Original Article

Anatomic and functional results in tragal cartilage tympanoplasty in adults: Correlation with prognostic factors

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ABSTRACT

Objectives: This study aims to evaluate the graft success and functional results of cartilage island graft tympanoplasties performed in adult patients.

Patients and Methods: Medical records of patients operated on for chronic otitis media at our clinic were reviewed. One hundred and ninety-five patients (212 ears) older than 16 years of age that had undergone tympanoplasty operation and that had been followed up for at least six months postoperatively, were included in the study. The prognostic factors that could have impact on graft success were analyzed. The pure-tone average and postoperative gain in air-bone gap (ABG) were recorded as the mean of 0.5, 1 and 2 kHz thresholds.

Results: Graft success was achieved in 191 patients (90%), and graft perforation occurred in 21 patients (10%). When the risk factors that might lead to graft perforation were analyzed separately, the presence of cholesteatoma (p=0.014), and not performing mastoidectomy during tympanoplasty (p=0.031) were significantly associated with graft perforation. The average preoperative ABG, including all types of tympanoplasty operations was 40.20±17.3 dB, and postoperative ABG was 30.14±19.21 dB (p<0.05).

Conclusion: The presence of cholesteatoma and tympanoplasty without mastoidectomy were found to affect graft success negatively. Cartilage island graft is an effective technique for tympanic membrane closure and significant hearing improvement.

Keywords: Cartilage graft; chronic otitis media; tympanoplasty.

The aims of tympanoplasty, first defined in 1952 by Zöellner[1] and Wullstein,[2] is the eradication of infection, preservation of normal anatomy as much as possible, and to obtain an intact tympanic membrane. Although many types of graft materials have been used in chronic otitis media (COM) surgery, temporalis muscle fascia (TMF) is the most commonly used today. In the last 20 years, the use of cartilage grafts has increased because of the low success rate of TMF, particularly in cases with recurrent and total perforation, chronic mucosal dysfunction, seriously atelectatic tympanic membrane, and revision.[3,4]

Cartilage is obtained from the auricular tragus or concha region, and its structural lithe matrix is composed of type 2 collagen and elastic fibers. Studies suggest that cartilage graft is a material resistant against retraction and resorption, with a high-tension resistance, a low rejection rate, a similar conduction character to the tympanic membrane, and is readily available.[5-7] Numerous cartilage

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tympanoplasty techniques have been reported in the literature.[8,9] Today, the composite perichondrium-cartilage island graft (PCIG), which was defined by Goodhill,[10] and the palisade cartilage graft, which was defined by Heermann,[11] are the most frequently preferred grafts. The PCIG is usually obtained from tragal cartilage. Studies suggest the use of a large piece of cartilage for a wide perforation (>50% perforation in tympanic membrane; TM), total atelectasis, and pars tensa retraction cholesteatoma as well as in patients without a malleus that has undergone ossicular reconstruction.[3,8]

Although many factors affecting the success of tympanoplasty surgery have been defined, previous study outcomes have been inconclusive. The literature includes the anatomical and functional results of cartilage and/or TMF, but there is only a limited number of studies about prognostic factors.[3-5,8,12] In recent years, palisade and PCIG materials have been the most frequently preferred in our clinic.

The present study evaluated the prognostic factors that may influence graft success in adult patients over the age of 16 years, who underwent cartilage tympanoplasty for COM with or without cholesteatoma.

PATIENTS AND METHODS

The patients that underwent surgery between January 2004 and January 2015 for COM (otorrhea for at least three months, mucopurulent exudate collection in the external ear canal; EEC and/or middle ear, or tympanic membrane perforation on otoscopic exam) or cholesteatoma were retrospectively evaluated. Patients who had previously undergone radical or Bondy-modified radical mastoidectomy, surgery for either atresia of the external ear canal or chronic otitis, and those under the age of 16 years were not enrolled in the study. The study comprised 195 patients (212 ears), that underwent cartilage tympanoplasty and were postoperatively followed for at least six months. The study was approved by the Başkent University School of Medicine Research Committee (Research project IRB No: KA15/310).

The poorer-hearing ear was chosen for surgery in patients diagnosed with bilateral COM. Anamnesis of the patients was retrieved from patient files and surgery reports. The following variables were analyzed as predictive values:

- Age (≤ 40 and >40)

- Gender

- Status of contralateral ear (without COM vs. with COM)

- Active ear infection

- Disease duration

- Otoscopy findings (Size of perforation (<50% vs. > 50%), presence of adhesion, hyaline in the remnant membrane, retraction pouch, presence of polyp and cholesteatoma, and whether the middle ear mucosa is dry or wet);

- Information retrieved from the surgery notes (type of incision, intact canal or open cavity approach to the external ear canal, ossicle, mucosa, facial canal, mastoidectomy);

- Postoperative follow-up period and findings of graft membrane examination that were recorded.

The patients were called for control visits in the postoperative 1st and 2nd week, 21st day, 2nd, 3rd and 6th month, and every year thereafter. The graft being intact or mobile for at least six months and the absence of atelectasis or lateralization were considered the criteria for anatomical graft success.

Additionally, mean threshold values of air and bone conduction at 0.5, 1 and 2 kHz on the audiograms performed during the preoperative and postoperative periods, and the "gap change," which was defined as the difference between air conduction and bone conduction threshold values at the same frequencies, were calculated and recorded. With regard to early (in one year) and late (at least 36 months) outcomes, air-bone gap (ABG) closure also included 20 dB, which is stated in the American Academy of Otolaryngology-Head and Neck Surgery Committee on Hearing and Equilibrium guidelines, and was considered a "successful" outcome.[13]

There were four types of tympanoplasty performed: type 1 (ossicle is intact), type 2

(one ossicle is missing or broken/separated; ossicle interposition or repair), type 3 (graft is placed on the head of stapes), and type 4 (partial ossicular reconstruction prostheses (PORP), or total ossicular reconstruction prostheses (TORP).

Surgical techniques

The surgeries were performed under general anesthesia by three experienced specialists for all patients. In our clinic, surgical techniques performed for COM do not differ according to pathology. Usually, a perichondrium-cartilage island graft is used, and the palisade technique is performed less frequently. Thinned tragal cartilage was used in all patients. Tragal cartilage is preferred for being thin, flat, and adequately large. While the cartilage was derived from tragus at the beginning of surgery, particularly in patients with an atelectatic, adhesive retraction pouch, in some patients, cartilage was prepared based on the course of surgery. The shape of incision is decided depending on the localization of perforation, which were the external ear canal and the status of anterior wall. A postauricular incision was performed in 179 ears, whereas endaural and transcanal surgical approaches were performed in 39 and two ears, respectively. The indications for open cavity tympanoplasty, by reducing the external ear canal, are extensive disease (granulation or cholesteatoma) that could not be removed by the intact canal technique and an eroded posterior wall of the external ear canal. Mastoidectomy is not routinely performed.

Patients were discharged from the hospital with oral medication following one or two days of hospitalization. They received systemic antibiotics for 10 postoperative days and then a topical antibiotic was used; tampons in the external ear canal were removed on the 14th-21st postoperative days. Patients with temporal fascia grafts were not included in the study.

Statistical analysis

Data were analyzed using PASW version 17.0 (SSPS Inc., Chicago, IL, USA) software. The statistical analysis of categorical variables was performed using a chi-square test. A p value less than 0.05 was considered significant. Multivariate logistic regression analysis with enter method was performed to identify independent prognostic factors and to assess their relative importance. The preoperative and postoperative ABGs on pure-tone average (PTA) were compared using Student t test.

RESULTS

In our clinic, cartilage tympanoplasty was performed for COM on a total of 253 patients by three experienced specialists between January 2004 and January 2015. There were 58 patients excluded, as they had no postoperative follow-up data or did not meet the eligibility criteria. Finally, 195 patients (212 ears) were enrolled in the study. Seventeen patients underwent bilateral cartilage tympanoplasty. A total of 96 male ears (45.3%) and 116 female ears (54.7%) underwent the surgical procedure. The mean age of the patients was 35.8±14.1 (range, 16 to 73) years. There were 86 patients (40.1%) aged over 40 years. Of the ears that underwent a surgical procedure, 105 (49.5%) were right and 107 (50.5%) were left. The mean postoperative follow-up period was 16.3±2.0 months (range 6-162 months). The follow-up duration was longer than two years for 45 ears (21.3%) and between six months and two years for 167 ears (78.7%). Audiological analysis was performed for at least six months following surgery.

Surgery-related complications, such as sensorineural hearing loss, wound site infection or hematoma were not found in any of the patients. The rate of anatomic graft success was 90% (191 ears) with perforation observed in 21 ears (10%). None of the patients developed atelectasis or lateralization; eight had cholesteatoma, five had retraction pouch and eight had myringo-tympanosclerosis. A "pinhole" marginal perforation occurred in the postoperative period in 13 ears.

Revision surgery was performed in eight ears, according to pathological status; one canal wall-down (CWD) and three canal wall-up (CWU) tympanomastoidectomies were performed for four ears that had chronic otitis with cholesteatoma.

The size of perforation was larger than half in 108 (50.9%), but smaller than half in 83 ears (39.2%). Severe atelectasis was observed in 21 ears (9.9%) and cholesteatoma

Table 1. Types of tympanoplasty and air-bone gap gains

	Air-bone gap gains			
	<10 dB (n)	11-20 dB (n)	>20 dB (n)	Number
Type 1	60	62	18	140
Type 2	7	7	2	16
Type 3	24	12	5	41
Type 4	6	6	1	15
Number	97	87	26	212

was determined in 39 (18.4%). No significant difference was determined between perforation size and adhesive membrane and graft success (p=.097, Pearson chi-square). Of the ears with cholesteatoma (n=39), 24 underwent intact canal wall (ICW) mastoidectomy and nine underwent CWD mastoidectomy, whereas mastoidectomy was not performed in six ears. In the ears that underwent ICW, a second-stage procedure was planned after 12-18 months for probable residual cholesteatoma and ossicular reconstruction. Anatomical failure was determined in one out of nine patients who underwent the CWD procedure.

Cartilage tympanoplasty type 1 was performed in 139 ears (65.6%), type 2 was performed in 17 ears (8.0%), type 3 was performed in 39 ears (18.4%) and type 4 was performed in 17 ears (8%). The preoperative and postoperative mean PTA-ABG values were 40.10±17.23 and 30.64±19.27, respectively. Comparing preoperative and postoperative ABGs, a decrease higher than 10 dB was observed in 119 ears (56.13%) with a significant decrease in gap difference (p=.00). A decrease in the threshold higher than 20 dB was determined in 29 ears (13.6%), and no significant difference was observed (p=.560).

The types of tympanoplasty and ABG gains are demonstrated in Table 1. There was no significant difference between these gains (p=.277).

Regarding the risk factors for anatomic graft success in cartilage tympanoplasty, a relationship was determined between not performing mastoidectomy and the presence of cholesteatoma in COM surgery (p=.03 and p=.014, respectively). No significant relationship was determined with

Table 2. Association between graft perforation and prognostic factors

Prognostic variables	Number	Perforation (n)	P value*
Age (>40)	85	9	0.785
Gender			
Male	96	6	0.105
Female	116	15	
Bilateral disease	107	12	0.519
Presence of hyaline in temporal muscle	73	8	0.710
Retraction pouch	43	5	0.672
Cholesteatoma	39	8	0.014
Wet middle ear	57	3	0.170
Malleus (-)	19	2	0.924
Mastoidectomy (-)	87	4	0.031
Open cavity approach	12	2	0.420

the other prognostic variables, including an age >40 years, gender, bilateral disease, presence of hyaline in the membrane, retraction pouch, wet middle ear, malleus, and open cavity approach (p=.785, p=.105, p=.519, p=.710, p=.672, p=.170, p=.925 and p=.420, respectively) (Table 2).

The evaluation of the relationship between a perforation size larger than half (perforation occurred in 16 of 20 ears) and graft success revealed a significantly lower success rate (p=.025).

Postoperative failure was determined in one out of every 21 atelectatic ears, which was not significant (p=.51).

DISCUSSION

Success in tympanoplasty surgeries results from a healthy graft as well as a dry and pneumatized middle ear. Studies have demonstrated that cartilage, as a graft material, has similar properties to the tympanic membrane and is a resistant and enduring material with high rates of anatomical graft success. In large series, anatomical success rates range between 92% and 100%.[3,10,14-29] Austin[20] determined the anatomic success rate of a cartilage shield graft to be 98.4% in those with an atelectatic middle ear, total tympanic membrane perforation, tympanoplasty failure and in the ears with cholesteatoma, which had been reported as high-risk, and defended it is a convenient technique. In the present study, the absence of atelectasis or lateralization, in addition to the graft's being intact, were considered as successes. Accordingly, graft success in a mean follow-up period of 16.7 months was 90% in our series. Moreover, a significant relationship was determined between the presence of cholesteatoma and not performing mastoidectomy and graft perforation.

Although cartilage has been suggested as the first choice in tympanoplasty surgeries in 'risky COM patients' (those with atelectasis, chronic Eustachian tube dysfunction, recurrent perforation, adhesive processes, subtotal or total perforation and nasal inhalation problems),[3,6,21] it has been demonstrated that the success rate is higher in type 1 tympanoplasty surgeries than TMF only, when performed for near-total pars tensa perforation.[22] Based on these study results, PCIG can be preferred to TMF and perichondrium, particularly in large perforations,[23] and when the postero-superior quadrant of TM prevents retraction pouch recurrence.[24] Additionally, presence of hyaline in the remnant tympanic membrane may lead to substantial graft failure, due to inadequate tissue supply.[5] The literature has limited information on the role of hyaline in the surgical success of cartilage tympanoplasty.

The other significant factors for success include the presence of the malleus, a contralateral ear, hyaline on the perforation and the absence of the posterior wall. The malleus is suggested as the most important determinant for the adaptation of tympanic membrane and reconstruction of hearing.[25] Additionally, absence of the posterior wall of the external ear canal is a factor effective in lateralization. Lateralization and graft failure may develop due to impaired connection between graft and ossicle chain.[30] The literature describes surgical success to be low in the presence of contralateral ear pathology,[12,31] and high with the CWD procedure.[4]

In the present study, we determined that TM perforation >50%, hyaline on the perforation margins, presence of the malleus, contralateral ear and the open cavity approach are not significant prognostic factors. We suggest that a perichondrium-cartilage island graft is a suitable material for large perforations, and hyaline on the perforation margins. We also think that a cartilage island graft can be used in CWD patients, even though the mucosa and pneumatization of the middle ear are pathophysiologically extremely impaired, and there is total or near-total tympanic membrane perforation in these patients.

Although the normal anatomy of the external ear canal has been preserved and the cavity problem has been eliminated, the incidence of otorrhea decreased and/or the rate of hearing improvement increased with the canal wall-up procedure in cholesteatoma surgery. Further, the rate of recurrent cholesteatoma was found to be higher than with the CWD procedure. Therefore, second-look surgery is suggested after ICW mastoidectomy concurrent with tympanoplasty.[32,33] Dornhoffer[3] defended the idea that likely residual cholesteatoma should

be considered in the event the disease became prominent in the anterior, or if conduction hearing loss is increased after posterior cartilage membrane reconstruction. In that study, the author determined the recurrence rate to be lower than 10% during the mean four-year follow-up period after tympanic membrane reconstruction performed by palisade technique in cholesteatoma surgery. In the present study, we determined that a cartilage island graft in cholesteatoma surgery unfavorably influences the anatomical success. We estimate that an island graft will delay diagnosing residual cholesteatoma, as it causes an opaque view in nearly the whole membrane. Therefore, perforation may occur due to disease progression.

McGrew et al.[34] suggested that mastoidectomy together with tympanoplasty enhances postoperative success but that the success rate is lower in the small cavity. The general opinion is that a good-pneumatized mastoid leads to a good pneumatized middle ear. A precise mastoid connection compensates for the sudden pressure changes in the middle ear.[35] It has been reported that the addition of mastoidectomy to tympanoplasty, even in the absence of infection, will reduce the progression of disease and the risk of probable revision surgery in the long run.[3,29,34] Mishiro et al.[36] also suggested that mastoidectomy does not influence graft success. In the present study, we determined that not performing mastoidectomy together with cartilage tympanoplasty negatively influences success.

Evaluation of functional outcomes in comparative studies on cartilage-perichondrium island graft revealed similar or better data to that of fascia. In these studies, significant outcomes have been obtained in large series, with regard to at least 10 dB and a higher decrease in ABG.[3,4,6,7,18,20,37] The outcomes change according to the type of tympanoplasty; as was expected, better acoustic outcomes have been obtained in tympanoplasty type 1.[3,20] In ossicular reconstruction surgeries (TORP, PORP) or type 3 tympanoplasty, Austin obtained successful outcomes. Along with the use of shield graft in type 3 tympanoplasty, significant outcomes have been observed in hearing function, due to the additional contribution of cartilage thickness (2 mm) and atelectatic and retracted manubrium mallei, and it was suggested as an advantageous technique.[20] In the present study, overall, the comparison between preoperative and postoperative ABG revealed 10 dB and higher gain, which was significant.

An opaque graft hindering the view of recurrent cholesteatoma includes the unfavorable features of cartilage tympanoplasty.[3] For this reason, second-stage surgery should be performed in adult patients 12-18 months after cholesteatoma surgery, and patients should be evaluated for ossicular reconstruction.

In the present study, we obtained a low success rate by not performing mastoidectomy during tympanoplasty in COM surgery or low anatomic success for cartilage island graft in cholesteatoma surgery. Based on these results, we think that healthier outcomes will be obtained by enhancing pneumatization of the mastoid via mastoidectomy, even though we know that cartilage is a more enduring material than temporal fascia. Moreover, it should be taken into account that diagnosing residual cholesteatoma may be delayed in chronic otitis patients with cholesteatoma. In the present study, different types of tympanoplasty and the presence of various pathologies were limiting factors. The results of the present study should be validated by prospective studies conducted in more homogenous groups.

Conclusions

In the present study, the factors that cause graft failure include not performing mastoidectomy during tympanoplasty and the presence of cholesteatoma. We achieved an anatomic success rate of 90%, despite the presence of different types of tympanoplasty. The absence of any difference between the type of tympanoplasty, in terms of functional outcomes, and ABG closure at 10 dB, support the assertion that perichondrium-cartilage graft is a preferable material.

Declaration of conflicting interests

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