patients. At other times, the reasons are not stated.

In this report, the method of meta-analysis is applied to articles presenting results in pediatric tympanoplasty in an effort to define factors that positively or negatively influence outcome.
METHODS

A MEDLINE search of the English-language literature from January 1, 1996, to May 1, 1997, was conducted using a combination of the key words pediatric or child and tympanoplasty or myringoplasty. Thus, 4 searches were conducted, yielding 651 abstracts. The content of each abstract was reviewed in an attempt to find articles that presented results of surgical intervention. Whenever doubt remained as to the content of the article, it was read in full. The reasons for exclusion are displayed below.

Exclusion Criteria	No. of Articles
Total abstracts identified	651
Nonotolaryngologist audience	96
Other otologic procedures (eg, trauma, aural atresia)	70
Pathophysiology of otitis media	68
Surgical management of chronic otitis media (eg, cholesteatoma, ossiculoplasty)	259
Tympanoplasty results	129
(adults not separated from children)
Accepted articles	30

Articles were excluded if the focus of the report was presented to a nonotolaryngologist audience, including epidemiological reviews, articles presenting medical management strategies, or those detailing audiologic, anesthetic, or radiologic concerns. Articles discussing surgery for otologic conditions such as congenital deformities, traumatic injury, middle ear tumors, or lesions confined to the external canal were eliminated in an effort to produce a more homogeneous population of patients undergoing surgery for sequelae of otitis media. Among those articles discussing surgery for chronic otitis media, exclusions included articles that are limited to the discussion of ossiculoplasty, cholesteatoma, or limited myringoplasty techniques (ie, fat myringoplasty) or that introduce a medical device. Articles introducing technical modifications often represented a highly selected patient population, thus necessitating exclusion. Additional exclusions included articles discussing such topics as cavity reconstruction or obliteration, management of the atelectatic ear, or philosophy of staging.

The principal reason for exclusion of the remaining articles was the inability to extract age-specific data from a series of patients consisting of both children and adults. Many of the articles under the subheading “Surgical Management of Chronic Otitis Media” could also have been excluded for this reason. Other articles did not include data but merely presented an author’s opinions. Several authors have written more than 1 paper on this subject, presenting the same patients with longer follow-up. When the same series of patients was reviewed, only the most recent article (usually with the greatest number of subjects) was included in the analysis.

Any article that could provide data addressing the effect of age, surgical technique, presence of infection, status of the contralateral ear, function of the eustachian tube, size of the perforation, or adenoïdectomy was included. For analysis of age, data were tabulated for the ages of 6 to 18 years in 1-year increments. Success rates were reported for each age in some articles, while in others the success rate for those children older or younger than a given age were reported. Surgical technique was separated into medial grafting or underlay technique vs lateral grafting or overlay technique. Infection was classified as either present or absent (dry ear) at the time of surgery. The contralateral ear was specified as normal or abnormal. The reported presence of perforation, otorrhea, effusion, or atelectasis was considered abnormal. Eustachian tube function was considered normal or abnormal, although methods of testing tubal function varied among studies. Size of the perforation was classified as either more or less than 50% of the total surface area of the TM. Finally, for analysis of the effect of adenoidectomy, patients having prior or concurrent adenoïdectomy were compared with those with retained adenoids.

A total of 30 articles were included in data analysis. Seventeen of the articles were case series limited to type 1 tympanoplasty. In the remaining articles, most cases were type 1 tympanoplasties.

A uniform definition of success was necessary to compare publications. For the purposes of this review, success was defined as an intact TM following surgery. This definition was the most widely reported measure of success in the selected articles. Other defining characteristics, such as hearing result and incidence of postoperative complications, are equally important and are presented independently. In nearly all articles, the investigators do not report the relationship between hearing result or incidence of postoperative otitis media and the factors identified previously (age, perforation size, prior adenoïdectomy, status of the contralateral ear, eustachian tube dysfunction, or infection at the time of surgery).

For each study, the success rate (defined as number of postoperative intact TMs per number operated on) was calculated for each category of interest. Two investigators reviewed the studies and assigned values by consensus. When a variable was compared within studies, the mean weighted difference in success rates is reported. This was done for analysis of the effect of perforation size, prior adenoïdectomy, eustachian tube function, age, and status of contralateral ear. For age data, the mean weighted difference was calculated for each age, and a linear regression analysis was performed. The analysis of the effect of infection and surgical technique necessitated a comparison between studies; therefore, we used an unpaired t test.

Sensitivity analyses were conducted by deleting the most positive and most negative study, adjusting for age of follow-up, and adjusting for tympanoplasty type. Adjustment for follow-up time consisted of grouping all articles with less than 1 year of follow-up and those with 1 year or more. For a given study, all patients were assumed to have the minimum follow-up reported (range, 1 month to 5 years). Thus, each variable was analyzed in short-term and long-term studies only. Adjustment for tympanoplasty type involved separate analysis of articles that reported results on type 1 tympanoplasty only. Sensitivity analyses were performed for each factor of interest using all 4 methods. All calculations were performed in Microsoft Excel 5.0.

Table 1 presents statistical measures and 95% confidence intervals for each of the comparisons. In addition, all the data were analyzed according to the follow-up interval and type of operation. Linear regression analysis of the success rate over time did not show a statistically significant decline. Articles that included only type 1 tympanoplasties did not have...
reported results on dry ears only. For infected ears, 44 of 60 healed, while 408 of 514 dry ears healed. The weighted mean success rates were 73.3 for infected ears and 81.2 for dry ears. An unpaired t test found no significant difference (P = .26), unaltered by sensitivity analysis.

Technique was addressed in 18 articles, although none compared results of medial grafting with lateral grafting. Success for lateral grafts was achieved in 692 of 830 cases and for medial grafts, 872 of 1069. The weighted mean success rates were 88.8 for medial grafts and 90.9 for lateral grafts. The unpaired t test found no significant difference (P = .86). Sensitivity analysis did not change the interpretation of this result.

Nineteen articles provided data for calculation of success rate according to age. For each age, the numbers of articles presenting data were as follows: age 6 years, 5; age 7 years, 5; age 8 years, 10; age 9 years, 9; age 10 years, 8; age 11 years, 11; age 12 years, 7; and age 13 years, 8. The mean weighted differences of success at younger vs older than a given age were calculated, and linear regression analysis yielded a slope of −2.92 (P = .005), indicating an association of greater success with advancing age. The slope of the linear regression did not materially change on sensitivity analysis.

The incidence of postoperative complications, excluding recurrent perforation, reported in all studies was tabulated. These results are given below, but data are not sufficient to determine which preoperative factors predict a greater incidence of postoperative problems.

Hearing results are also reported as a combination of available studies (Table 2). The hearing results are given for all studies and those studies reporting results of type 1 tympanoplasty only. Nonhearing ears were specifically excluded from most works.

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<tr>
<th>Table 2. Hearing Results</th>
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<td><strong>No. (%)</strong></td>
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<tr>
<td><strong>All Cases</strong></td>
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<tr>
<td><strong>Type 1 Only</strong></td>
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<tr>
<td><strong>Postoperative Air Bone Gap, dB</strong></td>
</tr>
<tr>
<td>0-10</td>
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<tr>
<td>0-20</td>
</tr>
<tr>
<td>0-30</td>
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<tr>
<td>&gt;30</td>
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<tr>
<td><strong>Postoperative Speech Reception Threshold, dB</strong></td>
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<tr>
<td>0-10</td>
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<tr>
<td>0-20</td>
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<tr>
<td>0-30</td>
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<tr>
<td>&gt;30</td>
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The factors chosen for analysis have long been identified by surgeons as variables that could potentially in-
fluence the outcome of tympanoplasty. Because the TM must heal by secondary intention, the size of the perforation may influence the results. The status of the contralateral ear and tests for eustachian tube function attempt to predict the likelihood of recurrent otitis media. Adenoidectomy can lessen the incidence of recurrent otitis media with effusion and, therefore, may also serve to predict a lower incidence of recurrent disease. The patient’s age as a predictor of success emerged through experience of otologic surgeons. The most common explanation for this relationship is that the younger patient’s age will predict a lower incidence of recurrent disease. The age-related criteria for surgery outlined earlier. Surgical technique is also commonly cited as a factor in outcome, although it is not inherently obvious why the position of the graft in relation to the remnant of the TM should make any difference at all.

In viewing the results of this study, attention is directed to the numbers of patients included in each analysis. Naturally, the greater the number of observations, the more reliable the conclusion that can be reached as to the effect of a variable on outcome. One of the limitations of this analysis was the tendency of authors to state they had investigated the effect of a given factor and found no difference in outcome, yet they did not report the raw data. A nonsignificant finding, however, does not imply equivalence of the 2 groups being compared. The possibility of missing a significant effect of a given factor when one exists can be remedied by accumulating additional data.

The relationship between age and outcome was not compromised by a paucity of data. Interestingly, this outcome is opposite of the consensus opinion of the authors of the studies. Twenty-five of the 30 articles state that there is no difference in success based on the patient’s age. An analysis of how the authors reached their conclusion is enlightening. Four of the 5 who do find a difference provide data for all age groups studied, and their conclusions are drawn through retrospective analysis. The fifth article prospectively excluded children younger than 8 years. Of those that believe there is no difference, Black et al found poorer results in the youngest patients, but these results did not reach statistical significance in their respective series. Gersdorff et al found results poorer in children when compared with adults. Kessler et al found no difference in short-term success rates but noted a greater incidence of reperforation in children younger than 6 years. Ophir et al find no difference, yet an earlier report from their institution concluded that age was a significant factor.

Children younger than 9 years were prospectively excluded by Podoshin et al and those younger than 8 years were excluded by Attallah. Vartiainen and Nuutinen did not perform tympanoplasty in children younger than 10 years undergoing mastoidectomy for otitis media and observed spontaneous healing in 15 of 20 cases. Their data also suggest that they operated on few dry perforations in children younger than 7 years. In several studies, less than 10% of the patients were younger than 8 years. The numbers of patients younger than 8 years of the total are as follows: Hamans et al, 4 of 70; Friedberg et al, 4 of 70; Blanshard et al, 2 of 59; and Claes et al, 17 of 181. The ability to correctly identify any relationship between age and success rate in an individual study is compromised by prospective exclusion of a given age group or small sample size of the population in question.

To further investigate the accuracy of the age-dependent success rate, data were analyzed for the age ranges of 7 to 13 years, 8 to 13 years, and 9 to 13 years. The slope of the linear regression for each of these was −1.92 (P = .01), −1.81 (P = .06), and −2.71 (P = .03), respectively. Serial exclusion of the youngest patients did not eliminate the relationship between age and success rate. When only articles reporting results of type 1 tympanoplasty are analyzed, the slope of the regression is even more pronounced. The issue of age is best addressed in future reports by providing data for groups of patients in 1-year increments. Future data can be combined with the present analysis; however, more data may not alter the age-dependent success rate displayed herein.

The cause of this relationship between age and success remains to be elucidated. The overwhelming sentiment in these articles (and otolaryngologists as a whole) is that age is unimportant. Obviously, there is no inherent difference in wound healing ability among children. From the standpoint of potential to heal, we believe this viewpoint is correct. Thus, the basis for this relationship resides in patient selection. Something that is more prevalent in the younger age groups must account for this result. As noted earlier, a popular assumption is that the rate of otitis media is higher in the younger children. If this theory is correct, then preoperative characteristics that pose greatest risk for recurrence of otitis media may also predict an unfavorable result with surgery in the younger children.

This analysis was performed using the postoperative status of the TM as the primary criterion of success. Although this is indeed important, it appears that insufficient insight into patient selection is gained when reporting results as intact or not intact. A stricter definition of success is needed. The ultimate objectives of the surgery are repair of an anatomic deformity and improved function, but a lower incidence of recurrent disease is critical for long-term success. Reporting of results should probably address all these outcomes. Both 2- and 5-year outcomes would provide a better perspective on the stability of the result, which is especially important when considering surgery in children.

Future reports of tympanoplasty results can address recurrence of otitis media by simply stating its presence or absence during the follow-up interval. Recurrent disease may not alter the status of the TM; however, it does require additional treatment. Focusing on recurrence of the underlying disease will also define which patients benefit most in reducing episodes of otitis media. Hearing results should be reported using the American Academy of Otolaryngology–Head and Neck Surgery guidelines. Individual case summaries are the most amenable to future meta-analysis, but reporting results according to selected preoperative variables can also be used. For instance, hearing results may be expressed against age.

The anatomic status of the TM would be expected to influence the hearing result, with the best outcome in patients with intact ossicles and normal aeration of the
middle ear. Simply noting whether the TM is intact does not communicate any information about postoperative eustachian tube function or the potential need for additional intervention. Below is an outline of a method for classification of anatomic results after tympanoplasty.

<table>
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<tr>
<th>Postoperative Finding</th>
<th>Score</th>
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<tr>
<td>Normal</td>
<td>1</td>
</tr>
<tr>
<td>Atelectasis, transient effusion</td>
<td>2</td>
</tr>
<tr>
<td>Chronic effusion, myringitis, tube placement</td>
<td>3</td>
</tr>
<tr>
<td>Recurrent perforation, cholesteatoma, revision surgery</td>
<td>4</td>
</tr>
</tbody>
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More thorough analysis of results may lead to identification of preoperative factors that, alone or in combination, greatly affect the outcome. The potential benefit to the surgeon is a refinement of the indications for surgery. Certain preoperative factors could also suggest an alternative technique. Examples might include performing cartilage tympanoplasty if recurrent atelectasis is likely, using a vascularized graft if poor wound healing is predicted, or deferring surgery for hearing if the near-term incidence of recurrent disease is excessive.

Selecting patients for surgery is done on a case-by-case basis. Each presents with a unique combination of anatomic deficits, impaired function, unremitting infection, and expectations for improvement. The goal of the surgeon is to produce the best possible result for each. A categorical refusal to operate on a patient because of age would exclude some from significant benefit. In other instances, postponing surgery may be the wisest move. Our decision making will improve with more information on how to select the best possible candidates for surgery.

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REFERENCES