Inlay Butterfly Cartilage Tympanoplasty: Anatomic and Functional Results

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Abstract To evaluate anatomic/functional results of inlay butterfly cartilage tympanoplasty and compare those with the results of over-underlay perichondrium-cartilage island or temporalis fascia tympanoplasties. Patients who operated for primary type 1 tympanoplasty ($n = 78$) with inlay butterfly cartilage ($n = 25$), over-underlay perichondrium-cartilage island ($n = 36$) or over-underlay temporalis fascia ($n = 17$) graft from January 2005 to January 2015 were included in the study. Age, gender, pre-/postoperative otoscopy findings/audiograms, and follow-up time were obtained from the patient's file. Anatomic integrity rates of the tympanic membrane, the mean gains of air bone gap on pure tone audiogram at four frequencies (0.5, 1, 2, 4 kHz) and complications were reviewed parameters. Functional evaluation was made in patients with intact tympanic membrane. Anatomic integrity rates of the tympanic membrane was 92.00% for inlay butterfly cartilage tympanoplasty, 91.67% over-underlay perichondrium cartilage island tympanoplasty and 88.2% over-underlay fascia tympanoplasty. The mean gains of air bone gap on pure tone audiogram for the inlay butterfly cartilage, over-underlay perichondrium cartilage island and over-underlay fascia graft group were 11.28, 12.84 and 12.66 dB respectively. Inlay butterfly cartilage tympanoplasty is a reliable and simple technique

with satisfactory outcomes in selected cases. The anatomic and functional results after inlay butterfly cartilage tympanoplasty are parallel to the results of over-underlay perichondrium-cartilage island or temporalis fascia tympanoplasties.

Keywords Cartilage · Tympanoplasty · Butterfly · Tympanic membrane · Perforation

Introduction

Several techniques and graft materials have been used to reconstruct the tympanic membrane (TM) perforation since 1952 [1–3]. Under and overlay tympanoplasties are the most popular techniques. Meanwhile, fascia and perichondrium are mostly used as a graft material [4–6].

Reconstruction of the TM with the cartilage grafts is described as cartilage tympanoplasty and this technique is became popular during last two decades [6]. Palisade cartilage, perichondrium island cartilage, butterfly cartilage and reinforcement cartilage grafting techniques are subtypes of cartilage tympanoplasty [4, 6].

Eavey [7] described inlay butterfly cartilage technique for selected type 1 tympanoplasty cases with high success rate in 1998. This technique is easy, time saving, less expensive and does not require canal incisions or tympanomeatal flap manipulation [7].

In this study, the anatomic/functional outcomes and practical advantages of inlay butterfly cartilage tympanoplasty were evaluated in the light of the literature. The outcomes were also compared with the results of the primary type 1 over-underlay perichondrium cartilage island and temporalis fascia tympanoplasties.

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Materials and Methods

Patients who operated for primary type 1 tympanoplasty ($n = 78$) with inlay butterfly cartilage graft ($n = 25$), over-underlay island perichondrium-cartilage graft ($n = 36$) or over-underlay temporalis fascia graft ($n = 17$) from January 2005 to January 2015 were included in the study. Written informed consent was received from patients. Age, gender, pre-/postoperative otoscopy findings/audiograms, and follow-up time were obtained from the patient's file. Anatomic integrity rates of the tympanic membrane, the mean gains of air bone gap (ABG) on pure tone audiogram at four frequencies (0.5, 1, 2, 4 kHz) and complications were reviewed parameters. Functional evaluation was made in patients with intact tympanic membrane.

The anatomic and functional datas were statistically analyzed using Mann–Whitney U and Wilcoxon Signed Ranks tests (SPSS FW, SPSS Inc. Chicago, IL, USA).

Surgical Technique

The modified inlay butterfly cartilage tympanoplasty technique ($n = 25$), suggested by Lubianca-Neto [8], was used in this study. The perforation edge was circumferentially trimmed with sickle knife and forceps. The actual perforation size and shape were determined by the right angled hook. An incision was made on the medial surface of the tragus and 2 mm cartilage strip was left intact at the tragal dome area for aesthetic reason (Fig. 1). The cartilage was harvested with perichondrium on both sides. The graft, in the same shape with the perforation but approximately 2 mm larger than the actual size of it, was prepared with right angled hook and # 15 blade. Under microscopic view, the entire edge of the graft was scored circumferentially at a depth of 2 mm (Fig. 2). Then, the graft was placed into

Fig. 2 Entire edge of the graft was scored circumferentially at a depth of 2 mm

the edge of the perforation. It was controlled that, only lateral butterfly wing should be superficial to the TM. 30° oto-endoscope was used to check the anterior–inferior edge of the perforation in the cases with bulgy anterior wall of external auditory canal. Different from the original technique described by Eavey [7], a splint thickness graft was not used to cover the butterfly cartilage graft. Early anatomic and functional evaluation were made on 8th week after the surgery (Fig. 3).

For over-underlay perichondrium-cartilage island ($n = 36$) and temporalis fascia ($n = 17$) tympanoplasties, after the perforation edge was circumferentially trimmed with sickle knife and forceps, the posterior tympanomeatal flap was elevated. Manibrium mallei was cleaned from epithelial tissue. The grafts were placed under the annulus and over the malleus for both groups. Posterior tympanomeatal flap was replaced over the graft.

Fig. 1 Tragal incision (2 mm cartilage strip was left intact)

Fig. 3 Endoscopic view of the TM 6 months after the inlay butterfly technique

Results

The mean age of the butterfly cartilage group, the perichondrium cartilage group and the fascia group were 32.04 years (range, 11–73), 29.70 years (range, 12–58) and 32.40 years (range, 13–61) respectively. The butterfly cartilage group consisted of 9 men and 16 women. The perichondrium cartilage group consisted of 15 men and 21 women whereas, there were 9 men and 8 women in the fascia group. The mean follow up periods for the butterfly cartilage group, the perichondrium cartilage group and the fascia group were 27.4, 22.8 and 29.1 months respectively.

Anatomic integrity rates of the TM perforation for inlay butterfly cartilage, over- underlay island perichondrium cartilage and over underlay fascia graft group were 92.00% (23/25), 91.67% (33/36) and 88.2% (15/17) respectively (Table 1). Pre-/postoperative mean ABG obtained at 4 frequencies (0.5, 1, 2, 4 kHz) for the inlay butterfly cartilage, over underlay island perichondrium cartilage and over underlay fascia graft groups were $17.12 \pm 8.78/5.84 \pm 2.26$, $21.24 \pm 8.24/8.40 \pm 2.31$ dB, and 21.20 ± 6.9 dB/ 8.54 ± 4.36 dB respectively ($p < 0.001$; Wilcoxon Signed Ranks Test) (Table 2). These findings revealed the mean gains of ABG at four frequencies (0.5, 1, 2, 4 kHz) for the inlay butterfly cartilage, over-underlay island perichondrium-cartilage and over-underlay fascia graft groups were 11.28, 12.84 and 12.66 dB respectively ($p > 0.05$; Mann–Whitney U Test) (Table 3).

Table 1 Anatomic integrity rates of the TM

	Anatomic integrity rates of the TM (%)
Butterfly cartilage group (n = 25)	92.00
Perichondrium cartilage island group (n = 36)	91.27
Temporalis fascia group (n = 17)	88.2

Table 2 Changes in pre-/postoperative mean ABG obtained at 4 frequencies (0.5, 1, 2, 4 kHz) for all three groups are summarized ($p < 0.001$) (Wilcoxon Signed Ranks Test)

	Preoperative mean ABG obtained at 4 frequencies (0.5, 1, 2, 4 kHz) (dB)	Postoperative mean ABG obtained at 4 frequencies (0.5, 1, 2, 4 kHz) (dB)
Butterfly cartilage group	17.12 ± 8.78	5.84 ± 2.26
Perichondrium cartilage island group	21.24 ± 8.24	8.40 ± 2.31
Temporalis fascia group	21.20 ± 6.9	8.54 ± 4.36

ABG Air bone gap, kHz Kilohertz, dB decibel

Discussion

Several surgical techniques have been developed and numerous graft materials have been used for reconstruction of the TM perforations since tympanoplasty was first described by Wullstein [1] and Zollner [2] in the 1950s [3]. Both, underlay and overlay techniques have been accepted as a popular and reliable approaches for tympanoplasty during the last 50–60 years [5, 6]. Anatomic and functional success rates for primary tympanoplasty with perichondrium or temporalis muscle fascia are approximately 90 and 60% retrospectively [4, 6, 8–10]. However, both techniques require canal skin incisions and tympanomeatal flap manipulation [9, 10]. During these manipulations, anatomic position of the TM and annulus, integrity of the chorda tympani and ossicular chain may be affected [11]. So, both techniques have the risks of morbidity, require postoperative care and close follow-up [7].

To simplify the procedure and to decrease the potential risks of morbidity, new techniques have been developed, especially for isolated tympanic membrane perforations [12]. Transcanal inlay technique is an alternative approach for reconstruction of TM perforation in selected cases. Inlay technique with an adipose tissue for small perforation was performed by Gross et al. [13]. However, this graft material is not very reliable and not appropriate for larger TM perforations [7]. Eavey [7], achieved satisfactory results with cartilage graft by underlay technique in tympanoplasty and tympanomastoidectomy and decided to use the tragal cartilage perichondrium graft as an inlay tissue alternative for selected type 1 tympanoplasty patients. He reported encouraging results for small to medium sized tympanic membrane perforations with inlay butterfly cartilage technique using perichondrium cartilage graft [7]. This technique has several advantages. Surgery can be performed under local anesthesia for adults and mask anesthesia for children as an outpatient procedure. The incision is located only in the tragus. Because of the graft is instantly stable, middle ear support or external ear canal packing or ear dressing are not required. The patient comfort is enhanced. Due to the reduced surgery and

Table 3 The mean gains of ABG at four frequencies (0.5, 1, 2, 4 kHz) for all three graft groups are summarized ($p > 0.05$) (Mann–Whitney U Test)

	The mean gains of ABG at four frequencies (0.5, 1, 2, 4 kHz) (dB)
Butterfly cartilage group	11.28
Perichondrium cartilage island group	12.84
Temporalis fascia group	12.66

ABG Air bone gap, kHz Kilohertz, dB decibel

recovery room time, the procedure is less expensive [3, 7, 14, 15].

The rigid nature and thickness of the cartilage might adversely affect its acoustic transfer characteristics theoretically [16]. However, there are existing studies, demonstrating that audiologic outcomes of cartilage tympanoplasty are pretty good [6, 7, 14, 16, 17]. Dornhoffer [6, 18] and Mauri [15], also pointed out that, the perforation size and amount of cartilage used for grafting do not change postoperative audiologic outcomes. The preoperative ABG has been found the most important impact factor that appeared to affect the postoperative audiologic outcomes by Mauri [15]. Another concern related with the cartilage graft is to hide any disease such as cholesteatoma behind of the TM, due to the opaque nature of the graft. However, the middle ear can be evaluated because of the limited graft size in inlay butterfly cartilage technique [15]. On the other hand, fascia grafts are less opaque certainly, but not enough translucent that disease can be detected otoscopically [14]. Meanwhile if there is any suspicion of cholesteatoma, middle ear should be evaluated [15]. Diffusion MR can also be used to detect the cholesteatoma formation in these cases. However, following the inlay butterfly cartilage tympanoplasty, cholesteatoma was not observed in the literature [7, 12, 14, 15].

Selection of the patients is important for successful anatomic and functional results in inlay butterfly cartilage technique. TM perforation should be non-marginal and could be seen entirely by transcanal approach. Possible ossicular chain problem, cholesteatoma, severe myringitis and/or otorrhea are the exclusion criterias. Small (up to 1/3 of the TM's area) and medium (between 1/3 and 2/3 of the TM's area) sized perforations are ideal for this technique [7, 19].

At the end of the procedure, split thickness skin graft harvested from the forearm is used to cover the cartilage graft in the Eavey's [7] original technique. External auditory canal packing or ear dressing is not required. Anatomic integrity rate of the TM perforation was reported as 100% by his publication [7]. Lubianca-Neto [3] has modified this technique by elimination of the skin graft cover to

improve patient comfort and to decrease morbidity. He reported that this surgery can be performed under local anesthesia in adolescents and adults with 90% take rate. Postoperative hearing gain was achieved 94.4% of the cases [3]. Mauri et al. [15] compared the efficacy of modified inlay cartilage tympanoplasty ($n = 34$) with the underlay temporalis fascia tympanoplasty ($n = 36$) in a total of 70 patients. The take rates were reported as 85.3 and 83.3% respectively after mean follow up of 7.5 ± 3.8 months. Post operative ABG was ≤ 20 dB in 91.2% of the cases for the inlay tympanoplasty group whereas in 94.4% in the underlay tympanoplasty group [15]. Kim et al. [19] analyzed the outcomes of inlay butterfly cartilage tympanoplasty ($n = 56$) and underlay temporalis fascia tympanoplasty ($n = 56$) in a total of 112 patients. Anatomical integrity rates were reported as 96.4 and 91.1% retrospectively. Post operative ABG was ≤ 20 dB in 89.3% of the cases for the inlay tympanoplasty group whereas in 91.1% in the underlay tympanoplasty group [19].

Ghanem et al. [14] extended the original indications for inlay butterfly cartilage tympanoplasty. According to their experience, the size and location of the perforation do not mainly effect the anatomic or functional success. Necessary additional procedures such as tympanomastoidectomy and/or ossicular chain reconstruction also can be achieved. Even in cases with advanced middle ear diseases including cholesteatoma, that require retroauricular tympanomastoidectomy and tympanoplasty, perforation closure rate with large butterfly cartilage graft was reported as 92% by Ghanem et al. [14]. To cover the cartilage graft, split thickness skin graft was harvested from the arm 69.9% of the cases. In most of patients, despite the simultaneous necessity for tympanomastoidectomy, hearing results also reported as improved or remained stable [14].

In this study, anatomic integrity rates of the TM for inlay butterfly cartilage, over underlay island perichondrium cartilage and over underlay fascia graft groups were 92.00% (23/25), 91.27% (33/36) and 88.2% (15/17) respectively. Pre-/postoperative mean ABG obtained at 4 frequencies for the inlay butterfly cartilage, over underlay island perichondrium-cartilage and over underlay fascia graft group were $17.12 \pm 8.78/5.84 \pm 2.26$, 21.38 ± 6.71 dB/ 8.98 ± 3.94 dB, and 21.20 ± 6.9 dB/ 8.54 ± 4.36 dB respectively (Wilcoxon Signed Ranks Test) ($p < 0.001$). These findings revealed the mean gains of ABG at four frequencies (0.5, 1, 2, 4 kHz) for the inlay butterfly cartilage, over-underlay island perichondrium-cartilage and over-underlay fascia graft group were 11.28, 12.84 and 12.66 dB respectively (Mann–Whitney U Test) ($p > 0.05$).

Iatrogenic cholesteatoma was not observed in this study.

In conclusion, the anatomic and functional results after inlay butterfly cartilage tympanoplasty are parallel to the

results of over-underlay perichondrium-cartilage island or temporalis fascia tympanoplasties. So, we can say that, inlay butterfly cartilage tympanoplasty is a reliable and simple technique with satisfactory outcomes in selected cases.

Compliance with Ethical Standards

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

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

Human and Animal Rights For this type of study formal consent is not required. This article does not contain any studies with animals performed by any of the authors.

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