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Endoscopic Underlay Tympanoplasty Type 1: Ring-Shaped Versus Wheel-Shaped Composite Cartilage-Perichondrium Graft

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ABSTRACT

Background: Previously a techniques variety have been described and are currently utilized in tympanoplasty type 1, involving sandwich, underlay, overlay, plugging, rosette and pegging**.** The operative material and technique choice for tympanoplasty persists controversial**.**

Aim: We aimed to evaluate the wheel-shaped cartilage-perichondrium composite graft and functional and anatomical outcomes of ring in endoscopic tympanoplasty type I for repairing of large and subtotal perforation.

Methods: This prospective comparative study was carried out on fifty chronic suppurative otitis media patients tubotympaic type with large and subtotal tympanic membrane (TM) perforation. The participants were assigned randomly into two groups: Group A included 25 patients who were subjected to endoscopic tympanoplasty type 1 ring-shaped composite cartilage perichondrium graft. Group B contained 25 patients who were subjected to endoscopic tympanoplasty wheel-shaped composite cartilage-perichondrium graft.

Results: Post-operative pure tone audiometry (PTA) test in ring-shaped graft group was 20.2 ± 2.5, while in wheel-shaped graft group was 19.36 ± 2.53 with no statistically significant difference (p= 0.244) between the two groups.

Conclusion: Our study found that while both ring and wheel-shaped cartilage-perichondrium composite grafts can achieve successful graft acceptance, the wheel-shaped graft showed a significantly greater postoperative improvement in hearing outcomes, a higher rate of TM regeneration, and comparable graft success rates. Additionally, the choice of graft shape played a pivotal role in optimizing surgical outcomes, particularly in cases with significant perforation size. Our study highlighted the potential advantages of wheel-shaped grafts in enhancing hearing improvement and TM regeneration for patients with CSOM.

Keywords: Endoscopic tympanoplasty, Perichondrium, Perforation, Transcanal.

INTRODUCTION

Tympanoplasty type 1 presently employs a number of techniques that were previously described as sandwich, rosette, underlay, pegging, overlay, and plugging [(1)]**.** Material and surgical technique selection for tympanoplasty continue to be controversial [(2)]**.** Furthermore, an extensive grafting materials variety has been implemented, including allografts, homografts, and autografts [(3)]**.** Currently, the most frequently utilised autografts consist of veins, temporalis fascia (TF), areolar tissue, periosteum, and perichondrium. These autografts are applied using either the underlay or overlay technique [(4)]**.**

The cartilage application to reconstruct the posteriosuperior quadrant of the TM has demonstrated a reduction in the occurrence of recurrent retraction pockets due to the rigid nature of cartilage [(5)]**.** Well tolerated in the middle ear, the graft is straightforward to extract from the tragus or conchal bowl. Nevertheless, the thickness of cartilage has prompted criticism regarding its potential impact on hearing outcomes [(6)]**.**

In previous research, endoscopic tympanoplasty demonstrated superior outcomes in terms of postoperative recovery and morbidity. Therefore, it may serve as a viable substitute for microscopic tympanoplasty. Endoscopes may one day be employed in all ear procedures, including cholesteatoma, stapedotomy, and cochlear implant procedures [(7)]**.**

A modified cartilage–perichondrium composite graft, referred to as a "ring" graft, is comprised of a ring-shaped cartilage piece positioned peripherally and a perichondrium sheet adhered to it. This particular graft variant possesses the benefits associated with perichondrial grafts, TF grafts, and cartilage–perichondrium composite grafts, while excluding their drawbacks [(8)]**.**

We aimed to compare the functional and anatomical outcomes of ring- and wheel-shaped cartilage-perichondrium composite graft in endoscopic tympanoplasty type I for repairing a large and subtotal perforation.

PATIENT AND METHODS

This prospective comparative study included 50 patients presented in Outpatient Clinic of Benha University Hospitals with chronic suppurative otitis media (CSOM) tubotympaic type with large and subtotal TM perforation. The patients were randomly allocated by sealed envelopes into two groups: **Group A** included 25 patients who were subjected to endoscopic underlay tympanoplasty type 1 ring-shaped composite cartilage perichondrium graft. **Group B** included 25 patients who were subjected to endoscopic wheel-shaped composite cartilage-perichondrium graft. The study duration was 6 Months.

Inclusion criteria: Patients aged above 12 years and below 60 years old. Patients who had CSOM tubotympaic type with subtotal and large sized TM

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perforation inactive for at least 3 weeks without any other inner, middle or external ear diseases.

Exclusion criteria: Patients aged below 12 years and above 60 years old, patients with uncontrolled systemic diseases or coagulopathy as diabetes mellitus, tuberculosis, patients with recent traumatic perforation, patients with previous ear surgery and evidence of cholesteatoma or sever tympanosclerosis and patients with sensory neural hearing loss.

All patients underwent complete ENT examination, full history taking including: Personal history (Age, name, and gender) and medical history (drugs used). Complete general examination. Endoscopic ears examination was undergone for every participant to confirm the perforation size and site and middle ear mucosa state. The central perforation was either subtotal or large. Pure tone audiometry was done for hearing loss measuring with air-bone gap (ABG) measurement.

Surgical technique: All cases were operated under general anesthesia. The endoscopic approach was utilized in all participants. **Group A:** The tragal cartilage graft diameter was between 12 and 15 mm. A circular cartilage section was removed from the graft's centre utilizing an ear speculum or a number 15 scalpel blade with a pointed apex. A circular, incised cartilage fragment was extracted via delicate dissection. It was ensured that the attached perichondrial sheet was not lacerated. By employing this technique, a perichondrial sheet featuring an affixed cartilage ring framework could be acquired. With care to preserve elastic, good rim of firm, intact cartilage (2-3mm), the cartilage ring was trimmed to the required perimeter so that the graft would be slightly larger than the membrane tensa. It was determined to refresh the TM edge perforation (Figure 1- Figure 4).

Following the TM and middle ear preparation, the cartilage and perichondrium of the graft were positioned medially and laterally, respectively, in order to serve as an underlay. The graft was positioned medial to the malleus handle. The TM remnant is used to cover the graft, while the posterior tympanomeatal flap is repositioned.

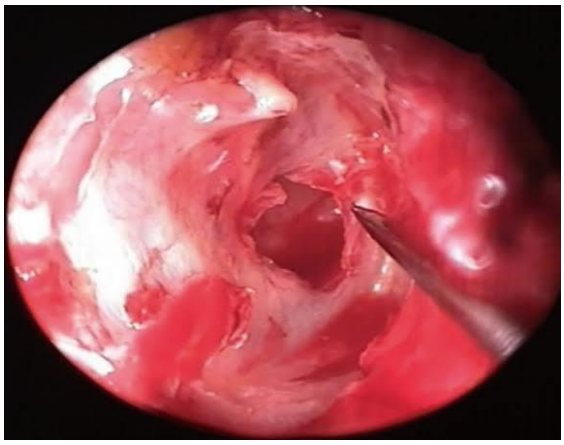

Figure (1): Refreshing the DCP's edge (RT. ear).

Figure (2): Harvesting tragal cartilage perichondrium graft.

Figure (3): Perichondrium cartilage transplant on one side.

Figure (4): Ring graft with central perichondrium.

Group B: Grafts were extracted from tragal cartilage in the course of the operation. It is composed of sliced cartilages that are 2 mm wide and the complete fold; its length is variable in accordance with the perforation. The only preserved portion of perichondrium was its lateral side. There are cartilaginous island layers on the perichondrium. Wheel-shaped composite cartilage-perichondrium graft (WSCCG); graft material in the shape of a wheel composed of four island cartilage units (Figure 5).

Figure (5): The WSCCG harvested from the tragal cartilage.

Gel foam was applied to the external ear canal laterally to the reconstructed TM in both groups, excluding the middle ear.

Post-operative care and follow up: Antibiotics for 3 weeks, removal of outer pack (1 week), removal of inner pack (3 weeks), endoscopic examination and documentation by endoscopic photography and pure tone audiogram were done after 3 months-6months [(2)]**.**

Outcomes: Full, complete TM healing without perforation was described as successful graft acceptance. The audiograms taken three and six months after surgery were used to measure hearing progress. The ABG closure to within 20 decibels was considered a successful hearing.

Ethical considerations: Benha Faculty of Medicine Ethics Committee gave its approval to this study. All participants gave informed written consents after receiving all information. The Helsinki Declaration was followed throughout the study's conduct.

Statistical Analysis

SPSS version 26.0 for Windows was utilized to collect, tabulate, and perform statistical analysis on all collected data. Range, mean, standard deviation, and median represented quantitative data. Utilizing numbers and percentages represented qualitative data. All significant statistical comparisons utilised two-tailed tests. P-value ≤ 0.05 for significance. Chi-square (X^2) test of significance was utilized to evaluate proportions between qualitative parameters. Independent t-test was utilized in order to compare between two independent groups with parametric quantitative data.

RESULTS

Regarding gender, a statistically insignificant difference existed between the two groups under investigation (p = 0.571). Age in ring shaped graft group ranged from 22 to 41 with a mean of 33.56 ± 4.98 while in wheel shaped graft group the age ranged from 25 to 46 with a mean of 32.36 ± 5.37 years with no statistically significant difference between the two groups (p=0.416) (Table 1).

Table (1): Demographic characteristics among the study groups

	Ring-shaped graft group (n = 25)	**Wheel-shaped graft group (n = 25)**	**Test of Sig.**	**p**
Gender			**X2 = 0.321**	**0.571**
Male	14 (56%)	12 (48%)		
Female	11 (44%)	13 (52%)		
Age (years)			**t = 0.82**	**0.416**
Mean ± SD.	33.56 ± 4.98	32.36 ± 5.37		
Median (IQR)	34 (30 - 38)	30 (29 - 37)		
Range (Min-Max)	19 (22 - 41)	21 (25 - 46)		

Table (2) showed side of perforation among the study groups. Regarding side of perforation, a statistically insignificant difference was observed between the two studied groups (p= 0.777).

Table (2): Side of perforation among the study groups

	Ring-shaped graft group (n = 25)	**Wheel-shaped graft group (n = 25)**	**Test of Sig.**	**p**
Side of perforation			**X2 = 0.081**	**0.777**
Right	13 (52%)	14 (56%)		
Left	12 (48%)	11 (44%)		

Table (3) showed that Pre-operative PTA in ring-shaped graft group ranged from 26 to 33 with a mean of 30.72 ± 1.95 dB, while in wheel-shaped graft group the Pre-op PTA ranged from 27 to 33 with a mean of 30.2 ± 1.63 dB with insignificant difference (p= 0.312) between the two groups. Post-operative PTA in ring-shaped graft group ranged from 15 to 25 with a mean of 20.16 ± 2.08, while in wheel-shaped graft group the post-operative PTA ranged from 24 to 32 with a mean of 27.08 ± 1.47 dB with highly significant difference (p= <0.001) between the two groups.

Table (3): Pre- and Post-operative PTA among the study groups

	Ring-shaped graft group (n = 25)	**Wheel-shaped graft group (n = 25)**	**Test of Sig.**	**p**
Pre-op PTA (dB)			**t = -1.023**	**0.312**
Mean ± SD.	30.72 ± 1.95	30.2 ± 1.63		
Median (IQR)	31 (30 - 32)	30 (29 - 32)		
Range (Min-Max)	7 (26 - 33)	6 (27 - 33)		
Post-op PTA (dB)			**t = 13.606**	**<0.001**
Mean ± SD.	20.16 ± 2.08	27.08 ± 1.47		
Median (IQR)	20 (19 - 21)	27 (26 - 28)		
Range (Min-Max)	10 (15 - 25)	8 (24 - 32)		

Table (4) showed that Pre-operative ABG in ring-shaped graft group ranged from 19 to 27 with a mean of 21.96 ± 1.81, while in wheel-shaped graft group ranged from 19 to 24 with a mean of 21.88 ± 1.42 with no statistical significant difference (p= 0.863) between the two groups. Post-operative ABG in ring-shaped graft group ranged from 10 to 16 with a mean of 12.92 ± 1.47, while in wheel-shaped graft group ranged from 17 to 23 with a mean of 19.48 ± 1.36 and a highly statistical significant difference was found between the two groups (p= <.001).

Table (4): Pre- and Post-operative ABG among the study groups

	Ring-shaped graft group (n = 25)	**Wheel-shaped graft group (n = 25)**	**Test of Sig.**	**p**
Pre-op ABG (dB)			t = -0.173	0.863
Mean ± SD.	21.96 ± 1.81	21.88 ± 1.42		
Median (IQR)	22 (21 - 23)	22 (21 - 23)		
Range (Min-Max)	8 (19 - 27)	5 (19 - 24)		
Post-op ABG (dB)			t = 16.393	<0.001
Mean ± SD.	12.92 ± 1.47	19.48 ± 1.36		
Median (IQR)	13 (12 - 14)	19 (19 - 20)		
Range (Min-Max)	6 (10 - 16)	6 (17 - 23)		

Table (5) showed Pre- and Post-operative word recognition scores (WRS) among the study groups. Pre-op WRS in ring-shaped graft group ranged from 85 to 97 with a mean of 92.04 ± 2.94, while in wheel-shaped graft group ranged from 86 to 96 with a mean of 90.6 ± 2.25 with no statistically significant difference (p= 0.058) between the two groups. Post-Op WRS in ring-shaped graft group ranged from 95 to 99 with a mean of 97.36 ± 1.19, while in wheel-shaped graft group ranged from 88 to 96 with a mean of 92.52 ± 2.38 with highly statistically significant difference (p= <.001) between the two groups.

Table (5): Pre- and Post-operative WRS among the study groups

	Ring-shaped graft group (n = 25)	**Wheel-shaped graft group (n = 25)**	**Test of Sig.**	**p**
Pre-op WRS			**t = -1.945**	**0.058**
Mean ± SD.	92.04 ± 2.94	90.6 ± 2.25		
Median (IQR)	93 (90 - 94)	91 (89 - 92)		
Range (Min-Max)	12 (85 - 97)	10 (86 - 96)		
Post-Op WRS			**t = -9.093**	**<0.001**
Mean ± SD.	97.36 ± 1.19	92.52 ± 2.38		
Median (IQR)	97 (96 - 98)	93 (90 - 94)		
Range (Min-Max)	4 (95 - 99)	8 (88 - 96)		

Regarding postoperative complications, there was no statistically significant difference between the 2 groups (p = 0.637) (Table 6).

Table (6): Postoperative complications among the study groups

	Ring-shaped graft group (n = 25)	Wheel-shaped graft group (n = 25)	Test of Sig.	p
Postoperative complications			**X2 = 0.222**	**0. 637**
Postoperative Infection	2 (8%)	3(12%)		
No	23 (92%)	22 (88%)		

In relation to graft success, table (7) showed that no statistically significant difference was observed between the two groups under investigation (p = 0.552).

Table (7): Graft Success among the study groups

	Ring shaped graft group (n = 25)	Wheel shaped graft group (n = 25)	Test of Sig.	p
Graft Success			**X2 = 0.355**	**0.552**
Intact	23 (92%)	24 (96%)		
Perforation	2 (8%)	1 (4%)		

DISCUSSION

CSOM, characterized by persistent ear discharge and TM perforation, persists a significant public health concern worldwide, specifically in low- and middle-income countries. This condition, often resulting from untreated or inadequately managed acute otitis media, can lead to hearing impairment and other complications if left untreated [(9)].

In the management of CSOM, surgical intervention is frequently necessary to return the TM integrity, improve hearing, and prevent recurrent infections. Among the various surgical techniques available, tympanoplasty type I, which involves the TM perforations repair, is commonly performed [(10)].

While, tympanoplasty type I has demonstrated efficacy in restoring hearing and preventing recurrent infections, the choice of graft material is a crucial aspect of the procedure. Traditionally, temporalis fascia (TF) has been the choice graft material due to its accessibility and favorable outcomes [(11, 12)]. However, the limitations of TF, such as its potential for atrophy and resorption, have prompted the exploration of alternative graft materials. Cartilage-perichondrium composite grafts have gained popularity as an alternative choice due to their structural stability and reduced risk of resorption [(13)].

Of note, this study represents a pioneering effort in the field of otolaryngology by directly comparing the functional and anatomical outcomes of ring and wheel-shaped cartilage-perichondrium composite grafts in the context of endoscopic tympanoplasty type I for the repair of large and subtotal perforations. While, numerous prior investigations have evaluated either ring or wheel-shaped grafts in isolation, often in comparison with the conventional TF graft, the current 76 study stands out as the first comprehensive examination of the relative merits of these two specific graft configurations. Detailed pre-operative assessments, surgical techniques, and post-operative care were standardized. Postoperatively, patients were evaluated for graft acceptance, hearing improvement based on ABG closure, and postoperative complications at 3 months and 6 months.

Regarding the patient's demographic characteristics involved in the present study, there was no statistically significant difference observed between the two groups (p = 0.571) with regard to gender. Ring-shaped graft participants ranged in age from 22 to 41 years, with a mean of 33.56 ± 4.98. In contrast, the wheel-shaped graft group comprised individuals ranging in age from 25 to 46 years, with a mean of 32.36 ± 5.37. Notably, there was no statistically significant difference (p = 0.416) identified between these two groups. With respect to the aspect of perforation, no statistically significant differences were observed between the two cohorts analysed (p = 0.777). In agreement with the current work, for type 1 tympanoplasty, **Velepic *et al.*** [(14)] compared retrospectively the graft success and hearing outcomes of the wheel-shaped composite cartilage graft (WSCCG) and the palisade and island cartilage graft. Out of the total patients, 53 (47.7 %) were males and 58 (52.3 %) were females. A total of 33.3 ± 14.9 years was the mean age of the patients.

Comparing the functional and anatomical outcomes of two distinct grafts—the WSCCG and TF utilized for total TM perforations or the subtotal reconstruction. Our findings are consistent with those of **Ciğer *et al.*** [(15)] who conducted a randomised trial on 90 patients (94 ears) who underwent type 1 tympanoplasty for non-complicated chronic otitis media TF with an average age of 33.0 ± 17.0 years, the WSCCG group comprised 24 (55 %) females and 19 (45%) males as patients (min. 19, max. 64). Age, gender, and perforation side did not differ significantly between the two groups from a statistical standpoint.

The pre-operative ABG for the ring-shaped graft group was 21.96 ± 1.81 for the mean, and 21.88 ± 1.42 for the wheel-shaped graft group. A statistically insignificant difference existed between the two groups. Regarding post-operative ABG, the mean for the ring-shaped graft group was 12.92 ± 1.47, while the mean for the wheel-shaped graft group was 19.48 ± 1.36. A statistically significant difference (p < 0.001) was identified between the two cohorts. The pre-operative

WRS for the ring-shaped graft group was 92.04 ± 2.94, whereas for the wheel-shaped graft group it was 90.6 ± 2.25. A statistically insignificant differences were found between the two groups. In relation to post-operative WRS, the wheel-shaped graft group exhibited a mean of 92.52 ± 2.38, while the ring-shaped graft group recorded a mean of 97.36 ± 1.19. An elevated statistically significant difference ($p < 0.001$) was identified between the two cohorts. Comparably, **Velepic *et al.*** [14] reported that the mean ABG was 22.7 ± 6.6 dB, and the WRS was 94.5 ± 6.6% in all patients preoperatively. Postoperatively, the mean ABG was 13.0 ± 4.7 and the mean WRS had increased significantly to be 97.0 ± 4.2. In line with the current work, **Ciğer *et al.*** [15] found that the preoperative ABG in the WSCCG group was 23.8 ± 9.9 dB while the postoperative ABG was 17.3 ± 11.6 dB. The ring group (Group II) of the study by **Mahmoud *et al.*** [16] exhibited a mean preoperative ABG of 21.3 ± 7.6 dB and a mean postoperative ABG of 10.5 ± 5.3 dB. Therefore, the average enhancement in ABG was 11.6 ± 3.9 dB, and this difference possesses a high degree of statistical significance. It is noteworthy that an early study conducted by **Albirmawy** [17] examined the audiological and anatomical outcomes of primary type one tympanoplasty utilizing a modified cartilage–perichondrium composite 'ring' graft through a retrospective analysis. An analysis was conducted on the medical records of 82 children who had dry TM perforation (of any size), an intact ossicular chain, and no prior ear surgery other than tympanostomy. It was noted that the utilisation of the ring graft technique in type one tympanoplasty led to a notably higher rate of graft acceptance (95 %). In the ring graft, the average speech reception threshold and ABG for pure tone improved significantly. Additionally, a trend toward improved postoperative outcomes was found in the ring group.

Regarding postoperative complications, the two groups analysed in the present study did not differ statistically significantly ($p = 0.637$). Regarding graft success, the two groups analysed did not differ significantly from one another ($p = 0.552$). However, the wheel-shaped graft group" appears to have a slightly higher rate of graft success, with a lower incidence of perforation compared to the "Ring-shaped graft group. **Velepic *et al.*** [14] reported that there was one graft failure in the WSCCG group, which resulted in perforation at the anterior margin of the TM. They also concluded that the success rate of the WSCCG graft was higher, and the audiological results were better**.**

Consistently, **Ciğer *et al.*** [15] documented in their research that the wheel-shaped graft group achieved a graft success rate of 97.7 % (43/44) six months following surgery. Furthermore, the success rate remained at 97.7 % (43/44) throughout the initial year of the intervention. One patient in the WSCCG group experienced a perforation following the initial year. A fat-myringoplasty procedure was executed on this patient, yielding favourable results. There were no instances of grafted membrane retraction observed in any patient within the WSCCG group**.** The study done by **Mahmoud et al.** [16] observed a graft success rate of 95.8 % in the ring group. A single case (4.2 %) incurred a perforation following the operation.

A 100 % success was reported in an early study by **Poe and Gadre** [18] regarding the postero-superior retraction pocket excision using tragal cartilage-perichondrium (TCPC) grafts on 39 patients. In order to reduce recurrent retraction pockets, a TCPC graft was positioned in the posterior-superior quadrant of the TM. Recurrence of retraction was associated with TF graft at varying percentages (5–25 %). This resulted in subsequent failure and perforations. **Chen *et al.*** [19] similarly examined 102 patients who had undergone tympanomastoidectomy or tympanoplasty. In contrast, 27 patients (27.39 %) underwent conchal cartilage-perichondrium composite grafts, while 74 patients (72.16 %) underwent tragal cartilage-perichondrium composite grafts. Graft uptake was observed in every single patient. **Kazikdas *et al.*** [20] obtained a graft uptake rate of 95.7% in 22 patients who received TCPC grafts and 75% in 21 patients who had TF ($p = 0.059$). **Dornhoffer** [21] observed a success rate of 95% with the TCPC graft and 90% with the TF. It was discovered that the TCPC grafting technique yielded a greater success rate (ranging from 95% to 100%) in various tympanoplasty techniques than TF grafts [21, 22].

CONCLUSION

In conclusion, this prospective comparative study on endoscopic tympanoplasty type I for large and subtotal TM perforations found that while both ring and wheel-shaped cartilage- perichondrium composite grafts can achieve successful graft acceptance, the wheel-shaped graft showed a significantly greater postoperative improvement in hearing outcomes, a higher rate of TM regeneration, and comparable graft success rates. The choice of graft shape plays a pivotal role in optimizing surgical outcomes, particularly in cases with significant perforation size. Our study highlights the potential advantages of wheel-shaped grafts in enhancing hearing improvement and TM regeneration for patients with CSOM.

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