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Full-thickness versus sliced cartilage in type I tympanoplasty, comparative study

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Abstract

Introduction The use of cartilage in type I tympanoplasty is associated with concern about a poor audiological outcome. Slicing the cartilage could be a tool to overcome such a feared problem.

Objective To compare the healing and hearing outcomes of using sliced cartilage to full-thickness cartilage in type I tympanoplasty.

Methods Seventy patients with small to medium-sized central dry tympanic membrane perforation were included in this prospective study. The patients were randomly assigned to one of these two groups: group A: full-thickness cartilage tympanoplasty was done, and group B: partial thickness cartilage tympanoplasty was done. The assessment of healing and hearing was done at 3 and 12 months postoperatively.

Results The healing was achieved in 88.2% and 90.9% in group A and group B, respectively. In group A, the mean ABG was 23.44 dB preoperatively and 14.2 dB, and 12.6 dB in the first and second follow-ups, respectively. In group B, preoperative ABG was 23.58 dB compared to 7.9 dB and 6.93 dB in the two follow-ups, respectively. The results were significantly better in group B rather than group A at both follow-ups.

Conclusion Hearing results are better when sliced cartilage is used in tympanoplasty type I than full-thickness cartilage.

Keywords Cartilage tympanoplasty, Myringoplasty, Hearing outcomes, Healing outcomes, Full-thickness graft, Sliced graft

Background

The issue with using cartilage in type I tympanoplasty is the hearing improvement rather than the graft take [1], as cartilage stiffness and rigidity may lead to more effective tympanic membrane healing [2]. However, its hearing outcome is inconclusive [3]. Theoretically and experimentally, cartilage slicing could attain comparable hearing results to the fascia. Nevertheless, this has not been established clinically [1]. This article investigates sliced cartilage in an attempt to contribute to the previous literature on its audiological role in type I tympanoplasty.

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Methods

Patient selection

We prospectively investigated 100 patients: aged 12—50 years, diagnosed with small to medium-sized central dry tympanic membrane perforation (< 50% of the tympanic membrane), and presented at the Otorhinolaryngology Department, Cairo University, Egypt, in the period from July 2018 to July 2020. Seventy patients were included in this study. Exclusion criteria included a history of previous ear surgery ($n=6$), history of active middle ear infection in the previous 3 months ($n=8$), cholesteatoma ($n=1$), anterior perforation

($n=6$), air–bone gap > 30 dB ($n=5$), or associated comorbidity that may impair healing as diabetes mellitus ($n=3$) or anemia ($n=1$). Data were recorded regarding the patient's demographics, clinicopathologic aspect, treatment, and follow-up. The study was approved by the research ethical committee of Faculty of Medicine, Cairo University.

Treatment

Preoperatively, the included seventy patients were subjected to detailed history taking and complete otorhinolaryngologic examination, including otoendoscopy to determine the size and site of the perforation. All patients underwent pure tone audiometry and the mean ABG of frequencies 500, 1000, and 2000 was calculated and documented. The patients were then randomly assigned to one of these two groups:

Group A: Full-thickness cartilage tympanoplasty was done.
Group B: Partial thickness cartilage tympanoplasty was done.

Written consent for all patients was obtained after a full explanation of the operation and other alternatives.

The procedure was done under general hypotensive anesthesia. The middle ear was approached transcanal utilizing a 4-mm endoscopy. Subsequently, the perforation edges were trimmed using an angled pick and crocodile forceps. The tragal cartilage was harvested using a number 15 surgical blade and small sharp scissors, and the perichondrium was dissected from both sides of the cartilage. The cartilage was refashioned approximately 2 mm wider than the size of the perforation. The cartilage graft was placed as one piece in all cases. In group A, the cartilage was used with its full thickness of around 1 mm, whereas in group B, it was sliced using a number 11 surgical blade to its half thickness of approximately 0.5 mm (Figs. 1 and 2). After packing the middle ear with gel foam, the cartilage was placed in an underlay fashion, deep to the handle of the malleus. Several small pieces of gel foam were placed in the external ear. The tragal incision was closed using silk 3/0 simple interrupted sutures. An ear pack impregnated with antibiotic ointment was inserted into the external canal, and a sterile dressing was applied. The duration was recorded for every patient.

Postoperatively, the patients were given an oral antibiotic for 5 days. After 5 days, the dressing and ear pack were removed. The patients were then instructed to use local ear drops for 3 days. The stitches were removed after 1 week.

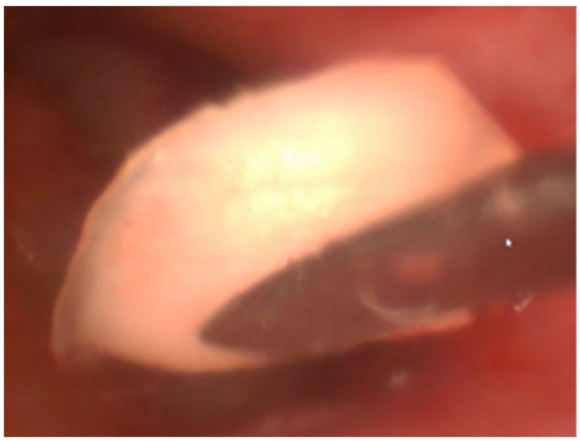

Fig. 1 Sliced cartilage using the blade

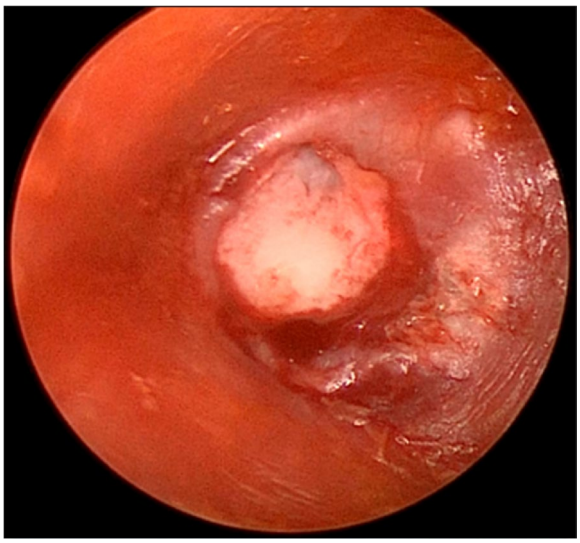

Fig. 2 Sliced one-piece cartilage tympanoplasty, left ear

Follow-up

The follow-up was done 3 and 12 months postoperatively. The healing was evaluated endoscopically at each follow-up, and the hearing was assessed by pure tone audiometry with the same parameters used preoperatively. In the follow-ups, the audiological gain was measured twice. The first audiological gain was the difference between the preoperative ABG and the postoperative one in the 3 months follow-up and the second audiological gain was the difference in the ABG between the two follow-ups.

Statistical tool

The statistical package for the Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY, USA) was used in coding and the entry of Data. Quantitative data were

Table 1 Demographic and clinicopathologic characters in both groups (expressed in terms of the number of patients except age range)

		Group A		Group B		*P* value
Age range		**17–36**		**13–49**		**0.052**
Sex	**Male**	9	26.5%	11	33.3%	0.539
	Female	25	73.5%	22	66.7%	
Cause	**Trauma**	5	14.7%	5	15.2%	1
	Infection	29	85.3%	28	84.8%	
Side	**RT**	16	47.1%	16	48.5%	0.907
	LT	18	52.9%	17	51.5%	
Perforation site	**Posterior**	10	29.4%	11	33.3%	0.729
	Center	24	70.6%	22	66.7%	
Perforation size	**Small**	12	35.3%	12	36.4%	0.927
	Medium	22	64.7%	21	63.6%	

Table 2 The success rate in each group

	Group A		Group B		*P* value
Healed	30	88.2%	30	90.9%	1
Failed	4	11.8%	3	9.1%	

summarized in terms of mean, standard deviation (SD), median (med.), minimum (min.) and maximum (max.), and quantitative variables which were compared using the non-parametric Mann–Whitney test. For categorical data, frequency (count) and relative frequency (percentage) were used in summarizing it, and the chi-square (χ^2) test was performed in its comparisons. The exact test was used when the expected frequency was less than 5. The statistical significance was set at p-values less than 0.05.

Results

Demographic and clinicopathologic characters

This study began with 70 patients, of whom 35 patients were assigned to group A, and 35 were assigned to group B. Three patients lost their postoperative follow-ups and were excluded from the study. Consequently, 34 patients remained in group A while 33 patients remained in group B. Patients' characteristics are depicted in Table 1.

Healing outcomes

Complete healing was achieved in 30 patients in group A and 30 cases in group B (Table 2). No cases demonstrated lateralization, medialization, or reperforation during the period of the follow-up.

Hearing outcomes

In group A, the mean ABG was 23.44 dB preoperatively and 14.2 dB and 12.6 dB in the 1st and second follow-ups, respectively. In group B, preoperative ABG was 23.58 dB compared to 7.9 dB and 6.93 dB in the two follow-ups, respectively. The p value was < 0.05 in both follow-ups (Table 3) (Fig. 3).

Discussion

In the past decade, cartilage has proven to be a highly effective and reliable graft for tympanic membrane repair. Unfortunately, the primary objective of tympanoplasty, the closure of the defect using cartilage, was not accompanied by the secondary objective of tympanoplasty, the improvement of hearing level. The use of cartilage may

Table 3 Hearing outcomes in both groups in both follow-ups

	Group A			Group B			*P* value
	Mean	**SD**	**Median**	**Mean**	**SD**	**Median**	
Preoperative ABG	23.44	4.84	23.00	23.58	3.49	23.00	0.885
Postoperative ABG (3 months)	14.20	4.35	14.00	7.90	2.35	8.00	< 0.001
1st audiological gain	8.40	3.50	9.00	16.03	2.09	16.50	< 0.001
Postoperative ABG (1 year)	12.60	3.67	13.00	6.93	2.45	5.00	< 0.001
2nd audiological gain	1.60	1.16	2.00	0.97	0.93	1.00	0.025

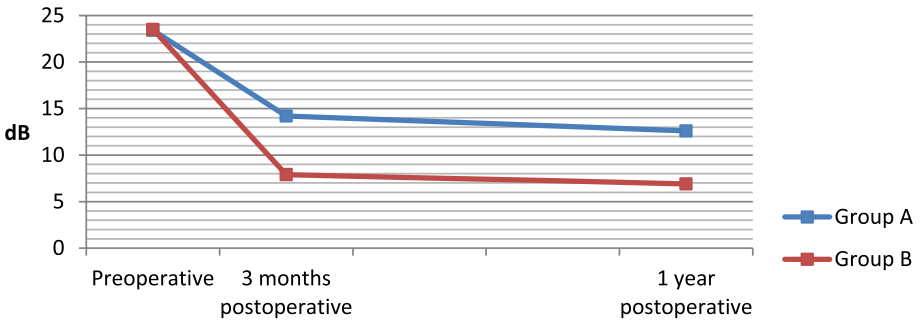

Fig. 3 Hearing outcomes in both groups

interfere with sound transmission resulting in impaired hearing. This concern led to reconsidering of cartilage usage and halted some surgeons from relying on it in tympanic membrane closure [4].

Initially, laboratory studies suggested that sliced cartilage would improve audiological outcomes. Zanhert et al. in 2000 [5] investigated the acoustic transfer properties of conchal cartilage specimens using a laser Doppler interferometer in-ear model of the external canal and tympanic membrane. They achieved an acoustic transfer loss comparable to the tympanic membrane by splitting the cartilage to a thickness less than 0.5 mm. Lee et al. in 2007 studied the frequency-amplitude response of cartilage thickness in a cartilage-tympanic membrane model using computed tomography and finite elements analysis. They used cartilages of different thickness and perforation size and compared their response to that of normal tympanic membrane. The optimal cartilage thickness for each perforation size was determined to be between 0.1 and 0.2 mm for large and medium-sized perforations and 1 mm for small perforations [6].

Despite the similarity of the results of these experimental studies, clinical studies demonstrated contradictory findings. Khan and Parab, in 2011, and Chakraborty et al., in 2018, used sliced cartilage of 0.5-mm and 0.2-mm thickness, respectively, and achieved good acoustic results [7, 8]. Their studies were not comparative ones, whereas Mokbel et al. used 0.2-mm thickness cartilage graft and Nemade et al. used 0.5-mm thickness cartilage graft and conducted a prospective comparative research. Comparing sliced cartilage to full-thickness cartilage and fascia grafts, they discovered that sliced cartilage and fascia are significantly better in terms of hearing gain [9, 10].

However, the findings of Atef et al., Vadiya et al., and Parelkar et al. who compared sliced and full-thickness cartilage grafts together contradict the previously mentioned findings. They discovered no additional acoustic benefits in slicing the cartilage [1, 11, 12]. Additionally, the work of Dornhoffer and Gerber comparing full-thickness cartilage to perichondrium and fascia grafts, respectively, supported the good audiological outcome of full-thickness graft [13, 14]. Furthermore, a meta-analysis contracted in 2016 suggested a better audiological outcome with full thickness [15].

Numerous technical and parametric factors may account for the variable results of clinical trials. Some previously cited studies, such as those by Dornhoffer and Gerber, did not specify the exact thickness [15]. In addition, Gerber did find a less audiological gain in full-thickness grafts, although it was not significant [14]. Furthermore, in the endoscopic work of Parelkar et al.'s study, they attributed the surgical technique as a significant factor in the audiological outcome rather than the thickness of the graft. In addition, they demonstrated that the same factor contributes to the low success rate of the tympanoplasties in their study by different surgeons of different learning curves. This factor could add to the variable results between different studies. In addition, the audiological gain was assessed once 2 months postoperatively, while the subjective assessment was the core of their 1-year follow-up [1]. The meta-analysis conducted in 2016 included eight eligible studies, all of which were retrospective, and none was a randomized controlled study. Moreover, they compared each cartilage subgroup (full thickness and sliced) to the temporalis fascia but did not do so collectively in a single comparison. Finally, they concluded that full-thickness cartilage yielded the best audiological outcome. They stated that this different conclusion is because they excluded the studies whose results were based on only a 3-month follow-up as they assumed that a 1-year follow-up is crucial for the stability of the cartilage in the middle ear. During this period, sliced cartilage may be prone to shrinkage resulting in worse hearing outcomes [15]. Although the phenomenon of cartilage resorption with time has been reported in several clinical and animal studies, it could be applied to cartilage of any thickness, not sliced one only. In addition, the precise duration for such alteration has not yet

been determined [16–18]. The majority of the previous studies used cartilage with perichondrium attached to one or both sides. The addition of perichondrium to cartilage may alter its vibratory properties [3]. Thinning the cartilage with perichondrium attached to it could lead to a curling effect [11, 19]. Therefore, Dornhoffer stated that the full-thickness graft is one that should be used. The curling effect could lead to residual perforations and affect the hearing outcome [1, 15]. The authors used cartilage alone without perichondrium in the current study to overcome this documented morphological aspect and hypothesized audiological issue. Other variable factors, as middle ear inflammation and persistent Eustachian tube dysfunction, may alter the acoustic properties of the cartilage plate in different studies [20].

In our research, the use of sliced cartilage achieved significantly better hearing outcomes than full-thickness plates. This difference was detected in both the 3-month and 1-year follow-ups, which is consistent with the findings of Mokbel et al. and Nemada et al. in their prospective comparative work. It could be noted that they used cartilage without its perichondrial layer [9, 10].

The results of the second audiological gain in this current study also demonstrated the improvement of ABG closure with time reported in other studies. This phenomenon could be explained by the process of remodeling cartilage with the tympanic membrane and malleus together with cartilage resorption over time. Therefore, larger perforations may require longer follow-up to reach better healing and hearing results, as suggested by some authors [8, 15]. In this study, the second audiological gain is relatively better in group A compared to group B, indicating that full-thickness cartilage could finally achieve a comparable audiological result to sliced cartilage if the follow-up period is more extended than 1 year. In group B, however, the ABG at the 1-year follow-up was not significantly lower than at the 3 months' follow-up. In other words, waiting a long time for cartilage to stabilize and give its final functional results is not necessary in the case of using sliced cartilage in low-risk perforation, but it is necessary in the case of using full-thickness cartilage, if we assume that it could achieve the same final audiological gain at the end.

Good hearing outcomes resulting from the use of sliced cartilage could encourage the surgeons to depend on it in their future tympanoplasties, but they may be concerned again by the rigidity of the thinned cartilage and thus failure to achieve the primary objective of tympanoplasty. However, the risk of losing rigidity by using sliced cartilage could be refuted based on this current study. The authors found comparable success rates between full-thickness tympanoplasty and sliced cartilage tympanoplasty after 1 year of follow-up (~88% in group A versus ~91% in group B with a p value of 1). In addition, neither retractions nor reperforations occurred after a 1-year follow-up. Although this is a relatively short follow-up period to obtain a solid conclusion regarding the cartilage rigidity, Khan et al. followed up on 223 ears who underwent tympanoplasty using sliced cartilage for four years and only three recurrent perforations were encountered [21]. In addition, Nemade et al. worked on high-risk perforations and followed up with their patients for 5 years, emphasizing the stability of the cartilage of thin thickness, even if middle ear pressure was high [10].

In the current study, the authors used the blade to slice the cartilage, which aligns with the procedure in many previous publications [11, 12]. In contrast, other surgeons in their publications used cartilage slicers [1, 7, 9]. According to Parab et al., the disadvantage of using a blade in slicing the cartilage is the wasting of remaining cartilage, which could not be used in future reconstructions. They stated many advantages to using their cartilage slicer, depending mainly on the precise slicing measurements [22]. Nonetheless, in this study, the authors achieved the desired thickness approximately using the blade with similar results to their studies. In addition, the presence of thickness irregularities in the cartilage might affect the position of maximum vibration of the graft, but it does not affect the volume vibration of the entire graft [20].

The current study limitations included limited number of patients and not studying the effect of Eustachian tube dysfunction. For future studies, the authors suggest the study of the effect of sliced cartilage in large perforations and other types of tympanoplasties other than type one tympanoplasty and comparing it to standard techniques in the literature.

Conclusion

Sliced cartilage in type one tympanoplasty achieved better hearing outcomes than full-thickness cartilage, without affecting graft take rates, increasing technical difficulties, or increasing the risk of complications.

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Authors' contributions
MA, AE, AM, MS, and MS, the surgical work of this study. AE, follow-up of the patients, data gathering and interpretation, writing, correspondence. MA, editing. AA, supervision. All authors gave their permission for submission of this manuscript to the *Egyptian Journal of Otolaryngology and Head & Neck Surgery*.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The ENT Department, Faculty of Medicine, Cairo University ethics committee and Kasr AlAiny School of Medicine ethics committee approved the research protocol.
Informed consent to participate was provided by all participants in this study.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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