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Ten Top Considerations in Pediatric Tympanoplasty

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Abstract

Tympanoplasty in children poses some different challenges from the same procedure in adults. The aim of the current article is to review 10 important considerations in pediatric tympanoplasty that focus on these differences and help to optimize the chance of successful outcome.

Keywords

pediatric tympanoplasty, tympanic membrane perforation, CSOM, ear surgery, review

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The focus of pediatric tympanoplasty has always been on the rates of success. We have been puzzled as students and humbled as consultants by seemingly idiosyncratic cases of failure and our inability to predict them. This seemingly mysterious inability to predict outcome has led us to explore pediatric tympanoplasty from a point of view beyond the traditional one in which technique is central. In this exploration, we sought to explore our own decision making to see if it might simplify our management of children with tympanic membrane perforations. We asked, When is the best time to repair a child's perforated tympanic membrane? How can the chance of successful repair be optimized?

Despite extensive surgical experience and a multitude of publications on techniques and outcomes in type 1 tympanoplasty, recent reviews show that decision making and the achievement of good results remain disconnected and challenging in children.¹ It does appear that rates of successful closure are lower than in adult series, but there is no consensus on what factors are predictive of this diminution in documented success. For example, conflicting studies show that age is² or is not^{3,4} predictive, that the status of the contralateral ear is^{5,6} or is not³ predictive, and that prior adenoidectomy is^{4,7} or is not⁸ predictive of successful repair. Some find no significant indicators of successful outcome at all.⁹ It is likely that the number of failures in these series is too small to detect significant causes reliably; meta-analysis

of such studies may be the only way to reveal true predictors of success.² Surgical decisions must often be made in the absence of evidence-based consensus, and we present here the considerations that we take into account in pediatric tympanoplasty.

Perforation of the eardrum in a child does pose different challenges from perforation in an adult, of which lower successful closure rates are only part. Local and regional pathophysiological differences stem from incomplete development and are demonstrated by the greater risk of otitis media (acute and serous) in young children. The maturity and relative contribution of underlying parameters such as the immune system, adenoid hypertrophy, growth and function of the eustachian tube, and pneumatization of the mastoid are hard to determine in any given child. On the other hand, wound healing is less commonly compromised by smoking or diabetes. Behavioral differences are also relevant: poor compliance with water precautions, learning to swim, and frequent participation in water sports commonly affect children's perforations. Also important, children typically require general rather than local anesthesia for tympanoplasty, which emphasizes the need to optimize success and avoid the need for revision surgery. Finally, as with all pediatric surgery, the attitude of the parents, as well as the patient, directly influences surgical planning. The number of variables in play obviates the use of a strict algorithmic approach. This article hopes to aid in decision making and thereby improve outcome.

We hope that this article therefore will be of value to a number of readers. First, otolaryngologists who have a general practice will find a review of the literature and can access the latest thinking and techniques within the references cited. Second, primarily adult otologists will gain some insight into a subpopulation within their practice in a manner that highlights specific ways they differ from the adult patients. Third, pediatric otolaryngologists who are supposed to know about children can learn from the adult

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experience with tympanoplasty as it is presented here. The article is not meant to be a “how to operate” article but rather a “how to approach and think about operating” article.

1. Health of the Child

Fitness of the child for anesthesia is a prerequisite that needs no discussion. However, the health of the upper respiratory tract influences middle ear function and should be evaluated by specific assessment of the nose and the contralateral ear. Adenoid hypertrophy is associated with otitis media, peaking at age 3 to 5 years and regressing between 7 and 10 years.¹⁰ Adenoidectomy helps to relieve middle ear effusions in young children.¹¹ The benefit of prior adenoidectomy on tympanoplasty has not been proven convincingly.^{4,7,8} Nevertheless, it can be anticipated that a child with obstructive adenoid hypertrophy may have less chance of a good outcome from tympanoplasty, so we consider treating the adenoids or awaiting regression prior to tympanoplasty. Similarly, published literature is contradictory on the predictive status of the contralateral ear.^{3,5,6} Although status of the 2 ears can be asymmetric, we prefer to delay surgery when there are signs of ongoing contralateral dysfunction such as acute otitis media, effusion, or tympanic membrane (TM) retraction. For example, we find it best to wait to close a perforation resulting from a retained tube until the contralateral ear's tube is out and the middle ear remains aerated, preferably over at least one winter. We are not enthusiastic about repairing a perforation when the contralateral TM is atelectatic in case “successful” closure results in bilateral atelectasis, possibly with worsening of hearing in the treated ear.

2. Hearing

Parental concern about their child's hearing is one of the factors that initiates a consultation for TM perforation. Although tympanoplasty typically does improve hearing thresholds a little, especially at low frequencies, there is unlikely to be enough of a gain for parents or the child to notice a difference except in cases in which there is a larger loss such as with subtotal perforations. Interestingly, we have shown that larger perforations were more likely to have noticeably improved hearing postoperatively likely because they had larger hearing losses preoperatively and the postoperative improvement is proportional.¹² The inability to appreciate a slight improvement in hearing in the operated ear will almost certainly occur if hearing is normal in the contralateral ear. Thus, unilateral hearing loss is not usually a good enough reason alone to proceed with tympanoplasty. The negative quality-of-life impact from operations that fail to provide adequate gain in hearing has been shown clearly in adults¹³ and is likely no different in children. Surgery may be indicated to improve hearing for bilateral loss or if closure of the perforation would facilitate hearing aid use. As with adults, worse hearing in the contralateral ear is often a contraindication to surgery.

3. Age

Although the influence of age on the success of tympanoplasty is still debated,^{1,14} age is the only factor that has been shown by meta-analysis to influence outcome, with success improving with every year up to age 13 years.² Most of the individual studies in this analysis had insufficient power to show the benefit from delaying surgery, yet these underpowered studies are perhaps one reason many continue to believe that age does not influence outcome. Our aim is to optimize the chance of successful closure, and for many children, this will mean waiting until they are older. However, age alone is not of overriding importance—the age-related variables of adenoid and contralateral ear status combined with the other factors outlined in this article are used to guide the choice of timing of the procedure.

Consider, for example, a 4-year-old child who had no history of otitis media and had received ventilation tubes, with a resulting perforation, for hyperbaric oxygen therapy after carbon monoxide (CO) exposure. Compare this with a 14-year-old with a craniofacial syndrome and bilateral perforations and frequent otorrhea. Age, although an important factor, must be considered in context. With this line of reasoning considered, we would suggest that a surgeon rarely proceed with a tympanoplasty at the age of peak adenoidal activity and size but rather wait until the adenoid pad begins its natural regression in both activity and size at age 7 years or until it is usually complete in regression by age 10 years.

For the thoughtful surgeon, age can be an important point to consider. When a child is referred following a failed attempt at perforation closure, the natural inclination is to proceed with a more invasive surgical technique, assuming, for example, that after a failed patch tympanoplasty, the eardrum might do better with an underlay graft. The parents too think this is reasonable, but perhaps in the months or years since the graft failed, the eustachian tube system has developed and, as evidenced by an aerated contralateral middle ear, the upper respiratory system has matured. We often naturally unnecessarily delay repairing a child's eardrum because we fear intervention in our hands will yield the same result as the referring physician, forgetting that the patient presenting to us is now different and fresh, and independent thinking must be embraced. Age is an important factor.

4. Characteristics of the Perforation

A small hole is easier to repair than a large one, especially if it is in an easily accessible location and does not reach the margin of the TM after removal of the scarred edge. A noninflamed ear is also easier to repair, as bleeding is less likely to obscure visualization. Size and location of perforations probably do influence the success of outcome, although this is difficult to prove, as different techniques and decision-making algorithms are used according to the properties of the perforation.¹ For the time being, in the absence of evidence, common sense is the only tool we

have to consider the characteristics of tympanic membrane perforation.

In considering the effect of otorrhea on rates of closure, meta-analysis indicates that tympanoplasty on a discharging ear is as successful as on a dry ear.² Our preference is to control otorrhea as effectively as possible with topical antibiotics and water precautions. If this maintains satisfactory control of the perforation, there need be no rush to proceed with surgery. Recurrent otorrhea that appears to be secondary to upper respiratory tract infection implies that the locoregional health of the child may be suboptimal for a repair, so it may be advantageous to delay tympanoplasty.

The surgeon must also consider that the perforation may itself be the cause of the ongoing otorrhea. The middle ear has a relatively high temperature and humidity compared with the external auditory canal. These environmental characteristics are significantly altered by the presence of a perforation, and it follows that the size of the perforation (and possibly the location) will be directly related to the amount of alteration in these characteristics. Here again the decision to operate, or not, must be tailored to the specific child in question. When conservative measures are not acceptable or effective, it is reassuring to note that surgery can be equally successful in wet ears.

5. Surgical Approach

What works well for one surgeon may not work so well for another. In tympanoplasty, choice of approach, graft material, and graft placement technique are heavily influenced by training, case load, resources, and experience: there is not one technique that suits all surgeons or all patients. No matter what approach is taken, the technique must include thorough freshening of the scarred perforation edge because that is the reason the eardrum has not healed naturally (**Figure 1**). Having exposed fresh and hopefully well-vascularized edges (the removal, or leaving of tympanosclerosis, in order to affect vascular perfusion is a manuscript in and of itself), the eardrum may heal itself.¹⁵ The surgeon's job is to improve the chances of this occurring by placing a scaffold to guide the healing edges to each other.

For our tertiary care population, we have traditionally favored a postauricular approach that provides a combination of the donor site for fascia graft and optimum access to pediatric-sized anatomy especially for anterior perforations that are hard to visualize because of the convexity of the child's anterior canal wall. Transient disadvantages include an outstanding ear and delayed return to contact sports while the wound heals. Recently, we have employed an entirely endoscopic approach in selected cases. Avoidance of an external incision is surprisingly pleasing to parents and children. Length and width of the ear canal determine access: both increase with age, so endoscopic tympanoplasty is not necessarily easier in older children. Tragal perichondrium is used as a graft, but it is important to note that the tragus is smaller in children than in adults, whereas the TM is of adult size. This approach can only be used successfully

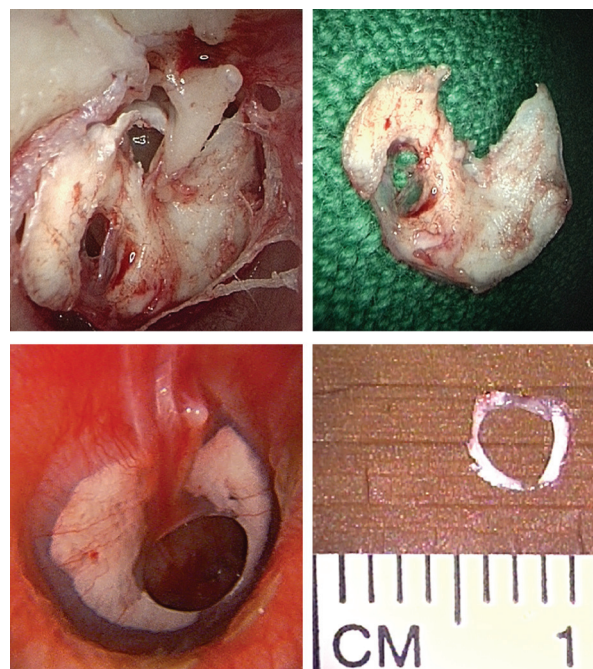


Figure 1. (Upper panel) Complete plaques of dense tympanosclerosis can be removed from the drum at tympanoplasty. This can help to improve hearing outcome. (Lower panel) When less dense, tympanosclerosis can be incised at the time of careful stripping of the edge of the perforation to promote healing.

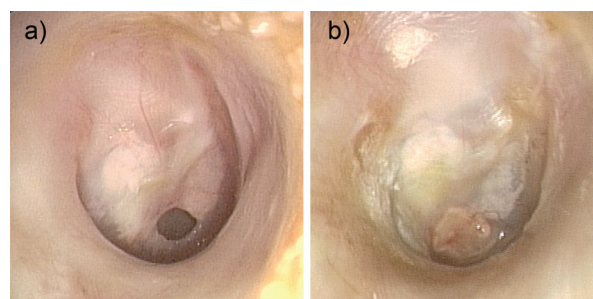


Figure 2. (a) Endoscopic photograph of the right tympanic membrane showing a small anteroinferior perforation at the site of previous tube placement. (b) Postoperative result, 2 months after permeal placement of a cartilage "butterfly" graft in the perforation.

when the tragus is significantly larger than the perforation. We only use a permeal microscope approach for small tube site perforations and currently favor the cartilage butterfly graft^{16,17} over fat plug or synthetic patch myringoplasty, as shown in **Figure 2**.

The advantage of adding cortical mastoidectomy to surgery for TM perforation has been uncertain, although a recent randomized controlled trial found no significant benefit.¹⁸ With our case load, it is rarely needed, only being offered in cases of active chronic suppurative otitis media that cannot be controlled medically, especially with recurrent perforation.

6. Surgical Adjuncts

Because so many variables may contribute to outcome, it is difficult to quantify the contribution of different aspects of technique to success. For example, simple excision of the edge of a perforation or a retraction pocket may be followed by successful closure without any grafting of the defect. However, simple intuition suggests that if a graft is used, success is likely to be higher if it retains contact with the whole circumference of the TM defect. Adjuncts such as gelatin sponge or hyaluronic acid derivatives have been widely used to help push an underlay graft up onto the medial surface of the TM. Because of concern from animal models and clinical experience^{19,20} that these materials contribute to middle ear adhesions and so impair tympanomastoid ventilation, we prefer to avoid placing adjuncts in the middle ear space and, in preference, use surgical techniques to suspend the graft. This advantage can be inferred from the phenomenal success of the Williams clip technique, which effectively stapled the graft to the freshened edges.²¹ This technique, although theoretically sound, was very difficult for us to perform as easily as described, so we have abandoned it, but not the underlying principle it presented: the best aerated middle ear is one free of completely nonabsorbable material. We use techniques currently that do not rely on material in the middle ear to push the graft upward but rather allow the graft to be pulled upward. In these techniques, a large part of the graft is suspended on the bone of the ear canal, which is exposed on raising the tympanomeatal flap (**Figure 3**). Anteriorly, the graft is supported by pulling a small “peg” through a miniperforation (**Figure 4**), or pulling a “tab” of graft under the annulus anteriorly and through a small incision and flap on the anterior canal wall. A tab of graft is also often brought up over the neck of the malleus to provide anterosuperior support (**Figure 5**).

7. Consider Other Medical or Craniofacial Abnormalities

If evidence to guide intervention in pediatric TM perforation is contradictory or sparse for otherwise healthy children, there is even less on which to base decisions for children with other related health issues.²² Tympanic membrane retraction²³ and cholesteatoma²⁴ are very common in children with cleft palate, indicating potential for worse outcome from tympanoplasty. We take particular note of the status of the contralateral ear in such children to minimize the risk that successful TM closure might be followed by TM retraction. Reassuringly, some evidence suggests that outcomes may be no different with or without cleft palate.²⁵ In addition to the risk of long-term middle ear disease, Down syndrome provides the challenges of narrow canals, abnormal middle ear anatomy,²⁶ and poor cooperation with postoperative care. Despite these difficulties, tympanoplasty will often be especially important in Down syndrome to facilitate hearing aid use. In all patients with a narrow

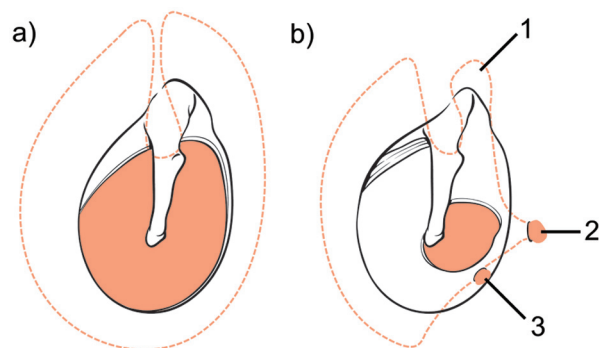


Figure 3. Diagram to show graft placement (in orange) in right underlay tympanoplasty with (a) large and (b) smaller perforations. As access to the middle ear is gained by elevation of the annulus posteriorly, the graft is stabilized under the posterior edge of the perforation by draping it up the posterior wall of the meatus. To anchor the graft securely under the other edges of the perforation, the annulus and canal skin can also be elevated anteriorly (a). For smaller perforations (b), a small tab of the graft can be brought up over the neck of the malleus to lie on the scutum superiorly (1), through a small meatal skin incision on the anterior canal wall (2), or, when there is sufficient drum remnant between perforation and annulus, through a small peg brought through a miniperforation in the adjacent tympanic membrane (3).

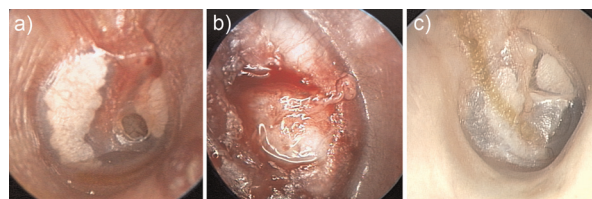


Figure 4. (a) This central perforation was repaired with tragal perichondrium using an endoscopic approach. (b) A large enough remnant of tympanic membrane was present between the perforation and annulus to allow a small “peg” of graft to be brought out through the drum to secure its anterior edge. (c) Two months later, the perforation has healed closed.

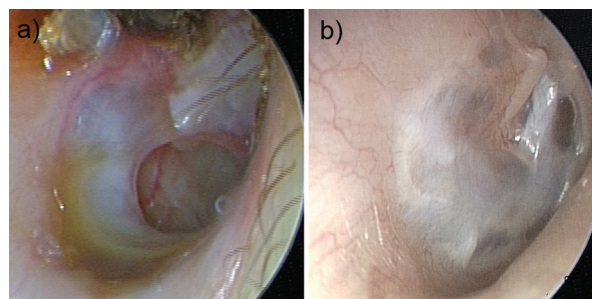


Figure 5. Proximity of the anterior edge of this perforation to the annulus provided inadequate drum remnant for “peg” fixation, so a “tab” of graft was brought up the anterior canal wall. A second tab was brought up over the neck of the malleus to secure the graft anterosuperiorly. (a) Preoperative and (b) 12 months posttympanoplasty with temporalis fascia.



Figure 6. A large keloid scar following a right postauricular incision for tympanoplasty. This was treated successfully with surgical removal.

meatus, it is appropriate to drill the canal wider for adequate surgical access.

8. Complications

The most common complication of pediatric tympanoplasty is graft failure. That is essentially the subject of this manuscript and has been addressed throughout. Consideration of potential surgical complications also must be considered in determining if any particular child is a candidate for tympanoplasty. Injury to the chorda tympani and further hearing loss also can occur, but rarely. Unsightly keloid scars can arise from postauricular or even endaural incisions (**Figure 6**). Permeatal surgery should be favored in children considered to be at risk of keloid formation. However, we have the misfortune of managing keloids within the external auditory canal, so this technique itself is no guarantee that keloids will not complicate the repair.

Care must always be employed when raising the tympanomeatal flap in children in case the jugular bulb is dehiscent at or medial to the annulus (**Figure 7**). The large jugular bulb can be underappreciated because preoperative imaging of the child is not routinely performed, nor should it be. There are groups of children, such as those with achondroplasia or Phelps syndrome (X-linked stapes gusher syndrome—DFN3), in whom the jugular bulb resides relatively higher and is more exposed than otherwise noted in our experience.

Attention is always given to the relative proximity of the facial nerve to the lower end of a postauricular incision in children. This risk is greatest during infancy because of

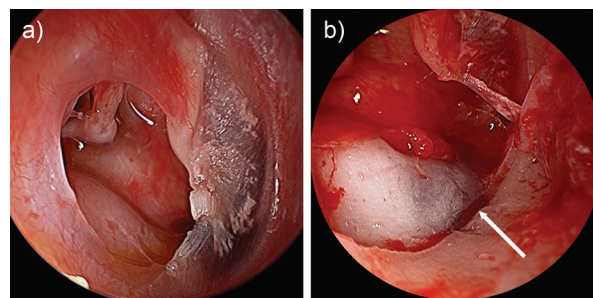


Figure 7. (a) A high jugular bulb can be seen through this right tympanic membrane perforation. (b) Elevation of the annulus revealed a dehiscence in the bone covering the jugular bulb within the annular groove (arrow). Care is required to avoid tearing the jugular in such situations.

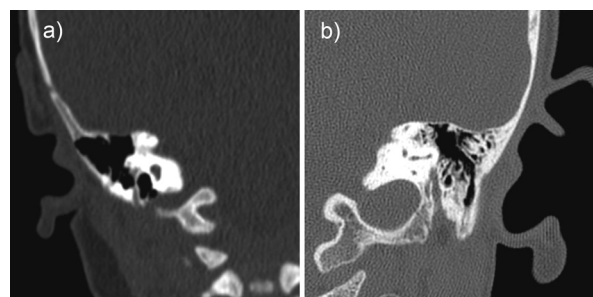


Figure 8. Coronal computed tomography scan of the temporal bone showing the vertical portion of the facial nerve in (a) a 2-month-old and (b) an older child. The nerve is relatively close to the surface in young infants as the mastoid tip does not develop until later.

underdevelopment of the mastoid tip (**Figure 8**), so although the vulnerability of the facial nerve in pediatric otology must never be forgotten, the risk is less significant at the typical age range for tympanoplasty.

9. Postoperative Care

Less cooperation with postoperative care can be expected from children than adults. We prefer to pack the ear canal of children following tympanoplasty, as this provides protection against water entry and helps reposition the tympanomeatal flap against the underlying bone. Inadvertent pack removal followed by nose blowing in one of our young children did cause extrusion of a tympanomeatal flap out of the meatus on one occasion, so demonstrating the risk of suboptimal compliance and an additional benefit of keeping a pack in! We use a single pack as many children would refuse to allow a second item to be removed from their canal. It is worth warning the parents of young or uncooperative children in advance that sedation may occasionally be required for pack removal. Evidence suggests that postoperative systemic (oral) antibiotics do not contribute to the success of tympanoplasty, although they have been recommended to reduce postoperative infection in wet ears.^{27,28}

10. Be Prepared to Change

If there is any advice we routinely give our trainees, it is to be prepared to change. Much of what we learn in our residencies is obsolete before we leave clinical practice, if not sooner. In otology today, management of tympanic membrane perforations is a case in point. There are innovative techniques for perforation closure introduced at almost every major meeting. The otologist dealing with the pediatric perforation must be prepared to embrace these changes.

Uses of growth factors and other adjuncts to enhance healing have been presented, and these techniques allow treatment permeatally, obviating the need to routinely raise a tympanomeatal flap.²⁹⁻³¹ Recently, the addition of an esterified hyaluronic acid disk to the old technique of fat graft myringoplasty has demonstrated encouraging outcomes^{32,33} and again likely demonstrates the way this repair is going, and soon. These techniques have huge potential advantages in children especially but also have even larger implications in the economics of health care delivery in North America.

As important as the need to embrace change is for the pediatric otologist, the need to maintain a nonalgorithmic approach is equally critical. It is hoped that this article demonstrates that no single factor or technique portends a good outcome reliably. Each child comes with an independent set of factors that can affect the rate of surgical success. Even with tissue-engineered solutions to these surgical problems, it will remain the major job of the surgeon to decide how and when they are employed. For the foreseeable future, unlike our surgical thinking, that will not change.

Author Contributions

Adrian L. James, author; **Blake C. Papsin**, author.

Disclosures

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