Atelectasis of the middle ear is a variable collapse of the middle ear space, associated with retraction pockets formed by loss of the lamina propria leading to extreme atrophy of the tympanic membrane. It is a recognized sequela to protracted tympanic hypoventilation associated with otitis media with effusion and is a common condition in children. Many of the retraction pockets remain stable, while others undergo a breakthrough, producing tympanic disruption that results in a perforation with borders adherent to the incudostapedial joint, and/or to the promontory, and/or to other anatomical structures of the tympanic cavity (Figure 1), or resulting in progression to a cholesteatoma. Much controversy still surrounds the etiology, evolution, and treatment of retraction pockets. In particular, discussion about how epidermal structures of atelectasis get into the middle ear to cause a cholesteatoma is still controversial. The exact incidence of progression is unclear, and in the international literature there is no reliable indicator to predict either progression or stability of a retraction pocket.

Tympatic disruption secondary to a pars tensa retraction is included in grade 5 of the classification of atelectasis by the Sadé classification (Luntz et al), in grade 4c of Tran Ba Huy’s classification, and also grade 5 of a recent classification of atelectasis especially developed for children (Erasmus atelectasis classification); stage 5 of Erasmus classification is the initial stage of a cholesteatoma, but it can also be a tympanic disruption of the atelectastic part of the eardrum without signs of cholesteatoma.
Eventhoughfortheinitialstagesofatelectasisthereis nogreementintheliteratureabouttheneedfortreatmentorthe possibilityofmanagementbywatchfulwaitingfortensaretractionresultinginan tympanicdisruption,surgicaltreatmenthas been suggested and is the topic of this study that focuses on the long-term results in pediatric patients after underlay myringoplasty with temporalis fascia or tragal perichondrium.

Methods

An observational, retrospective study was performed using the clinical records of children who received surgical treatment for chronic otitis media from January 1999 through December 2007 at the Department of Pediatric Otorhinolaryngology–Head and Neck Surgery of the University of Brescia, Brescia, Italy. Formal review and approval of the local ethics committee were obtained. The patients included in the study, after a clinical history of pars tensa retraction, had presented with a dry tympanic disruption with borders adherent to the incudostapedial joint, to the promontory, and/or to other anatomical structures of the tympanic cavity (Figure 1). Those patients who presented with keratin accumulation or cholesteatoma (Figure 2) or ossicular chain erosion (Figure 3), who previously submitted to tympanomastoid surgery, and who presented with craniofacial dysmorphisms were excluded from the analysis. The patients included in the study had received a myringoplasty by transcanal or postauricular approach under general anesthesia without mastoid surgery. All of us were involved in surgery, and we applied the same treatment policy, namely, a transcanal approach was chosen when the anterior tympanic annulus was completely visible and the retraction border was easily controllable through the ear speculum. For each type of approach, careful removal of the adherent retraction border and careful preservation of middle ear mucosa were the focal points of the technique. All myringoplasties were performed with an underlay technique using tragal perichondrium in a transcanal approach and temporalis fascia in a postauricular approach.

The study analyzed the anatomical results in terms of perforation or retraction of the neotympanum with a minimum follow-up of 5 years. Age; sex; side, position, and size of the tympanic disruption; surgical approach; graft material; and presence of contralateral disease were correlated with anatomical failure. Even though analysis of audiological results was not the aim of the study, these data were nonetheless collected according to the Committee of Hearing and Equilibrium criteria. Threshold frequencies of 0.5, 1.0, 2.0, and 3.0 kHz were used. Postoperative mean threshold differences were calculated for airbone gap (ABG). Bone threshold was also analyzed to document possible iatrogenic cochlear damage. Personnel exclusively dedicated to pediatric audiology performed audiometric tests. All patients were evaluated by micro-otoscopy and/or otorhinolaryngologic examination within 2 months of surgery, and at 6 months, 1 year, and annually thereafter.

Statistical analyses were performed using the SPSS Inc statistical package. The impact of age on anatomical failure was tested with the Mann-Whitney U test. The impact of sex; side, position, and size of the tympanic disruption; surgical approach; graft material; and presence of contralateral disease on anatomical failure was tested using Pearson $\chi^2$ and Fisher exact tests. Results related to age of patients are expressed as means (SDs).

Results

Of a total of 433 surgical procedures on the middle ear in children, 65 fulfilled inclusion criteria and were considered for the analysis. The patient population included 33 girls (3 of whom
were operated on bilaterally with an interval between the 2 sides ranging from 7 to 20 months) and 28 boys (1 of whom was operated on bilaterally with a 9-month interval between the 2 sides). The ages of patients varied from 4 to 16 years (mean [SD] age, 10 [3.2] years). The right side was involved in 38 cases (58.5%), and the left side in 27 cases (41.5%). The site of tympanic disruption included the posterior superior quadrant in 30 cases, posterior inferior quadrant in 52 cases, anterior inferior quadrant in 54 cases, and anterior superior quadrant in 25 cases (Figure 4). The disruption involved only posterior quadrants in 11 cases (16.9%), the inferior anterior quadrant was also involved in 29 cases (44.6%), and the superior anterior quadrant was also involved in 25 cases (38.5%). A transcanal approach with underlay myringoplasty using perichondrium was performed in 17 cases (26.2%), and a postauricular approach with underlay myringoplasty using temporalis fascia was used in 48 cases (73.8%).

An intact tympanic membrane was obtained in 58 cases (89.2%) with a follow-up varying from 5 to 14 years (mean, 9 years). Among these cases were 4 patients with a stable grade 1 retraction of the tympanic membrane without adhesion to any middle ear structure. The 7 failures resulted in a small anterior perforation. There were no cases of iatrogenic cholesteatoma, anterior blunting, or lateralization of the neotympanum. The mean (SD) age of patients who had successful tympanic membrane repair was 10.1 (3.2) vs 9.6 (3.6) years for those with unsuccessful repair (P = .89). In addition, none of the other independent variables studied by univariate analysis were associated with the success of surgical treatment (Table).

All the ears with an intact tympanic membrane at the end of the study had a mean postoperative ABG of less than 10 dB.

After surgical failure, 7 ears had a postoperative ABG of less than 20 dB. No patients experienced postoperative bone threshold impairment.

Discussion

Retraction of the pars tensa of the tympanic membrane is a common and troublesome problem in pediatric otolaryngology, and there is no consensus as to the best treatment strategy.15 The point prevalence of pars tensa retractions in healthy children aged 5 to 16 years has been reported to be 0.3% to 3.7%,16 whereas more recently prevalence in southwest England was reported to be 7.9% of children with ages ranging from 105 to 140 months.17

Tensae retraction is a consequence of prolonged dysfunction of tympanomastoid ventilation that depends on gas diffusion through the middle ear and mastoid mucosa, pressure buffer of the mastoid air cell system, and gas exchange through the Eustachian tube.7 It has been suggested that control of middle ear gas homeostasis depends mainly on neuronal baroreceptors of the tympanic plexus.18,19 The direction of gas exchange depends on the differences in partial pressure of the component gases in the middle ear cleft and mucosa, and most of the gas exchange occurs around the antrum, where the epithelium is cuboidal and well vascularized.7 When the mucosa is healthy, there is an equal rate of exchange because oxygen and nitrogen are absorbed by the mucosa at the same rate at which carbon dioxide is expelled.7 However, when the mucosa is inflamed and more vascularized, there is a greater rate of gas absorption.7

Small mastoid volumes tend to cause greater changes in pressure, which result in greater forces applied to the tympanic membrane.7 More pneumatized mastoids are associated with a larger mucosal surface, an increase in gas transfer, and more efficient regulation of middle ear pressure.7
Eustachian tube dysfunction affects the normal flow of gas by reducing its ability to help regulate middle ear pressure, even though Eustachian tube involvement in the mechanisms of middle ear gas regulation remains controversial.20,21 Some investigators20 argue that the Eustachian tube supplies gases to the middle ear and that its loss of function results in a reduction in pressure, while others21 propose the opposite, maintaining that gases are produced by the mucosa of the middle ear and mastoid and that the Eustachian tube functions only in gas evacuation.

Altered regulation of middle ear gas homeostasis leads to a proportional decrease in middle ear ventilation, causing negative pressure that, in association with structural changes to the membrane secondary to repeated episodes of inflammation,22 is the focal point in the formation of tympanic membrane retractions. There is limited information on the histological characteristics of retraction pockets, but the available evidence indicates that disruption of the middle collagen layer is a significant factor leading to collapsible and retracted sections of the tympanic membrane and, along with inflammation, may be the initiating factors causing disruption of the double collagen layer.23 When the collagen layer has not yet been disrupted, retraction pockets may revert to their normal lateral position.23

However, the irreversible retraction pocket, according to the theory of invagination-proliferation, can undergo cell mitosis in the basal layers of the epithelium, leading to hyperplasia, abnormal cellular migration, and microfoci of keratinization that disrupts the double collagen layer.23

When the breakthrough of the atrophic tympanic membrane results in tympanic disruption with a border adherent to middle ear structures, subsequent inflammatory episodes give rise to local sequelae of chronic otitis media, such as ossicular erosion, granulation tissue, or epithelial proliferation, possibly then giving rise to a full-fledged cholesteatoma (Figures 1-3). There is a diversity of opinion regarding management of tensa retractions: the options include watchful waiting, medical treatment (Valsalva or Politzer maneuvers, nasal steroids, and decongestants), and surgery. No evidence currently exists to either support or refute the role of surgery in the management of tympanic membrane retractions up to grade 4.8

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In contrast, tensa retraction resulting in a tympanic disruption is a well-defined indication for surgery for certain investigators12,13 and also, in our opinion, owing to the enhanced risk of recurrent episodes of otitis media and long-term complications. In this case, the question concerns the appropriate type of surgery: simple myringoplasty with fascia or perichondrium, myringoplasty with cartilage reinforcement, myringoplasty with ventilation tube insertion, or myringoplasty associated with cortical mastoidectomy with or without insertion of a ventilation tube (mastoid venting), in an attempt to improve middle ear ventilation.25,26

Most published studies indicate that mastoidectomy, ventilation tubes, and mastoid venting have little or no impact on the success of tympanoplasty in cases of atelectasis or perforations.13,37-38 One explanation for the inefficacy of mastoidectomy may be that gas exchange is probably less effective in the newly formed mucosa following mastoid surgery. Pressure equalization tubes can be ineffective, although such tubes improve retraction temporarily, but inevitably extrude, such that the ear would retract to its original state if the conditions that cause retraction persist.37 Regarding mastoid venting, some patients may find this procedure cosmetically unacceptable, and, moreover, restricted contact with water is required.33

Composite graft myringoplasty (cartilage with perichondrium or fascia) has recently gained a great deal of attention in the literature. Cartilage demonstrates high mechanical stability, considerable stiffness, and slower metabolism, and can therefore be considered as a reliable grafting material. Cartilage has a constant shape, is firmer than fascia, lacks fibrous tissue and has high levels of the highly resistant protein elastin. These features help retain the postoperative dimensions of the graft, and cover large perforations with stability. Moreover, at least in theory, cartilage grafting may prevent retraction pockets and reperforations.34

An important criticism of this procedure is that the opaque segment of the cartilage may conceal any evidence of cholesteatoma should it develop. Another problem can arise from the possible hiding of new middle ear effusion. The last criticism is that there can be a lack of epithelialization of the cartilage graft, and the presence of unepithelialized cartilage and/or perichondrium may be an ideal site for the development of a bacterial biofilm on the surface.35 Owing to these considerations, some investigators reserve cartilage reinforcement in children only for recurrent cases.2,36

Myringoplasty with fascia or perichondrium is still considered a valid option in children.14-37 Criticism on temporal muscle fascia is based on its composition of irregularly arranged elastic fibers and fibrous connective tissue that un-
derno postoperative changes in shape, shrinking, or even thickening that are radical and unpredictable.34,38

The reported recurrence rate of re-retraction with reinforcement cartilage varies from 5% to 45% for severe retractions.39-41 In general, the reported success rates of tympanoplasty in children range from 35% to 94%.42-44

When a comparison between fascia and cartilage myringoplasty for simple perforations is made, it seems that cartilage has better results in the short-term. In a recent analysis of the literature, the mean graft integration rate in the cartilage group was 92.4% (95%, CI, 87.8-96.0) and in the temporalis fascia group was 84.3% (95% CI, 76.9-90.5).24 There were no significant differences in functional results between fascia and cartilage, providing that cartilage graft is not thicker than 0.5 mm to optimize its acoustic characteristics.34,45

The group of pediatric patients that we evaluated is difficult to compare with those described in the existing literature for both selection criteria (only tympanic disruption secondary to a pars tensa atelectasis) and length of follow-up, which varies from 5 to 14 years (mean, 9 years). Most of the studies in the literature on tympanic retraction have broader inclusion criteria and much shorter follow-up times. The long-term success of myringoplasty with fascia or perichondrium in this group of patients was 89.2%. The failures were tympanic perforations, but there were no cases of new progressive retraction.

Several prognostic factors for perforations after surgical repair of the tympanic membrane have been considered, including age, sex, site and size of perforation, technique used, active infection at the time of surgery, state of the ossicles and of the mucosa of the middle ear, and status of the opposite ear. However, there is no consensus of any effect on failure.46-52

In our group of patients, there were no factors that significantly influenced prognosis (Table). This could be due to the small sample size because there was a trend toward poorer results in left ears and when the anterior superior quadrant was involved in reconstruction and the need for a postauricular approach with temporalis fascia graft. Such associations were not statistically significant, although anterior superior tympanic disruption could indicate a problem of prevalent tubal dysfunction, and tragal perichondrium was used to repair only very small posterior defects. In addition, all of us are right-handed surgeons, which could have led to poorer results in the left ear because there is a less favorable angle of positioning the graft in the attempt to not damage the ossicular chain.

In our opinion, when the anterior superior quadrant is not involved or when evolution to cholesteatoma is not present, the retraction resulting in a tympanic disruption is likely the end of a previous inflammatory process that has reached a sort of equilibrium with no additional risk factors for new retraction, as frequently happens in children when they reach maturity and middle ear mucosa homeostasis improves. Considering the surgical procedure, careful preservation of middle ear mucosa to preserve its function of gaseous exchange is probably the most important point, and the results may be independent of the material used to repair tympanic membrane. This can also be demonstrated by the healing properties of the tympanic membrane when middle ear physiology is normalized as happens in traumatic perforations or in cases of simple excisions of the atelectatic part of the tympanic membrane with ventilation tube insertion as reported by some investigators.1,36,53-55 Most of these reports deal with grade 2 and 3 retraction according to Sade’s classification.36,53-55 The results in terms of cure are promising, with values of tympanic healing ranging from 65% to 80% after the initial procedure with a low risk of middle ear infection,1,36,53-55 but they probably cannot be compared with results in our population in which the atelectatic part to excise is absent owing to the tympanic disruption.

The failures that we observed are tympanic perforations prevalently involving the anterior superior quadrant that can be related by a technical defect or to recurrent episodes of otitis media due to persistent Eustachian tube dysfunction. Cartilage tympanoplasty is an interesting option and can be considered in revision surgery of these failures.

Conclusions

We report the results of surgical treatment of a unique group of children presenting with tensa retraction resulting in tympanic disruption. These patients are very difficult to compare with those described in previous studies. The most important aspect that we observed is that these patients, when surgical treatment is chosen, could be cured by type 1 tympanoplasty with perichondrium or temporalis fascia without recurring progressive retraction, even in the long-term period.

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