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Systematic Review

Comparison of Cartilage With Temporalis Fascia Tympanoplasty: A Meta-Analysis of Comparative Studies

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Objective: To systematically review the results of type 1 tympanoplasty with temporalis fascia (TF) versus cartilage in patients with chronic otitis media (COM) for graft integration and hearing improvement.

Data Sources: The English language literature (until June 1, 2016) was searched, using Medline (via PubMed), Scopus, ProQuest, Ovid, Cochrane database, and Google Scholar.

Review Methods: A comprehensive review of the literature was performed. Prospective and retrospective studies enrolling patients with COM were included. Relevance and validity of selected articles were evaluated. Heterogeneity was assessed using I^2 statistics. For dichotomous variables, absolute rate differences, and number needed to treat (NNT) were calculated. For continuous variables, standard mean differences were calculated.

Results: A total of 11 prospective and 26 retrospective studies involving 3,606 patients were included. In general, the overall graft integration rates of cartilage and fascia tympanoplasty were 92% and 82%, respectively (NNT = 11.1, $P < 0.001$). Although there was no significant difference in the air–bone gap (ABG) closure of < 10 dB between the two groups, the subanalysis of prospective studies showed that patients in the TF group had less mean postoperative ABG ($P = 0.02$). Subgroup analysis of palisade grafts compared with that of TF graft revealed a significant difference in the graft integration rate favoring cartilage tympanoplasty ($P = 0.01$).

Conclusion: Cartilage grafting seemed to show a higher graft integration rate compared with TF grafting. Both cartilage and fascia tympanoplasty provided similar improvements in the hearing outcome postoperatively. Large prospective trials are necessary to collect high-quality data.

Key Words: Comparison, graft integration, hearing, outcome, tympanoplasty, meta-analysis.

Level of Evidence: NA.

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INTRODUCTION

Chronic otitis media (COM) is any structural change in the middle ear system associated with a permanent defect in the tympanic membrane (TM).[1] Tympanoplasty is the surgical repair of the TM and/or the middle ear ossicles. Since the introduction of tympanoplasty by Wullstein in 1952[2] and Zoellner in 1955,[3] different types of graft materials have been used to reconstruct the TM. These include temporalis fascia (TF), skin, periostea, perichondrium, dura mater, cartilage, vein, and fat.[4]

Temporalis fascia remains the most commonly used material for TM reconstruction, with a success rate of 93% to 97% in primary tympanoplasties.[5] However, the situation gets more complex, and failure rates are considered higher in cases of Eustachian tube dysfunction, retraction pocket, adhesive otitis media, and subtotal or total perforation. Therefore, graft materials that are more rigid than fascia (i.e., cartilage) and more resistant to infection, resorption, and retraction have been proposed as more appropriate for TM reconstruction.[6–8] There have been several adaptations to cartilage tympanoplasty techniques. Tos classified these methods into the following six primary groups [9]:

Group A: Cartilage tympanoplasty with palisades, stripes, and slices with attached perichondrium on the ear canal side

Group B: Cartilage tympanoplasty with foils, thin plates, and thick plates, not covered with the perichondrium

Group C: Tympanoplasty with cartilage-perichondrium composite island grafts that can be located superior or posterior or both

Group D: Tympanoplasty with special total pars tensa cartilage-perichondrium composite grafts

Additional supporting information may be found in the online version of this article.

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Group E: Cartilage-perichondrium composite island graft tympanoplasty for anterior, inferior, and subtotal perforations

Group F: Special cartilage tympanoplasty methods such as inlay butterfly cartilage tympanoplasty and composite chondroperichondrial clip tympanoplasty

Despite the availability of different methods of cartilage tympanoplasty, there is no consensus on aspects such as the most appropriate thickness of the cartilage graft and the best technique of cartilage tympanoplasty. It has been suggested that the increased thickness, stiffness, and the mass of the cartilage may negatively influence the integration of the graft and the hearing results.[10]

So far, several reviews on the comparison of cartilage and TF grafts for clinically relevant outcome measures of TM closure and hearing outcome have been published. However, these reviews included studies in which participants were included regardless of graft type (i.e., palisade grafts, shield grafts) and perforation size (subtotal or total).[4,11] Moreover, studies were included regardless of the type of tympanoplasty (i.e., with ossiculoplasty or mastoidectomy),[11] or only graft integration or graft take was measured.[11] Lyons et al.[12] appraised only the results of one-piece cartilage graft (that included island or butterfly grafts) in adults with COM. The minimum follow-up duration of the included studies for hearing improvement was 3 months. Recently, Yang et al.[13] published the results of a meta-analysis in type 1 tympanoplasty. They included only the retrospective studies with duration of follow-up more than 12 months comparing cartilage grafting with TF. In addition, two different surgical techniques for cartilage grafts (full-thickness and sliced cartilage grafts) were compared with TF grafts.

The aim of this review was to perform a meta-analysis of the different types of studies comparing cartilage and fascia tympanoplasty to pool and analyze a large quantity of data regarding these issues.

MATERIALS AND METHODS

An extensive search of the literature was performed in Medline (via PubMed), Scopus, ProQuest, Ovid, Cochrane database, and Google Scholar up to June 2016. The clinical question in PICO format (P = patient problem/population, I = Intervention, C = Comparison, O = Outcome) in our study included the following: a) patient: with COM undergoing type 1 tympanoplasty; b) intervention: cartilage graft; c) comparison: TF graft; and d) outcome: graft integration and hearing improvement. Primary outcomes were comparison of graft integration rates and hearing results of type 1 tympanoplasty with cartilage graft or TF graft. Secondary outcomes were comparison of the effectiveness of the different techniques of cartilage tympanoplasty and TF tympanoplasty, comparison of trimmed ($\leq$ 0.5 mm) or nontrimmed (full thickness) cartilage grafting with TF grafting, and comparison of the results in children and adults. During the search, the key words "tympanic," "membrane," "tympanoplasty," "myringoplasty," "cartilage," and "fascia," in combination with Boolean operators, were utilized to obtain prospective and retrospective comparative studies simultaneously containing all search terms.

Results were complemented with manual selection of articles listed in bibliographies. No restrictions regarding publication date, status, and population numerosity were applied.

Our study was performed in accordance with the meta-analysis of observational studies in epidemiology guidelines.[14] The number of studies initially selected was 120 (Fig. 1). At the first level of filtering, titles and abstracts were analyzed to identify articles concerning the subject of our inquiry. Only studies involving patients with COM were considered as eligible. The ears could be wet or dry. We did not apply any limitation regarding the duration of follow-up. Instead, we used subgroup analysis and meta-regression for further analysis. Patients with a history of ossicular discontinuity, ossiculoplasty, cholesteatoma, previous ear surgery (except ventilation tube insertion), or syndromes affecting the status of the middle ear were excluded.

Using predefined criteria, two reviewers (M.M.J., R.S.) independently evaluated the included articles on the type of comparative study, relevance, and validity (using the critical appraisal table of Lyons' study[12]). A high scale of studies ($\geq$ 5) was considered as a low-bias study. Conflicts were solved by consensus. Relevance referred to the applicability of the study findings for answering the clinical query. Validity answered the question whether the results obtained met all the requirements of the scientific research method.

Meta-analyses were conducted for outcome measures shared by at least three studies. The meta-analyses were performed using Review Manager (RevMan, version 5.3) from the Cochrane Collaboration (Oxford, United Kingdom). Meta-regression analyses and publication bias tests were performed using Stata statistical software package (version 11.0, StataCorp LP, College Station, TX). Studies were divided into the following five subsets: low-bias prospective comparative studies (PCSs), all PCSs, low-bias retrospective comparative studies (RCSs), all RCSs, and all studies (including all PCSs and RCSs). For discrete variables, we calculated the absolute rate, the absolute rate difference (RD), and the number needed to treat (NNT) with their respective 95% confidence intervals (CI). Standard mean differences (SMDs) were estimated for continuous variables. Weighting was performed using an inverse variance model. Heterogeneity was assessed using I^2 statistics, and a P value of < 0.1 was considered significant (i.e., showing heterogeneity).[15] The I^2 statistic describes the percentage of variation between studies that is caused due to heterogeneity rather than chance.[16] I^2 values of 25%, 50%, and 75% are considered to indicate low, moderate, and high degrees of heterogeneity, respectively.[15] Due to local differences in hearing outcome assessments, perforation sizes, and potential selection biases (particularly among retrospective studies), we selected the random effects model.

Subgroup analyses were conducted to explore for potential sources of heterogeneity by comparing the results of prospective studies versus retrospective studies, children versus adults, the use of palisade or island techniques versus other techniques, and the use of trimmed cartilage versus nontrimmed cartilage. Potential sources of heterogeneity were explored further by meta-regression analysis. The factors investigated in the meta-regression included level of evidence, age group, duration of follow-up (as a continuous variable), and technique of cartilage tympanoplasty. Categorical variables were included in the meta-regression using dummy variables. Publication bias was assessed graphically using funnel plots and regression tests according to the method reported by Egger[17] and by the Begg test.[18] A P value of < 0.05 was considered as statistically significant.

RESULTS

A total of 37 articles were finally included[19–55] in our meta-analysis, resulting in a pooled population of 3,606 patients: 1,795 undergoing cartilage tympanoplasty and 1,811 undergoing fascia tympanoplasty. There were 11 PCSs,[19–29] three of which were randomized.[20,28,29] The remaining 26 comparative studies were retrospective.[30–55] Three prospective studies[19,20,29] and 12

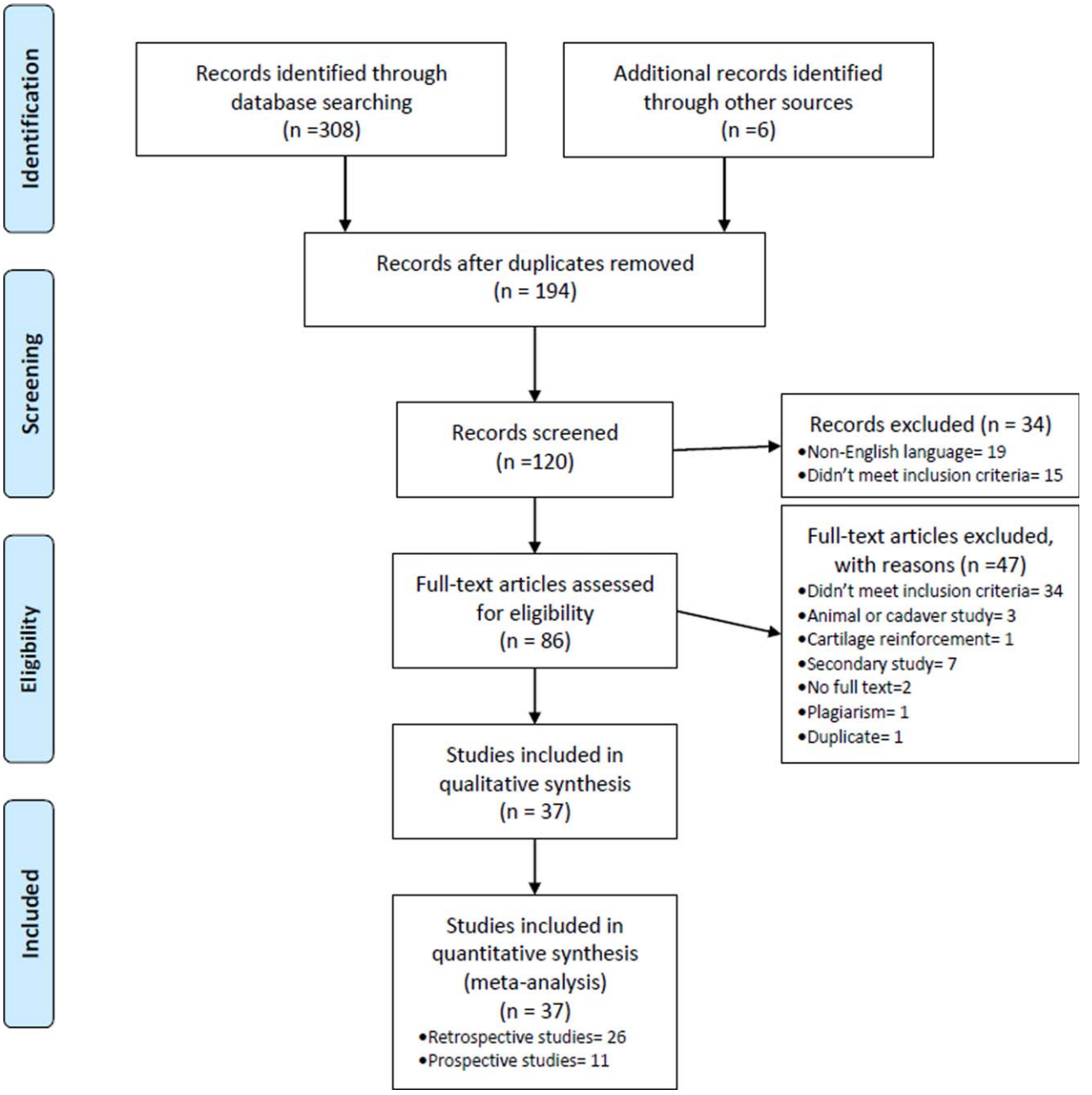


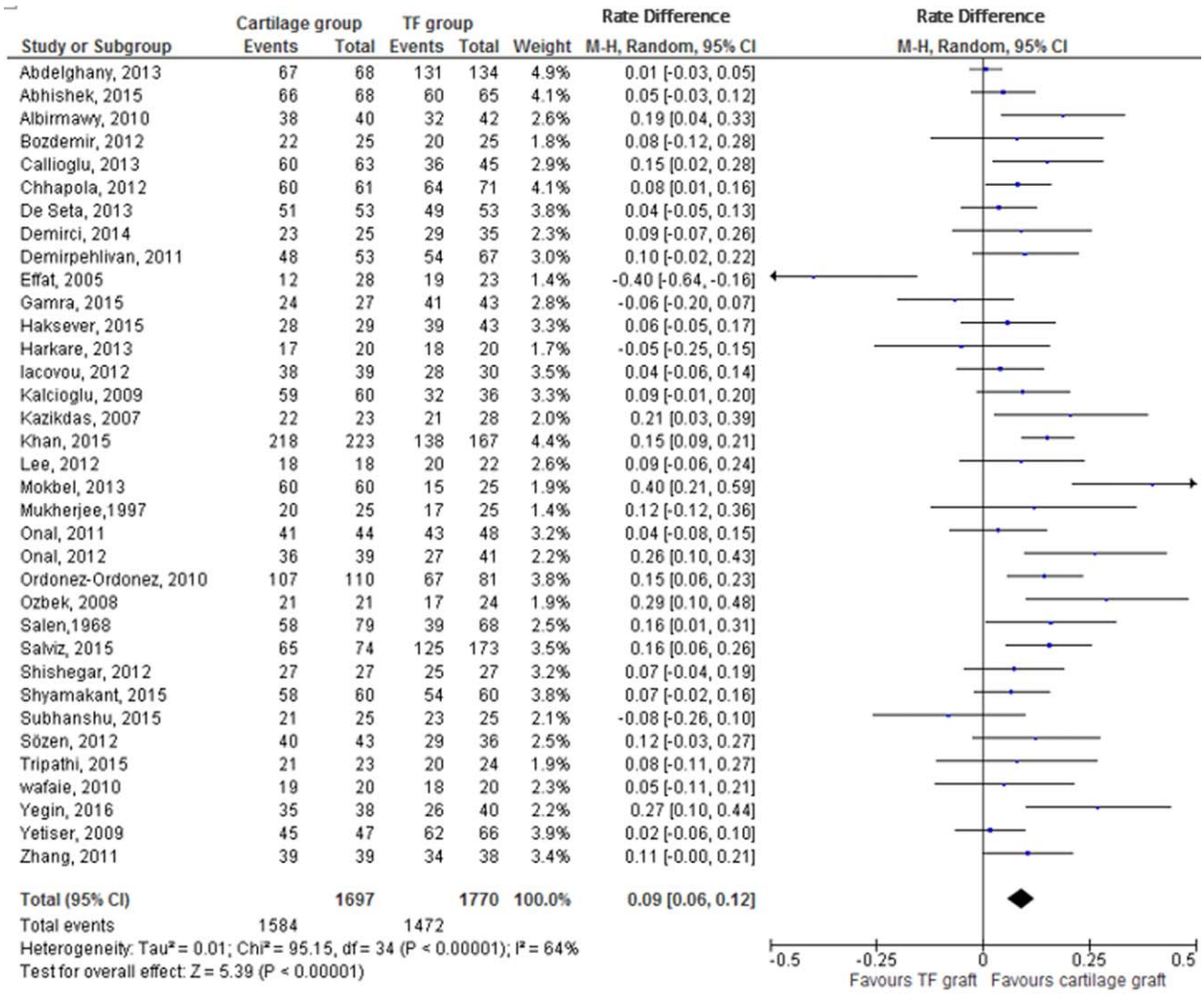
Fig. 1. Flowchart of the study's inclusion and exclusion criteria. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

retrospective studies[30–32,34,39,46,47,50,52–55] were considered as low-bias studies (see the online Supporting Table SI about the characteristics of the included studies).

Primary Outcomes

Data regarding graft integration rate (Fig. 2) were available for 35 eligible articles (11 prospective studies[19–29] and 24 retrospective studies[30–42,45–55]). Fifteen of them were at low risk of bias (score $\geq$ 5 in the quality assessment). Graft integration rate was higher for the cartilage tympanoplasty in the analysis of overall studies, and the difference was significant (RD = 0.09; 95% CI [0.06; 0.12]; $P < 0.001$). The NNT was 11.1 (95% CI [8.3; 16.6]). In the subset analyses of studies, there were differences between the two groups, although the difference was not significant in low-bias PCSs.

Data regarding postoperative air–bone gap (ABG) closure of < 10 dB (Fig. 3) were available for 13 studies (5 prospective studies[20,21,24,26,29] and 8 retrospective studies[30,31,37–39,46,47,49]). Five RCSs and two prospective studies were at low risk of bias (score $\geq$ 5 in the quality assessment). Air–bone gap closure of < 10 dB was not significant different between the two groups in the analysis of the four subsets (overall studies: RD = −0.01; 95% CI [−0.07; 0.04]; $P = 0.65$).



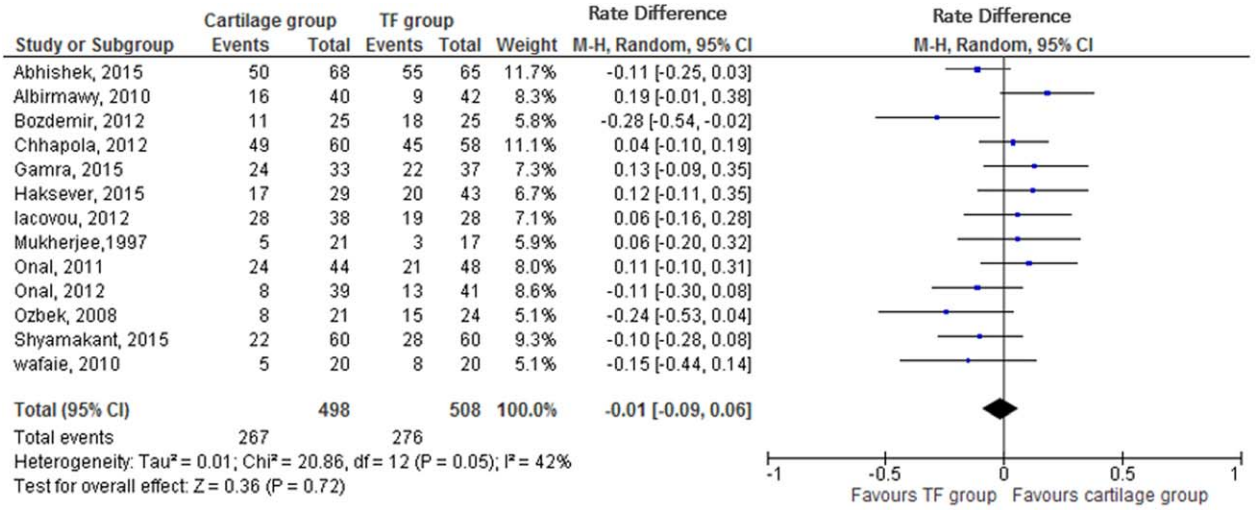
Outcome	Cartilage/Fascia	RD [95%CI]	NNT	P value	I^2
Graft integration					
Low bias PCSs	.97/ .95	.03 [-.01, .07]		.17	0%
All PCSs	.95/ .89	.06 [.01, .12]	16.16	.03	63%
Low bias RCSs	.91/ .79	.11 [.06, .16]	9.09	<.001	43%
All RCSs	.93/ .81	10 [.06, .14]	10.00	<.001	57%
Overall	.93/ .83	.09 [.06, .12]	11.11	<.001	64%

Fig. 2. Forest plot of graft integration rates for cartilage and fascia. CI = confidence interval; M-H = Mantel-Haenszel method; NNT = number needed to treat; PCS = prospective comparative studies; RD = rate difference; TF = temporalis fascia. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Data regarding postoperative mean ABG (Fig. 4) were available for 20 included studies (6 prospective studies[19,22,23,26,28,29] and 14 retrospective studies[32,34,39,41–47,49,52–54]). Because there were two prospective studies with a low risk of bias, we did not perform the meta-analysis in this subset. There were contradictory results in the four subsets. Although PCSs reported that the mean postoperative ABG was more in cartilage grafting (i.e., in favor of fascia grafting), meta-analysis of the retrospective studies revealed contradictory results.

Secondary Outcomes

Because the hearing outcome should be followed up for at least 1 year to obtain a stable result, the outcomes were reevaluated according to duration of the follow-up. A total 24 studies[19–22,24,30,31,33–36,38,39,41,42,45–47,49,50,52–55] were available for the analysis of graft take rate. The RD for graft integration rate was 0.09 (95% CI [0.05, 0.13]; $P < 0.0001$). In the subset of PCSs, five studies were available for analysis. The RD for graft integration rate was 0.03 (95% CI [−0.01, 0.08]; $P = 0.12$). In the



Outcome	Cartilage/Fascia	RD [95%CI]	NNT	P value	I^2
ABG closure <10dB					
Low bias PCSs					
All PCSs	.57/ .63	-.05 [-.13, .03]	-	.21	0%
Low bias RCSs	.47/ .43	.00 [-.15, .16]	-	.98	62%
All RCSs	.50/ .47	.01 [-.11, .13]	-	.87	55%
Overall	.53/ .54	-.01 [-.09, .06]	-	.72	42%

Fig. 3. Forest plot of air–bone gap closure < 10 dB for cartilage and fascia. CI = confidence interval; M-H = Mantel-Haenszel method; NNT = number needed to treat; PCS = prospective comparative studies; RD = rate difference; TF = temporalis fascia. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

subset of RCSs, the RD for graft integration rate was 0.10 (95% CI [0.06, 0.15]; $P < 0.0001$). Ten studies[20,21,24,30,31,38,39,46,47,49] with duration of follow-up more than 12 months were available for analysis of ABG closure of <10 dB. The RD was 0.01 (95% CI [−0.08, 0.10]; $P = 0.85$). In addition, the RD was nonsignificant (0.02 and 0.01, respectively) in the subsets of PCSs and RCSs. A total of 14 eligible studies[19,22,34,39,41–43,45–47,49,52–54] were assessed for SMD of postoperative ABG. The analysis showed no significant SMD between the cartilage graft and TF graft ($P = 0.25$). Of 14 studies, 12 were found to be retrospective. The SMD was −0.013 ($P = 0.09$). The detailed results are available in online Supporting Table SII.

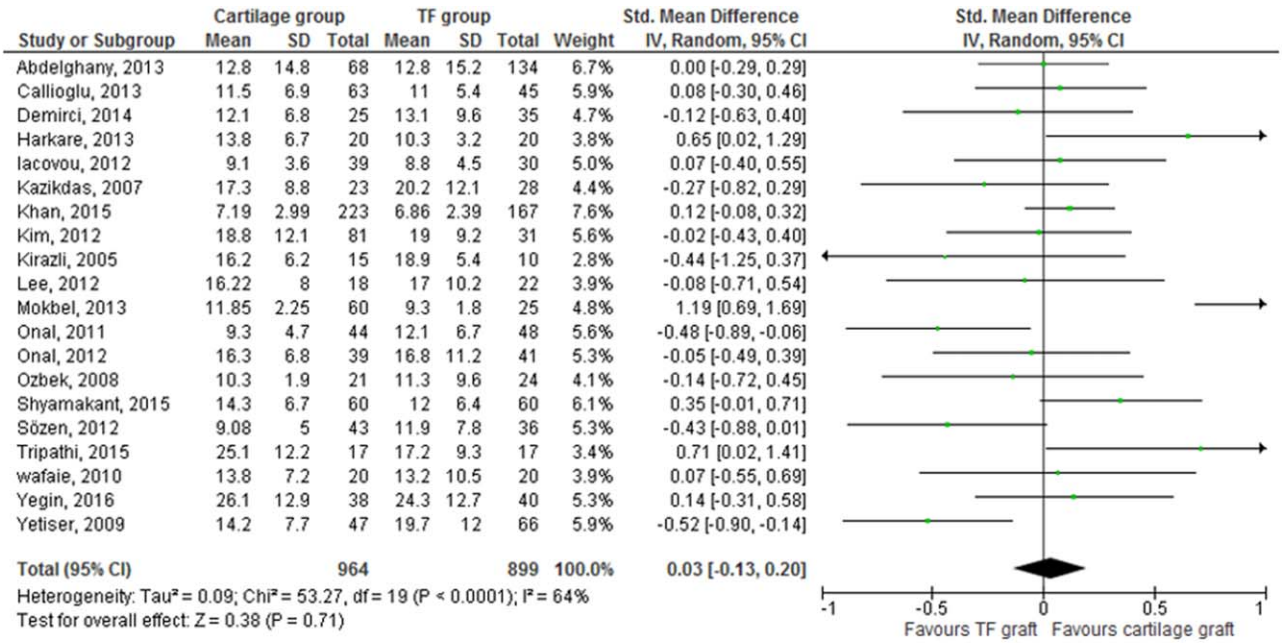
Details of the technique used for cartilage tympanoplasty were available for 35 included studies. Two studies[35,45] compared two techniques of cartilage tympanoplasty with TF tympanoplasty. The number of studies that had used similar techniques allowed us to pool and analyze data regarding graft integration rate and hearing improvement in three groups based on the Tos classification (Table I).

Eight reviews on the comparison of palisade grafts and TF grafts have been published.[25,27,28,35,39,41,45,49] When only the PCSs were considered, the graft integration rate was not significantly higher after cartilage tympanoplasty (92.0% vs. 89.5%; RD = 0.02; 95% CI [−0.07, 0.12]; $P = 0.60$), but when all the studies were included, there was a statistically significant difference in the graft integration rate favoring cartilage tympanoplasty (93.5% vs. 84.2%; RD = 0.08; 95% CI [0.02, 0.14]; $P = 0.01$) (Table I). The NNT was 12.5 (95% CI [7.1; 50]). In other words, to accomplish one more graft integration (NNT) postoperatively, an average of 12.5 patients need to undergo palisade cartilage tympanoplasty instead of TF tympanoplasty. For comparing the hearing improvement in the two groups, data of five studies were available.[28,39,41,45,49] Meta-analysis of postoperative ABG revealed an SMD of −0.20. This was in favor of the TF group; however, the difference was not statistically significant.

So far, there are only three reviews on the comparison of island graft (group C) and TF graft for graft integration.[19,24,50] There was no significant RD of graft integration in the two groups (RD = 0.09; 95% CI [−0.13; 0.31]; $P = 0.43$).

Regarding island tympanoplasty (group E), data about graft integration rate, ABG closure of < 10 dB, and postoperative mean ABG were available for 18,[20,21,26,29,31–35,40,45–47,51–55] 7,[20,21,26,29,31,46,47] and 11 studies,[26,29,32,34,44–47,52–54] respectively. The graft integration rate resulted in a statistical significance (RD = 0.11; 95% CI [0.08; 0.14]; $P < 0.001$). The NNT was 9.09 (95% CI [7.1; 12.5]). There was no significant difference in the hearing improvement of the two groups (Table I).

We performed subgroup analysis for comparison of trimmed or nontrimmed cartilage grafting with TF grafting. Regarding palisade cartilage tympanoplasty, we



Outcome	Standardized mean difference	Standard error	95% CI	P value	I^2
Post-operative ABG					
Low bias PCSs					
All PCSs	.47	.10	.09, .85	.02	74%
Low bias RCSs	-.18	.10	-.33, -.03	.02	39%
All RCSs	-.08	.05	-.19, .03	.16	29%
Overall	.04	.03	-.13, .20	.71	64%

Fig. 4. Forest plot of mean post-operative air–bone gap for cartilage and fascia. CI = confidence interval; M-H: Mantel-Haenszel method; PCS = prospective comparative studies; TF = temporalis fascia. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

TABLE I.
Graft Integration Rate, Air–Bone Gap Closure of < 10 dB and Mean Postoperative ABG in Patients Who Had Different Techniques of Cartilage Tympanoplasty or Temporalis Fascia Tympanoplasty*.

	PCSs		RCSs		Overall	
Outcome	RD [95% CI]	*P* Value	RD [95% CI]	*P* Value	RD [95% CI]	*P* Value
Graft integration						
A: Palisades	.02 [−.07, .12]	.60	.11 [.03, .19]	.006	.08 [.02, .14]	.01
C: Island					.09 [−.13, .31]	.43
E: Island	.06 [.2, .11]	.005	.12 [.09, .16]	< .001	.11 [.08, .14]	< .001
ABG closure of < 10 dB						
A: Palisades						
C: Island						
E: Island	−.07 [−.15, .02]	.11	−.06 [−.18, .06]	.35	−.06 [−.13, .01]	.07
	SMD [95% CI]		SMD [95% CI]		SMD [95% CI]	
Postoperative ABG						
A: Palisades			−1.40 [−4.21, 1.41]	.33	−.20 [−2.82, 2.43]	.88
C: Island						
E: Island			−.22 [−.40, −.04]	.02	−.03 [−.33, .06]	.18

Based on Tos Classification; ABG = air–bone gap; CI = confidence interval; PCSs = prospective comparative studies; RCSs = retrospective comparative studies; RD = rate difference; SMD = standard mean difference.

TABLE II.
Graft Integration Rate, ABG Closure of < 10 dB and Mean Postoperative ABG in Children or Adults Undergoing Cartilage Tympanoplasty or Temporalis Fascia Tympanoplasty.

	Children		Adult		Overall	
Outcome	RD [95% CI]	*P* value	RD [95% CI]	*P* value	RD [95% CI]	*P* Value
Graft integration	.14 [.02, .25]	.02	.13 [.03, .23]	.008	.09 [.06, .12]	< .001
ABG closure of < 10 dB	.04 [−.19, .28]	.72	−.15 [−.28, −.02]	.02	−.01 [−.07, .04]	.72
	SMD [95% CI]		SMD [95% CI]		SMD [95% CI]	
Postoperative ABG	.11 [−.22, .43]	.52	.23 [−.32, .77]	.41	.04 [−.13, .20]	.71

ABG = air-bone gap; CI = confidence interval; RD = rate difference; SMD = standard mean difference.

found eight studies. Three of them[35,39,41] compared trimmed cartilage grafting with TF grafting. Pooled graft integration rates were 92.5% versus 82.4%. Rate difference between the two groups was nonsignificant ($P = 0.15$). Other studies[25,27,28,45,49] used nontrimmed cartilage. Pooled graft integration rates were 94.2% versus 86.0%. The difference between the two groups was significant (RD = 0.09, $P = 0.03$). Regarding island cartilage tympanoplasty, we found 18 studies. Three of them[20,21,33] compared trimmed cartilage grafting with TF grafting. Pooled graft integration rates were 97.2% versus 91.5%. The difference between the two groups was significant (RD = 0.06, $P = 0.02$). Other studies[26,29,31,32,34,35,40,45–47,51–55] used nontrimmed cartilage. Pooled graft integration rates were 94.2% versus 80.9%. The difference between the two groups was significant (RD = 0.12, $P < 0.001$). Due to the low number of studies, we could not assess the effect of cartilage thickness on hearing improvement.

Regarding possible impact of perforation size of TM or mastoidectomy on our findings, we performed analysis in the patients with a subtotal perforation (> 50%) in which no mastoid surgeries were done. Data were available for 15 included studies (6 prospective studies[22,23,25,27–29] and 9 retrospective studies[33,41,44,46,47,49,52,54,55]). Although findings of RCSs and PCSs showed that pooled graft integration rates were in favor of the cartilage group, meta-analysis of the included studies about the hearing improvement revealed contradictory results in RCSs and PCSs (online Supporting Table SIII).

Data are sparse regarding cartilage tympanoplasty in only children or only adults. Overall, six studies presented results in only children. Palisade (group A[28,49]) and island (group E[34,53]) techniques were used. In addition, two researchers did not mention the type of cartilage tympanoplasty.[30,37] The graft integration rate resulted in a statistical significance (RD = 0.14; 95% CI [0.02; 0.25]; $P = 0.02$). The NNT was 7.14 (95% CI [4.00; 50.00]). There was no significant difference in the hearing improvement of the two groups (Table II). Overall, eight studies presented results in only adults. Palisade (group A[45]), thin and thick plate (group B[23]), island (group C[50]), and island (group E[26,29,31,33,44,45]) techniques were used. The graft integration rate resulted in a statistical significance (RD = 0.13; 95% CI [0.03; 0.23]; $P = 0.008$). The NNT was 7.69 (95% CI [4.34; 33.33]). The results were contradictory regarding hearing improvement (Table II).

Meta-Regression

Meta-regression analyses were carried out for outcomes of interest to explore potential influencing factors (Table III). Results of the meta-regression on graft integration rate indicated that the pediatric group was associated with higher rate ($P = 0.03$). In addition, the type of study (level of evidence) was found to be associated with mean postoperative ABG ($P = 0.01$).

Publication Bias Assessment

Funnel plot was performed for all the included studies to determine the publication bias from the literature. Begg and Egger tests were performed to quantitatively test the asymmetry of the funnel plot. All

TABLE III.
Outcome of Meta-regression Analyses for Graft Integration Rate and ABG Closure of < 10 dB and Mean Postoperative ABG.

	Graft Integration Rate		ABG Closure of < 10 dB		Mean Postoperative ABG	
	Co.	*P* Value	Co.	*P* Value	Co.	*P* Value
Level of evidence (prospective vs. retrospective)	.044	.157	−.027	.837	−.529	.017
Age group (children vs. others)	.117	.037	−.075	.728	.267	.180
Age group (adults vs. others)	.003	.921	−.174	.305	.026	.910
Follow-up	.002	.162	−.003	.773	.010	.170
Cartilage tympanoplasty (palisades vs. others)	.028	.556	−.062	.810	.112	.634
Cartilage tympanoplasty (island vs. others)	.038	.287	−.148	.510	.028	.881

ABG = air–bone gap; CI = confidence interval; Co.: meta-regression coefficient; RD = rate difference; SMD = standard mean difference.

outcomes were distributed symmetrically in the funnel plots, indicating no obvious publication bias. No evidence of publication bias was determined for the graft integration rate (P_{Begg} = 0.462, P_{Egger} = 0.109), the ABG closure of < 10 dB (P_{Begg} = 0.464, P_{Egger} = 0.846), and the mean postoperative ABG (P_{Begg} = 0.697, P_{Egger} = 0.938).

DISCUSSION

The results of this review show that overall graft integration rates of tympanoplasty with cartilage graft and TF graft are 92% and 82%, respectively. Of every 11 patients undergoing cartilage tympanoplasty, graft integration was observed in one subject more than with TF tympanoplasty. However, this superiority did not persist when only the low-bias PCSs were analyzed. This finding might be due to the low number of patients in the low-bias studies or the use of various techniques in cartilage tympanoplasty.

For hearing improvement, we extracted postoperative ABG closure of < 10 dB or postoperative mean ABG from the included studies. Although there was no significant difference between cartilage grafting and TF grafting, the meta-regression analysis indicated that the mean ABG was statistically significantly worse in those who underwent cartilage graft as compared to those who underwent TF graft. Results of this review with regard to hearing improvement are consistent with other reviews,[4,11,12,56] which observed no difference in hearing outcome between cartilage and fascia grafting.

There has been much debate about the optimal technique of cartilage tympanoplasty. Only two retrospective studies[35,45] compared different techniques of cartilage grafting together, including a total of only 71 patients. Although Lee et al.[45] reported 100% graft integration in the palisade and island cartilage tympanoplasty, the results of Demirpehlivan study[35] were in favor of island technique. Regarding hearing improvement, Lee et al.[45] described that the mean difference of postoperative ABG in the two techniques was 5 dB, in favor of island technique. Among the various techniques of cartilage tympanoplasty, the pooled data were sufficient for three groups (A, C, E). Only the palisade (group A) and island (group E) techniques followed better graft integration rate. Again, the hearing improvement outcome in these groups was similar to that of TF tympanoplasty.

Although in the island technique both the trimmed and nontrimmed cartilage had a better graft integration than in TF grafting, in the palisade technique only the nontrimmed cartilage had a better outcome. In agreement with our result, Atef et al.[57] showed that there was no statistically significant difference in graft integration rate and hearing improvement between those treated with full-thickness and those treated with half-thickness island cartilage graft.

Regarding the effect of cartilage thickness on hearing improvement, there was only one prospective study. Mokbel[23] mentioned that there was a significant difference between postoperative mean ABG of the group with partial thickness and the group with full-thickness (9.9 dB vs. 13.8 dB) graft. These findings are consistent with previous studies[58,59] that showed a 0.5-mm cartilage plate seems preferable compared with 1-mm thick palisades. Zahnert[59] showed there are transmission losses at lower frequencies when large TM defects are reconstructed with thick pieces of cartilage. The transmission losses can be reduced by slicing thinner cartilage transplants.

Owing to the possible Eustachian tube dysfunction in children, we performed a subgroup analysis. There were six studies that compared cartilage and TF grafts in children alone. The graft integration rate was better with the use of cartilage when compared with fascia grafts in the subgroup analysis and meta-regression. The subgroup analysis of the hearing outcome (either ABG closure of < 10 dB or postoperative mean ABG) showed no significant difference between the two groups. In addition, eight studies were available that compared the outcomes of tympanoplasty with cartilage with TF graft in adults only. Again, the analysis of graft integration rate was in favor of cartilage grafting. However, there was no significant difference in the hearing outcome of the two groups.

The primary findings of our meta-analysis seem to complete the previous meta-analyses. Mohamad et al.[11] published a review of publications about tympanoplasty with or without mastoidectomy. Similar to our analysis, they found that tympanoplasty using cartilage with or without perichondrium had better morphological outcome than tympanoplasty using temporalis fascia. However, there was no statistically significant difference in hearing outcomes between the two grafts. 1 year later, Iacovou et al.[4] undertook a review of the literature. They showed similar findings. Lyon et al.[12] evaluated the effectiveness of type 1 tympanoplasty with one-piece composite cartilage-perichondrium (CCP) grafts compared to TF grafts in adult patients with a subtotal TM perforation. They found no evidence of superiority of one-piece CCP grafting over TF grafting in type 1 tympanoplasty regarding complete closure of a subtotal perforated TM 1 year or more postoperatively, or hearing improvement at a minimum of 3 months follow-up. The main findings of our meta-analysis seem to contradict the meta-analysis of Lyons et al. Unlike group C, results in group E lead on the fascia tympanoplasty with cartilage grafts showed a superiority of cartilage tympanoplasty in the integration graft rate. Yang et al.[13] focused on the difference between full-thickness cartilage (one-piece or palisade) and sliced cartilage (< 0.5 mm) compared with TF graft. The researchers found a significant difference of integration rate in thin or full thickness cartilage graft compared with TF graft. However, a significant hearing improvement was observed only in the full thickness subgroup. We analyzed the impact of cartilage thickness on different types of cartilage grafting. We showed a similar finding about integration graft rate in the island cartilage graft. However, in the palisade cartilage graft subgroup, only full thickness graft had a significant difference.

We acknowledge the following limitations of the present study. First, the included studies were

prospective or retrospective comparative studies. Second, some studies analyzed only data of participants who completed the follow-up,[21] which could result in underestimation of the effect in the graft group with better performance because these patients might refrain from returning for follow-up. Third, there is heterogeneity between the studies regarding the duration of follow-up. Recently, Tan et al.[60] conducted a meta-analysis and demonstrated that there is no correlation between the follow-up period and success rate. Fourth, the size and location of the perforation differed between the studies, and some studies did not describe either of these perforation characteristics. Fifth, some studies included patients without COM.[30,39] Finally, the studies included in our review had different inclusion and exclusion criteria regarding bilateral disease.

CONCLUSION

This meta-analysis fills the gap in the current literature on cartilage tympanoplasty, providing the most up-to-date information in this area. Current available evidence suggests the superiority of cartilage grafting over TF grafting in type 1 tympanoplasty in both adults and children with COM in terms of graft integration ($P < 0.001$), whereas the hearing outcome in the two groups was comparable. Thus, cartilage tympanoplasty can be regarded as a preferable graft in type 1 tympanoplasty. Ultimately, cartilage grafting ideally should be compared with its TF counterpart within a large, well-designed, prospective, randomized study.

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