



Does cartilage tympanoplasty impair hearing in patients with normal preoperative hearing? A comparison of different techniques

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Abstract

Objectives To evaluate and compare functional outcomes of tympanoplasty procedures with temporalis fascia and four different types of cartilage grafts in chronic otitis media (COM) cases with normal preoperative hearing levels.

Methods Records of patients who underwent type 1 tympanoplasty for non-complicated COM in a tertiary medical center between January 2010 and January 2017 were reviewed. Patients with central or marginal and dry perforations of the tympanic membrane, normal middle ear mucosa, intact ossicular chain and patients with a preoperative pure tone average (PTA) level of 25 dB or less and a word recognition score (WRS) of 88% or greater were included in the study. Graft success rates, preoperative and postoperative functional outcomes, and anatomical results were analyzed.

Results One hundred and forty-four patients who met the inclusion criteria were evaluated in the study. PTA and Air-bone gap (ABG) levels decreased significantly both in TF and CG groups after the surgery ($p=0.001$). Similarly, WRS scores increased significantly in both groups ($p=0.001$). There was not a significant difference in terms of PTA increase, WRS increase, and ABG closure levels between cartilage and TF groups. Increase in PTA, closure in ABG, and increase in WRS levels were compared among TF, WsCCG, MCG, PCG, and CPIG groups. The increase in PTA levels was also found to be significantly superior in the TF group ($p=0,023$). However, the multivariate analysis showed no significant difference for increase in WRS, closure in ABG and increase in PTA levels according to graft type ($p=0.285$; $p=0.461$; $p=0.106$, respectively) and gender ($p=0.487$; $p=0.811$; $p=0.756$, respectively).

Conclusion In COM cases with normal preoperative hearing, both TF and cartilage lead to superb functional and anatomical outcomes. There was not a significant difference in terms of PTA increase, WRS increase and ABG closure levels between cartilage and TF groups. The graft success rate of cartilage was found to be superior to TF, but there was not a statistically significant difference. Different types of cartilage grafts can be used in cases with normal preoperative hearing without the concern of hearing impairment.

Keywords Cartilage · Fascia · Tympanoplasty · Normal hearing · Hearing loss · Middle ear

Introduction

Temporalis fascia (TF) has been the most preferred graft type for tympanoplasty, since the introduction of tympanoplasty by Wullstein in the 1950s [1]. In the last decades, cartilage tympanoplasty has gained popularity and different techniques to harvest and shape the cartilage grafts have been described [2]. Many authors prefer cartilage grafts due

to their stiffness, rigidity, and resistance against retraction and perforation [2, 3]. Although some authors recommend the use of cartilage for cases with poor prognostic factors—such as total or subtotal perforations and atelectatic ears; some authors advocate the use of cartilage for also patients with low–middle ear risk index [4]. The latter emphasizes the higher graft success rate of cartilage when compared to TF [4].

Theoretically, a rigid material like cartilage can disrupt the sound-conductive characteristics of the tympanic membrane. Therefore, the thickness and stiffness of the cartilage is still a concern among some surgeons. We have observed that many colleges prefer TF for cases with low–middle ear risk factors and prefer cartilage grafts for high-risked

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perforations and/or revision cases. Functional outcomes of cartilage tympanoplasty and tympanoplasty with TF are widely documented in the literature. Almost all studies report that there is no statistically significant difference in terms of hearing outcomes between two grafts [5, 6]. However, there are a lack of data on the outcomes of these procedures in patients with normal preoperative hearing. The aim of this study is to evaluate the functional outcomes of both TF and cartilage in cases with a perforation of the tympanic membrane and normal preoperative hearing levels. We aimed to assess if different types of cartilage grafts would cause an impairment on auditory functions when compared to TF. Graft success rates, preoperative and postoperative functional outcomes, and anatomical results of different types of cartilage grafts alongside with TF were documented and analyzed.

Materials and methods

Records of patients who underwent type 1 tympanoplasty for non-complicated COM in a tertiary medical center between January 2010 and January 2017 were reviewed. The research protocol was approved by the faculty's Research Ethics Committee and informed consent forms were collected from all participating patients.

Subjects

Only patients older than 15 years of age were enrolled in the study. Patients with central or marginal and dry perforations of the tympanic membrane, normal middle ear mucosa, and an intact ossicular chain were included in the study. Preoperative pure tone audiometry tests were evaluated and only patients with a pure tone average (PTA) level of 25 dB or less were included. The word recognition scores (WRS) were also evaluated and the minimum WRS was 88%. The PTA values were calculated using 0.5-, 1-, 2-, and 3-kHz air-conduction thresholds [7]. The WRS values were measured using a recording of a 25-word list in the patient's native language at the maximum comfortable loudness level [8]. Patients who do not meet the audiologic criteria were not included in the study. Patients with traumatic perforations, inflamed/infected middle ear mucosa, and patients who had previous otologic surgeries were also excluded. Patient groups were constituted according to the graft type used during the procedures.

Audiometric evaluation

All patients were examined with oto-microscope and pure tone audiometry tests were performed preoperatively and postoperatively. After the study was designed, patients

were called for a control visit and audiometric tests were repeated to present long-term outcomes. For patients who did not respond the call, charts were reviewed. Outcome measures were PTA, WRS, and air-bone gap (ABG) values [8]. Changes in these levels were documented, analyzed and compared between the groups. All audiometric tests were performed in the same institution using the same model of audiometry device. (Interacustics AC40, Interacustics, Denmark). The guidelines of the Committee on Hearing and Equilibrium for evaluation of conductive hearing loss were used for assessment [7].

Statistical analysis

Statistical analysis was performed with SPSS for Windows (SPSS version 23.0; SPSS Inc., Chicago, USA). Distribution of the data was assessed with the Kolmogorov–Smirnov test. Chi-square exact test was used for the comparison of categorical data. Independent and paired samples *t* test were used for the analysis of parametric variables, Wilcoxon and Mann–Whitney *U* tests were used for the analysis of non-parametric variables. Correlation analysis was performed via Spearman or Pearson correlation analysis depending on the type of the variable. The difference is accepted as statistically significant if the value of *p* was <0.05.

Results

One hundred and forty-four patients who met the inclusion criteria were enrolled in the study. Characteristics of the study group are displayed in Table 1. Sixty-four (44.4%) patients were males and 80 patients were (55.6%) females. The mean age of the study group was 29.4 ± 12.9 years. Sixty-two (43%) patients were operated on the right ear and 82 (57%) patients on the left. The mean follow-up was 27.9 ± 26.1 months. Temporalis fascia (TF) and four types of different cartilage grafts were used for tympanoplasty procedures. There were 57 (39.5%) patients in the TF group and 87 (61.5%) in the cartilage group. The types of cartilage grafts were cartilage–perichondrium composite island graft (CPIG, $n = 23$, 15.9%), palisade cartilage graft (PCG, $n = 21$, 14.5%), wheel-shaped composite cartilage graft (WSCG, $n = 17$, 11.8%), and mosaic cartilage graft (MCG, $n = 26$, 18%). All cartilage grafts were harvested from the conchal cartilage and were placed under the fibrous annulus and over the manubrium mallei (over–under technique) [9]. TF was also placed with over–under technique. This technique was first described by Kartush et al. in 2002 as a modification of underlay tympanoplasty. In this technique, the entire drum remnant is elevated off of the long process of the malleus after the elevation of the posterior tympanomeatal flap. Then, the graft is placed over the malleus but

Table 1 Characteristics of the study groups

	All cases	TF group	Cartilage group	<i>p</i>
<i>n</i> (%)	144 (100)	57 (39.5)	87 (60.5)	
Age (mean ± SD) years	29.4 ± 12.9	30.3 ± 12.3	28.8 ± 13.3	0.356
Gender Male <i>n</i> , (%) female <i>n</i> (%)	64 (44.4) 80 (55.6)	25 (43.9) 32 (56.1)	39 (44.8) 48 (55.2)	
Follow-up (mean ± SD) months	27.9 ± 26.1	29.5 ± 29.0	26.8 ± 24.1	0.544
Postoperative audiometry time (mean ± SD) months	20.0 ± 22.3	22.4 ± 24.5	18.5 ± 20.8	0.308
Graft success rate (%)	91%	87.7%	93.1%	0.270

Table 2 Functional outcomes of temporalis fascia and cartilage groups

	All cases	Fascia group	Cartilage group	<i>p</i> *
<i>n</i> (%)	144 (100)	57 (39.5)	87 (61.5)	
Pure tone average (PTA) (dB)				
Preoperative	19.1 ± 4.9	20.2 ± 3.7	18.4 ± 4.5	0.026
Postoperative	14.3 ± 7.0	14.1 ± 6.8	14.4 ± 7.2	0.818
Increase	4.8 ± 7.2	6.0 ± 6.4	4.0 ± 7.6	0.106
Word recognition score (WRS) (%)				
Preoperative	93.0 ± 3.9	92.5 ± 3.6	93.4 ± 4.0	0.180
Postoperative	95.0 ± 3.9	94.1 ± 4.1	95.5 ± 3.6	0.029
Increase	1.9 ± 2.9	1.6 ± 3.1	2.1 ± 2.8	0.285
Air-bone gap (ABG) (dB)				
Preoperative	13.5 ± 5.0	13.9 ± 4.7	13.1 ± 5.3	0.360
Postoperative	8.8 ± 6.8	8.9 ± 6.3	8.4 ± 7.2	0.998
Closure	4.8 ± 5.2	5.0 ± 3.8	4.7 ± 4.9	0.461

Italic values are significant

under the residual drum and annulus. The main advantages of this technique are wide exposure of the anterior middle ear, easier graft placement in cases with a medially retracted malleus and the supporting effect of malleus to minimize medialization of the graft [9].

Functional outcomes of TF and cartilage groups are presented in Table 2. PTA and ABG levels decreased significantly both in TF and CG groups after the surgery ($p=0.001$). Similarly, WRS scores increased significantly in both TF and CG groups ($p=0.001$). The preoperative PTA levels were significantly higher in the TF group, whereas postoperative WRS were significantly higher in the cartilage group. However, there was not a significant difference in terms of PTA increase, WRS increase, and ABG closure levels between two groups.

According to the univariate analysis, the graft type ($p=0.388$) and gender ($p=0.441$) did not have a significant impact on WRS increase and ABG closure levels. However, the graft type showed a significant impact on PTA increase levels ($p=0.03$) and ended up to be superior in the TF group. There was not a significant relationship between gender and PTA increase levels.

Increase in PTA, closure in ABG, and increase in WRS levels were compared among TF, WsCCG, MCG, PCG, and CPIG groups with Kruskal–Wallis test. The increase in PTA levels was also found to be significantly superior in the TF group ($p=0.023$). However, the multivariate analysis showed no significant difference for increase in WRS, closure in ABG, and increase in PTA levels according to graft type ($p=0.285$; $p=0.461$; $p=0.106$, respectively) and gender ($p=0.487$; $p=0.811$; $p=0.756$, respectively). Hearing outcomes of cartilage groups alongside with TF are presented in Table 3.

Increase in WRS levels showed a significant negative correlation with age ($p=0.007$). No other significant correlations were observed.

After a mean 27.9 months of follow-up, graft failure was detected in 13 (9%) patients. Seven patients were from the TF group and six were from the cartilage group. The graft success rates did not show a significant difference according to gender or graft type ($p=0.270$ and $p=0.298$, respectively).

The post-hoc power was calculated for alteration of WRS, ABG, and PTA levels and success rates between TF and cartilage groups. A 90% post-hoc power was calculated for increase in WRS with 0.5 effect size (es), 31% for closure in ABG (es=0.2), 51% increase in PTA levels (es=0.3), and 22% for success rates (es=0.1).

Discussion

The use of cartilage in tympanoplasty was first described by Heermann who introduced the cartilage palisade technique [10]. Since then, cartilage has been used in different shapes and techniques for tympanoplasty procedures. Various studies and reviews reporting the outcomes of this graft material have been published [2, 5]. Almost all studies point out that functional and anatomical outcomes after cartilage tympanoplasty are as good as that achieved in tympanoplasty with temporalis fascia. Therefore, some authors suggest the use of cartilage not only for high-risked or recurrent perforations but also for cases with low-risk factors; without fear of impaired hearing [11]. Although the outcomes of cartilage

Table 3 Hearing outcomes of cartilage groups alongside with temporalis fascia

	Temporalis fascia	CPIG	PCG	WsCCG	MCG
<i>n</i> (%)	57 (39.5)	23 (15.9)	21 (14.5)	17 (11.8)	26 (18.0)
Pure tone average (dB)					
Preoperative	20.2 ± 3.7	16.8 ± 5.7	19.1 ± 4.8	18.5 ± 6.3	19.3 ± 5.0
Postoperative	14.1 ± 6.8	11.1 ± 4.2	12.0 ± 4.6	16.4 ± 6.9	18.0 ± 9.3
Increase	6.0 ± 6.4	5.6 ± 3.9	7.0 ± 4.2	2.1 ± 10.3	1.2 ± 9.3
Word recognition score (%)					
Preoperative	92.5 ± 3.6	93.6 ± 4.8	93.6 ± 3.6	93.7 ± 4.6	92.8 ± 3.2
Postoperative	94.1 ± 4.1	95.3 ± 3.7	95.9 ± 3.3	94.1 ± 3.4	94.4 ± 3.7
Increase	1.6 ± 3.1	1.7 ± 2.4	2.2 ± 2.3	0.6 ± 3.9	1.6 ± 2.6
Air-bone gap (dB)					
Preoperative	13.9 ± 4.7	10.5 ± 4.4	12.3 ± 5.5	14.9 ± 6.2	15.0 ± 4.2
Postoperative	8.9 ± 6.3	5.3 ± 5.5	6.6 ± 5.0	10.7 ± 7.8	12.5 ± 7.7
Closure	5.0 ± 3.8	5.3 ± 5.1	5.4 ± 3.9	4.3 ± 4.1	2.9 ± 4.4

CPIG Cartilage–perichondrium island graft, *PCG* palisade cartilage graft, *WsCCG* wheel-shaped composite cartilage graft, *MCG* mosaic cartilage graft

tympanoplasties are well described in the literature, there is a lack of data regarding the outcomes of cartilage tympanoplasty in cases with normal preoperative hearing.

Considering that the cartilage is a rigid and thick material when compared to temporalis fascia, it can theoretically impair the sound-conductive properties of the tympanic membrane. Therefore, there is still controversy among surgeons regarding the use of cartilage in these procedures. Iacovou et al. researched the effect of cartilage tympanoplasty on the resonant frequency of the middle ear using multi-frequency tympanometry and compared the outcomes with tympanoplasty with TF [12]. The authors concluded that the sound-conductive properties of the tympanic membrane remain unchanged after tympanoplasty with tragal cartilage and cartilage grafts could be used without any concern regarding its impact on the middle ear mechanics. However, in their study, the preoperative PTA and ABG levels were also higher than the current study. Therefore, the study group was relatively heterogeneous regarding preoperative hearing levels. However, our findings concur with their study as there was not a significant difference between cartilage and TF groups in terms of increase in WRS, closure in ABG and increase in PTA levels.

Regarding the thickness and conductive properties of cartilage, the ideal thickness of cartilage was searched by Zahnert et al. [13]. The authors revealed that both conchal and tragal cartilage were useful for reconstruction of the tympanic membrane from the perspective of their acoustic properties. They also suggested that acoustic transfer loss of cartilage could be reduced by decreasing its thickness, where a 500 micron thickness was evaluated as a good compromise between sufficient mechanical stability and low acoustic transfer loss. In the current study, all cartilage grafts were harvested from the conchal cartilage and a

routine effort to thin the grafts did not take place. Besides graft material characteristics, the sound-conductive properties of the reconstructed tympanic membrane are strongly influenced by the reconstruction technique [14, 15]. Mürbe et al. investigated the acoustic transfer characteristics of cartilage palisades, cartilage island transplants, and cartilage plates of different thicknesses [15]. The authors reported that the 0.5-mm cartilage plate had preferable acoustic properties compared to palisade technique. However, the cartilage island technique showed vibration characteristics superior to plate or palisade techniques. In the current study, we also had the chance to compare the outcomes of different types of cartilage grafts. Although the conductive properties of the grafted membranes were not measured in our study, functional outcomes including PTA, ABG, and WRS scores were analyzed. We observed no significant difference in terms of hearing outcomes among four types of cartilage grafts. Not only the functional outcomes, but also the anatomical results of cartilage grafts were superior to TF in our study. The success rate of cartilage grafts after a mean follow-up of 26.8 ± 24.1 months was 93.1%, whereas the success rate of TF after a mean follow-up of 29.5 ± 29.0 was 87.7%. However, there was not a statistically significant difference in terms of graft success rate between two grafts ($p = 0.270$). In their review, Mohamad SH et al. evaluated the effectiveness of cartilage and fascia in Type 1 Tympanoplasty and the authors concluded that tympanoplasty using cartilage with or without perichondrium had better morphological outcome than tympanoplasty using temporalis fascia [5]. However, there was no statistically significant difference in terms of hearing outcomes between the two grafts. We also observed no significant difference in terms of functional outcomes between two graft materials.

Yilmaz et al. reported and compared the outcomes of cartilage tympanoplasty procedures in children and adult patients [16]. After the analysis of 136 cases, the authors concluded that the functional results of cartilage tympanoplasty were acceptable in both children and adult patients. They concluded that the cartilage graft can also be preferred in cases with a low risk of failure. Although our study does not include pediatric patients, literature evidence suggests that cartilage grafts can also be used in pediatric patients without the concern of hearing impairment.

The main limitation of our study is the retrospective design. However, to our knowledge, the current study is the only report which evaluates the outcomes of different types of cartilage grafts in chronic otitis media cases with normal preoperative hearing. We also compared the outcomes with TF to favor a graft type in these cases. We observed that both types of graft materials lead to superb functional and anatomical outcomes, but the graft success rate of cartilage ended up to be superior.

Conclusion

In COM cases with normal preoperative hearing, both TF and cartilage lead to superb functional and anatomical outcomes. The graft success rate of cartilage was found to be superior to TF, but there was not a statistically significant difference. Functional outcomes of four different types of cartilage grafts (WsCCG, MCG, PCG, and CPIG) were also compared and there was not a significant difference among these different types of grafts. We came to the conclusion that all the types of cartilage grafts evaluated in our study can be used in cases normal preoperative hearing functions without the concern of hearing impairment.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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