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OTOLOGY

Outcomes of endoscopic transcanal type 1 cartilage tympanoplasty

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Abstract

Purpose We aimed to evaluate air–bone GAP (ABG), graft success and hearing gain according to the size and location of perforation in patients who underwent endoscopic transcanal type 1 cartilage tympanoplasty due to the tympanic membrane perforation and chronic otitis media.

Methods The 104 patients (52 male and 52 female) who underwent endoscopic transcanal type 1 cartilage tympanoplasty, were evaluated retrospectively. Tragal cartilage grafts were utilized in all patients. Perforation size/location, duration of surgery, pre-operative and post-operative (6th month) average ABG, and pure-tone audiometric results (at 500–1000–2000–4000 Hz) as well as overall graft success were evaluated.

Results The mean duration of surgery was 45.60 ± 17.39 min. Perforations were most frequently located in anterior quadrant with moderate sized. The post-operative air-conduction results were significantly improved at 500–1000–2000–4000 Hz frequencies. Similarly, pre-operative air-conduction pure-tone average (PTA) (35.36 ± 11.9 dB) was significantly decreased (22.34 ± 7.9 dB) after postoperative 6 months ($p \leq 0.001$). The overall graft success rate was 93.2%. Moreover, pre-operative mean ABG (19.82 ± 7.4 dB) was significantly decreased (9.05 ± 4.3 dB) after postoperative 6 months ($p \leq 0.001$).

Conclusions Endoscopic transcanal type 1 cartilage tympanoplasty achieved a high graft success rate, and improved hearing results, regardless of the perforations' location and size. Endoscopic tympanoplasty provides high patient safety and comfort in middle-ear surgery by wide visualization, easy applicability, short-operation duration, low complication risk, and less invasive approach.

Keywords Tympanoplasty · Endoscopic ear surgery · Cartilage graft · Tympanic membrane perforation

Introduction

Endoscopic tympanoplasty or microscopic tympanoplasty is the treatment option commonly used in tympanic membrane reconstruction and chronic otitis media surgery. The main goal of both techniques is to form an intact, dry tympanic membrane by graft material that closes the perforation area, prevents chronic otitis media sequelae, and provides auditory improvement [1, 2].

Disadvantages of conventional microscopic surgery include poor visualization, reduced vascularity, and inadequate graft stabilization; moreover, it requires improved surgical skills. The limited visualization of the perforation margin may require more invasive procedures such as postauricular incision and canaloplasty [3]. Unlike conventional microscopic procedure, transcanal endoscopic surgery provides a minimally invasive and safe surgical approach, avoiding unnecessary incisions. This technique also allows wider visualization of deep and narrow areas [4].

Endoscopic tympanoplasty has been increasingly utilized otologic surgery with advantages of less pain and relatively shorter operation duration in recent years. Published data have documented the equal or better success rates compared to the conventional microscopic technique [4, 5]. Thus, we aimed to evaluate the ABG, graft success, and hearing gain according to the size and location of perforation in patients who underwent endoscopic transcanal type 1 cartilage tympanoplasty due to the tympanic membrane perforation and chronic otitis media.

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Materials and methods

Sample

Total number of 104 patients who underwent endoscopic transcanal type 1 cartilage tympanoplasty due to the chronic otitis media were included consecutively between May 2017 and November 2018 in this retrospective study. Inclusion criteria defined as; aged between 18 and 70 years old, absence of otorrhoea at least for 3 months, absence of inflammation or infection in middle-ear mucosa and mastoid cells, as well. In addition, participants were enrolled in the study after obtainment of written informed consent. Complete otorhinolaryngologic examinations and pure-tone audiometry tests were performed in all participants.

Measures

Average ABG and air-bone conduction pure-tone audiometry at 500–1000–2000–4000 Hz frequencies were performed in all participants pre- and post-operatively at 6 month intervals.

The location of tympanic membrane perforation was classified as; anterior, anterosuperior, posterior, and subtotal. Membrane perforation size was classified as; small (< 25% perforation area), medium (25–75% perforation area), and large (> 75% perforation area).

Operation procedure

All patients were operated under general anesthesia using a standard 18 cm, 0° standard endoscope with a diameter of 4 mm and 2.7 mm (Karl Storz; Germany). Tragal cartilage grafts were utilized as graft material.

Local anesthesia (Jetocain; lidocaine hcl and epinephrine, Adeka Medical, Istanbul, Turkey) was performed on the external ear canal and tragus (graft taking area) to reduce bleeding. Lateral circumferential incision was made at a distance of approximately 4–5 mm from the annulus after desepithelization of the perforation margins. The incision was extended at the superior and inferior to the annulus. The tympanomeatal flap was tilted forward to access the middle ear. The graft was prepared after the control of the osseous mobility. Tragal cartilage was used as graft materials. The tragus apex was protected to prevent cosmetic deformation. The graft area was sutured with 4.0 rapid—Vicryl. Perichondrium was left on the outer side of the cartilage graft, and a pocket was opened to accommodate the manubrium mallei on the tragal cartilage. The perichondrium was preserved from the tragal cartilage superior and the perichondrium was preserved on both sides. At the lateral part of the tragus, about 2–3 mm cartilage was left for the contour. Cartilage graft was prepared as island and cartilage was removed from the area where the malleus was placed and only perichondrium was left. Tragal cartilage was placed with under-overlay (under the annulus-over the malleus) technique (Fig. 1).

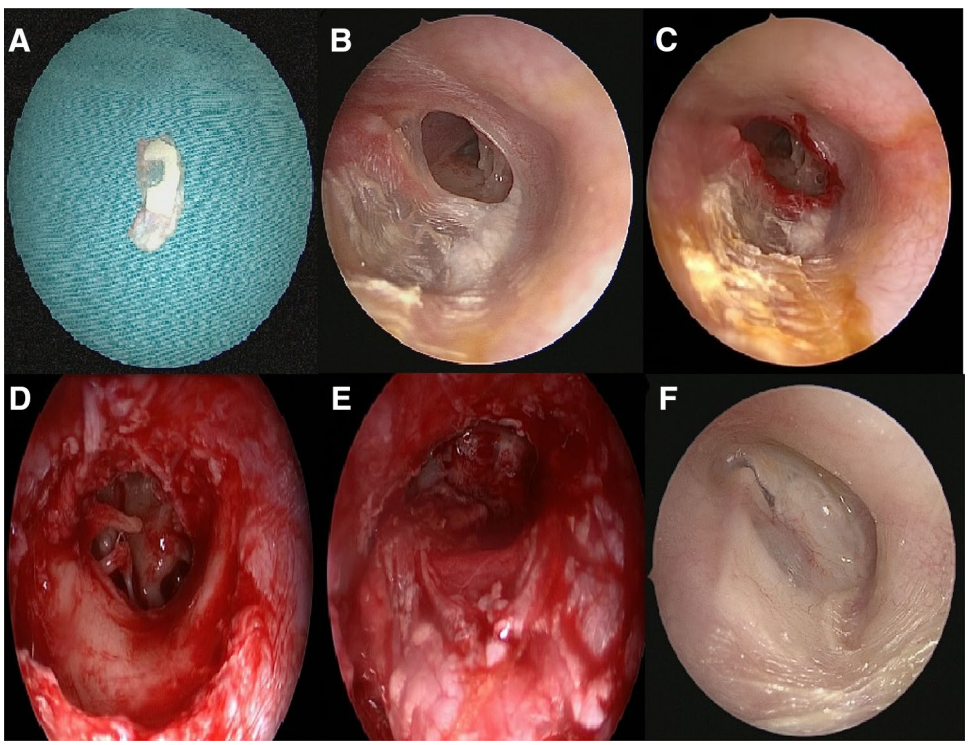

Fig. 1 **a** Tragal graft (an island-shaped composite cartilage graft-perichondrium prepared for malleus), **b** a view of pre-operative tympanic membrane (anterior perforation), **c** per-operative tympanic membrane appearance (aviation–desepitelization), **d** peroperative tympanomeatal flap level and middle-ear view, **e** peroperative graft placement, flap under-overlay form, and **f** appearance of tympanic membrane after post-operative 6 months

The graft was supported medially and laterally by Gelfoam. The time between the endoscopic examination of the tympanic membrane and packing of the external ear canal was recorded as the operation time.

Graft success was assessed by the absence of perforation on post-operative endoscopic examination. Perforation size/location, duration of surgery, pre-operative and post-operative (6th month) average ABG, and pure-tone audiometric results (at 500–1000–2000–4000 Hz) as well as overall graft success were recorded and evaluated.

Statistical analysis

All the data were analyzed with SPSS (Statistical Package for the Social Sciences) software for Windows (v21.0; IBM, Armonk, NY, USA). Individual and aggregate data were summarized using descriptive statistics including mean, standard deviations, medians (min–max), frequency distributions, and percentages. Normality of data distribution was verified by Kolmogorov–Smirnov test. Comparison of the variables with normal distribution was made with Student's *t* test and paired-sample *t* test. The variable parameters which were not normally distributed, the Mann–Whitney and Kruskal–Wallis tests were conducted to compare between groups. Evaluation of categorical variables was performed by Chi-square test. p values of <0.05 were considered statistically significant.

Results

The 104 patients included in this study were 52 (50.0%) male and 52 (50.0%) female, and the mean age of total participants was 32.81 ± 12.10 (ranged 18–67) years. The mean duration of surgery was 45.60 ± 17.39 (ranged 17–119) min. Of the patients, 55.8% ($n=58$) were operated on the right ear and 44.2% ($n=46$) on the left ear. Medium-size perforations were accounting for 53.8% ($n=56$) of total cases, followed by large-sized perforations (25.0%) and small-sized perforations (21.2%). In addition, perforations were most frequently (35.6%) located in anterior quadrant.

According to the air-conduction pure-tone audiometric results at 500–1000–2000–4000 Hz frequencies; the post-operative air-conduction results were significantly improved for all frequencies. Similarly, pre-operative air-conduction PTA (35.36 ± 11.9 dB) was significantly decreased (22.34 ± 7.9 dB) after post-operative 6 months ($p \leq 0.001$) (Table 1).

The overall graft success rate was 93.2% ($n=97$) after post-operative 6 months. Moreover, pre-operative mean ABG (19.82 ± 7.4 dB) was significantly decreased (9.05 ± 4.3 dB) after post-operative 6 months ($p \leq 0.001$) (Fig. 2). In our study, the highest mean value of post-operative ABG (14.93 ± 9.3 dB) was obtained from the antero-superior perforation surgery ($p=0.134$). Similarly, the gap was higher (12.13 ± 8.3 dB) in patients with perforation size $<25\%$ than the patients with a larger perforation area ($p=0.729$) (Table 2).

There were no major complications observed in the post-operative follow-up period. In early period, the patients had temporary facial paresis, nausea-vomiting, pain, and mild

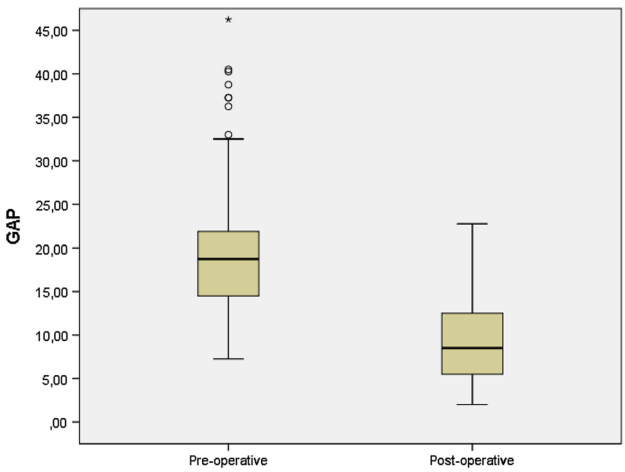

Fig. 2 Pre-operative and post-operative comparison of mean ABG

Table 1 Pre-operative and post-operative comparison of air-conduction pure-tone audiometry results

	Pre-operative ($n=104$) (mean ± SD)	Post-operative 6th months ($n=97$) (mean ± SD)	p value
500	36.65 ± 14.0	21.40 ± 8.6	<0.001*
1000	33.94 ± 12.9	20.30 ± 8.4	<0.001*
2000	33.41 ± 12.7	21.20 ± 9.3	<0.001*
4000	37.45 ± 14.8	26.47 ± 11.3	<0.001*
Air-conduction PTA	35.36 ± 11.9	22.34 ± 7.9	<0.001*
Air-bone GAP	19.82 ± 7.4	9.05 ± 4.3	<0.001*

*$p<0.05$ statistically significant

Table 2 Relation between mean GAP gain and clinical features of the perforations

Clinical variables	GAP gain (mean ± SD)	*p* value
Perforation localization		
Anterior	9.33 ± 5.5	0.134**
Anterosuperior	**14.93 ± 9.3**	
Posterior	9.94 ± 5.9	
Subtotal	10.96 ± 4.2	
Perforation size		
25%	**12.13 ± 8.3**	0.729**
25–75%	9.73 ± 5.5	
25–100%	10.65 ± 4.4	

Results of independent-sample *T* test analysis for mean ages between the patient and control groups

Highest values are indicated in bold

**$p < 0.05$ statistically significant

bleeding due to local anesthesia. Facial paresis was seen in two patients and completely recovered within 3 h after the operation. All patients were discharged the day after the operation.

Discussion

The success rate of tympanoplasty is affected by various factors such as the perforation location, perforation size, graft type, and visualization of the perforation area. In a meta-analysis conducted by Tan et al., overall graft success rate of 86.6% was reported as a result of 4704 screened published data associated with tympanoplasty in children and adults. Researchers reported that ABG closure increased by 6.1% in cases with < 50% perforation size, and also closure increased by 2.8% with utilization of cartilage (vs. fascia) graft [6]. However, Tseng et al. noted that perforation size or visualization did not affect the graft success rate and ABG closure in 59 patients (51% male, 49% female) who underwent endoscopic transcanal myringoplasty. Researchers reported 93% overall graft success rate and stated that poor visualization was only prolonged surgery duration [3]. Ayache et al. reported complete perforation in 27% and partial perforation in 73% of 30 patients who underwent endoscopic myringoplasty and also reported most frequently (87%) anterior quadrant localized perforation. Supportively, researchers concluded that the perforation size and location did not have any significant effect on the graft success rate or the ABG closure [7]. In the published data, cartilage tympanoplasty achieved better graft success rates than temporal fascia tympanoplasty, and the advantages of cartilage tympanoplasty in children and in patients with bilateral ear diseases are highlighted [8]. Similarly, in our study, perforations were most frequently located in anterior quadrant with moderate size. The overall success rate was 93.2% at the 6th month after cartilage graft surgery. In addition, perforation size and location were not significantly associated with the post-operative ABG.

Concerns about visualization of the perforation margin are not only related to the graft success rates, but also duration of the surgery is being affected. Thus, in the conventional microscopic surgery, poor visualization of the perforation margin significantly prolongs the surgery duration and increases the risk of complications [6]. Dündar et al. reported significantly lower duration of the surgery (51.37 vs. 67.03 min.) in endoscopic tympanoplasty group ($n = 32$) compared to the conventional microscopic group ($n = 29$) [9]. Recently, in a meta-analysis comparing the microscopic and endoscopic tympanoplasty data, conducted by Lee et al., the mean duration of the surgery was 97.12 min in microscopic tympanoplasty, while the endoscopic tympanoplasty achieved an average of 37.99 min shorter surgery duration [10]. In our study, although microscopic tympanoplasty was not applied in our patients; the mean duration of the surgery (45.60 ± 17.39 min) obtained by the endoscopic technique was seemed to be significantly shorter than the conventional method particularly based on the data in meta-analyses.

The hearing results after cartilage tympanoplasty are as valuable as the results of anatomic improvement and graft closure. Wick et al. documented a statistically significant improvement in PTA (11.5 > 10.7 dB) and ABG (11.4 > 10.6 dB) at the 5th and 8th months following endoscopic transcanal lateral cartilage tympanoplasty applied to 34 ears of the 31 patients [1]. Ayache et al. reported that the mean ABG value decreased from 17.7 to 7.9 dB with an average ABG reduction of 55% (ranged 29–81%) as a result of the endoscopic myringoplasty in 30 patients [7]. Nassif et al. compared microscopic ($n = 23$) and endoscopic ($n = 22$) tympanoplasty methods in pediatric patients between 2005 and 2010 years. The outcomes of both groups showed improvement in hearing results; in addition, ABG closure was 6.2 dB in microscopic method and 6.6 dB in endoscopic method. The researchers concluded that the endoscopic method is more reliable for both hearing benefit and anatomic improvement, and can be applied to all patients independent of age [11]. Kaya et al. reported that pre-operative air-conduction PTA (36.4 ± 15.1 dB) was significantly decreased (28.8 ± 14.3 dB) after post-operative 6 months of cartilage tympanoplasty in 93 patients with chronic otitis media. Similarly, researchers reported 22.1 ± 7.1 dB pre-operative ABG which improved to 13.3 ± 5.9 dB at 6th months and 11.9 ± 5.5 dB at 24th months significantly after surgery [12]. Supportively, in the present study, post-operative air-conduction results were significantly improved at all frequencies (500, 1k, 2k, ve 4 kHz). Similarly, pre-operative

air-conduction PTA and ABG were significantly decreased after post-operative 6 months.

In conclusion, endoscopic transcanal type 1 cartilage tympanoplasty achieved a high graft success rate, significant gap gain, and improved hearing results, regardless of the perforations' location and size. Endoscopic tympanoplasty provides high patient safety and comfort in middle-ear surgery by wide visualization, easy applicability, short-operation duration, low complication risk, and less invasive approach.

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Compliance with ethical standards

Conflict of interest Authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

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