

Endoscopic Tympanoplasty: Inlay Versus Underlay Cartilage Grafts

Endoskopik Timpanoplasti: İnlay Kıkırdağa Karşı Underlay Kıkırdak Greft

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ABSTRACT

Objective: Several graft placement methods have been described in tympanoplasty. The aim of this study is to assess the surgical effects of the endoscopic tympanoplasty utilizing inlay or underlay cartilage grafts.

Method: We reviewed medical records of 123 patients who experienced endoscopic tympanoplasty for chronic otitis media with a minimum twelve-month follow-up period. Perforations were divided into central, posterior, and anterior ones based on the place of the perforation relative to malleus handle. Graft success rate, air conduction pure tone audiometry (PTA) before and after surgery, hearing gain and reduction in air bone gap (ABG) were calculated following surgery.

Results: Any significant difference was not found between the groups in terms of the distribution of the follow-up period, age, location of perforation, and gender ($p>0.05$). The average air conduction (ACs) before, 6 and 12 months after surgery for the inlay group were 36.3 ± 13.7 dB, 25.4 ± 12.3 dB and 22.5 ± 10.5 dB, respectively. The corresponding air conduction were 35.6 ± 13.3 dB, 24.8 ± 12.4 dB and 22.7 ± 9.7 dB for the underlay group. A significant difference was found between the two groups in terms of ABG ($p=0.037$). There was no significant difference in the mean ABG in each group (small perforation $p=0.473$, medium perforation $p=0.876$ and large perforation $p=0.341$).

Conclusion: The inlay method can be used in eligible appropriate patients, with higher graft success rate, low risk of complications and shorter operation time as a reliable surgical option for treatment.

Keywords: chronic otitis media, endoscopic tympanoplasty, inlay cartilage, middle ear, underlay cartilage.

Öz

Amaç: Timpanoplastide çeşitli greft yerleştirme yöntemleri tanımlanmıştır. Bu çalışmanın amacı underlay kartilaj greft ve inlay kartilaj greft kullanılarak yapılan endoskopik timpanoplastinin cerrahi etkinliğini değerlendirmektir.

Yöntem: Kronik otitis media nedeniyle endoskopik timpanoplasti uygulanan 123 hastanın tıbbi kayıtları minimum on iki aylık takip süresi ile incelendi. Perforasyonun malleus koluna göre olan konumuna göre santral, posterior ve anterior olmak üzere perforasyonlar üçe ayrıldı. Greft başarı oranı, ameliyat öncesi ve sonrası saf ses odyometrisi (SSO), hava kemik boşluğu (HKB), hava kemik boşluğunda azalma ve işitme kazancı hesaplandı.

Bulgular: Takip süresi, yaş, perforasyon yeri ve cinsiyet dağılımı açısından gruplar arasında anlamlı fark bulunmadı ($p>0.05$). İnlay grupta, ameliyat öncesi ortalama hava iletimi $36,3\pm 13,7$ dB, ameliyatın altıncı ayında $25,4\pm 12,3$ dB, ameliyattan 12 ay sonra ise $22,5\pm 10,5$ dB olarak bulundu. Underlay grupta ise ameliyat öncesi $35,6\pm 13,3$ dB, ameliyattan altı ay sonra $24,8\pm 12,4$ dB ve ameliyatın 12. ayında $22,7\pm 9,7$ dB olarak bulundu. İki grup arasında HKB açısından anlamlı fark bulundu ($p=0,037$). Ortalama HKB değerinde perforasyon boyutları bakımından anlamlı farklılık yoktu (küçük perforasyon $p=0,473$, orta perforasyon $p=0,876$, geniş perforasyon $p=0,341$).

Sonuç: İnlay yöntemi yüksek greft başarı oranı, düşük komplikasyon riski ve kısa operasyon zamanı ile uygun hastalarda güvenilir bir cerrahi seçenek olarak kullanılabilir.

Anahtar kelimeler: endoskopik timpanoplasti, inlay kıkırdak, kronik otitis media, orta kulak, underlay kıkırdak.

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INTRODUCTION

Practice of endoscopic-assisted surgery in otology dates back to the 1990s (1). In recent years, an increasing number of surgeons have supported the application of endoscopes in aural surgery, and also several publications showed advantages of the cholesteatoma surgery, and also type 1 surgery (2,3). Especially in cases where the edges of the perforation cannot be evaluated microscopically due to exostosis and in cases requiring canaloplasty, endoscopes provide adequate vision. The most important advantages of the endoscopic method are the wide-angle view, high magnification and resolution. It provides visualization of deeper anatomical regions, including facial recess, epitympanum and sinus tympani (4). The most important weakness of the endoscopic method is that one hand gives endoscopic control while the other hand performs surgical manipulations on its own. It can be really difficult to perform operation under endoscopy, especially in cases of bleeding.

Several graft placement methods have been described in tympanoplasty. The most commonly used method is called underlay or overlay technique. Another graft placement technique is the inlay method, introduced by Eavey termed the butterfly cartilage tympanoplasty (5). Although small and medium-sized perforations were the first areas in which this technique was used, near-total central perforations were recently the areas in which it has been successfully applied (6). This technique is easier to apply as compared to other techniques without the outer ear canal flap elevation by transcanal approach (5).

Moreover, this technique is also preferred for myringosclerotic ear perforations. The absence of ear packing in the external auditory meatus and the short operation time are among the other advantages.

This study aims to assess the surgical effects of the endoscopic tympanoplasty utilizing inlay or underlay cartilage graft.

MATERIAL AND METHODS

We conducted a retrospective study on two groups of consecutive 123 adult patients who had chronic otitis media and underwent tympanoplasty at Otorhinolaryngology Department – Head and Neck Surgery between September 2014 and December 2019, with a minimum twelve-month follow-up period. The principles of Helsinki Declaration were applied for the research. The Institutional Review Board of School of Medicine approved the realization of this study (Ethics Committee Decision no: 19/10/33).

The required inclusion criteria for the patients were being at the age of over 12, lack of inflammation or infection signs, and otorrhea in the last three months as revealed during the microscopic examination of the middle-ear mucosa.

The exclusion criteria were as follows: presence of ossicular chain problem, marginal perforations, discordant hearing loss based on the size of perforation and cholesteatoma as the possible mastoid cell pathology which should be explored, and extensive myringitis. All the patients underwent a microscopic and endoscopic examination of the ear, and high-resolution computed tomography (HRCT) of the middle ear.

All of the perforations were divided into central, posterior, and anterior ones based on the place of the perforation relative to malleus handle. Perforations were grouped based on the size of the perforation relative to the whole tympanic membrane (TM). Perforation size was classified as percentage area of the TM as small < 25%, medium, 25- 75%, and large > 75%.

Surgical Indications

Indications for butterfly cartilage tympanoplasty in our practice were as follows: central localization of the perforation, lack of the tympanosclerotic plaques on the edges of the perforation, or inflammation and infection signs allowing otoscopic examination of the middle ear mucosa, absence of otorrhea within three months or clinical or radiological signs of ossicular chain destruction or cholesteatoma.

Surgical Technique

A pick was used to refresh the perforated remnant of the TM. In the underlay cartilage group, a lateral 4–6 mm circumferential incision was made from the membrane tympani annulus together with radial incisions. The tympanomeatal flap was raised. Middle-ear mucosa and mobilization of the ossicular chain were checked. After this process, the tragal cartilage was used to prepare a cartilage graft. Cartilage graft was excised with bilateral perichondrium flap, and 2–3 mm width tragal cartilage was left marginally for the cosmetic reasons. The perichondrium was elevated on the convex side to obtain a perichondrium flap. The cartilage was excised in an area that corresponded to the malleus. Gelfoam® was used for packing the middle ear, and the prepared graft was put in place. In the butterfly cartilage group, tympanomeatal flap was not elevated. Cartilage graft was inserted into the perforated TM.

All of the operations were performed by the transcanal endoscopic method. A 0° angle, 4-mm caliber, and 14-mm long endoscope connected to a camera and display screen was used. The first option in any case, was inlay butterfly graft. Underlay cartilage grafts were used in the presence of perforations affecting the malleus region and a marginal TM perforation. Then, the prepared graft was imbedded in the perforation. A 2–3 cm pack, impregnated with antibiotic was placed in the external auditory canal, while many parts of the sponge were then put on it.

All patients were discharged one day after surgery without any complication, and also, the patients did not need dressing. The first 5 cases were operated under general anesthesia, and local anesthesia was applied for the remaining patients.

Packing was performed with a dry sponge. After one-week, local ciprofloxacin drops were applied. The dry sponge was removed 14 days after surgery.

Audiological and Clinical Measurement

Graft success means that TM perforation was closed as revealed in microscopic or endoscopic

examination performed six months after surgery. All patients were evaluated with pure tone audiometry (PTA), which was measured as the thresholds mean at four frequencies (500, 1000, 2000 and 4000 Hz). After surgery, bone conduction thresholds and mean audiometric results under 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz at air and bone conduction thresholds were measured 6 and 12 months after surgery in both groups. Air conduction PTA before and after surgery, air-bone gap (ABG), hearing gain and air-bone gap reduction were calculated following surgery.

Statistical Analysis

IBM SPSS version 22.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. To compare the categorical data, chi-square exact test was used while to analyze the parametric variables, the independent and paired samples t-test were performed. To analyze the distribution of non-parametric variables, Wilcoxon and Mann-Whitney U-tests were performed. Shapiro-Wilk test was performed to determine the distribution pattern. Based on the type of the variables, Spearman or Pearson correlation analysis was used to analyze the correlation. $p < 0.05$ was considered statistically significant.

RESULTS

Data obtained from 123 patients were analyzed: 58 patients had the inlay cartilage butterfly, and 65 patients had the underlay cartilage grafts. Fifty-two (42.2%) patients underwent surgery on the right ear, and 71 (57.8%) patients were operated on the left ear. No significant difference was found between the groups in terms of the distribution of the follow-up period, age, perforation location, and gender ($p > 0.05$) (Table 1).

Sixty-five small, 45 medium-sized, and 13 large perforations were found. Thirty-eight anterior, 19 posterior and 68 central TM perforations were detected. The graft uptake rates for small, medium, and large perforations were as follows: 62/65 (95.3%), 39/45 (86.6%), and 10/13 (80.7%), respectively. In the comparison of the perforation site, the graft uptake rates of the cen-

Table 1. Demographic characteristics, distribution of perforation size and location between groups.

	Inlay (n:58)	Underlay (n:65)
Mean age (years)	32.04±16.31	31.09±16.13
Gender		
male	31	36
female	27	29
Size of perforation		
small	30 (51.7%)	28 (43%)
medium	18 (31%)	26 (40%)
large	10 (17.2%)	11 (17%)
Graft failure	5 (9.1%)	8 (12.3%)
Location of perforation		
anterior	15 (25.8%)	23 (36.1%)
posterior	13 (22.5%)	11 (17.3%)
central	30 (51.7%)	31 (47.6%)

tral, anterior and posterior perforations were 66/68 (97.5%), 29/36 (81.6%), and 16/19 (84.2%).

Mean hearing gain values and preoperative, and postoperative hearing results of the patients are shown in Table 2. Preoperatively 8 (6.5%), 40(32.5%), 54 (44%), 21 (17%) in the ears with ABGs of 0–10 dB, 11–20 dB, 21–30 dB, and >31 dB, while postoperatively corresponding improvements were achieved in 75 (61%), 42 (34%), 6 (5%), 0 respectively.

A significant difference was found between the two groups in terms of ABG ($p=0.037$). Distribution of hearing alteration according to the size of perforation is shown in Table 3. There was no significant difference in the mean ABG in each group (small perforation $p=0.473$, medium perforation $p=0.876$ and large perforation $p=0.341$). However, there was a significant difference between the medium and small perforations and small and large perforations ($p<0.05$). Mean operative times were 5.6 ± 8.5 min and 48.6 ± 19.5 min for the inlay and underlay methods, respectively.

Any significant complication was not seen in the

early and late postoperative periods. In the early postoperative period, two patients experienced temporary loss of taste due to damage to the chorda tympani nerve and four patients experienced temporary vertigo. Also, two patients had transient facial nerve paralysis due to infiltration anesthesia, and four patients had nausea and vomiting.

DISCUSSION

Endoscopes have been used intensively in the diagnosis and treatment of ear diseases in recent years. In the first publication on endoscopic tympanoplasty, the success rate was reported to be high (7). Endoscopic tympanoplasty reduced the rates of postauricular approach and complications without decreasing overall success rates. In a meta-analysis, authors demonstrated that any statistically significant difference did not exist between the microscopic and endoscopic type 1 tympanoplasties in terms of TM closure rates and hearing gain (8).

Using the endoscope with a wide-angle view makes surgery easier because various recesses of the middle ear cleft are visualized better, and also, the anatomy of the middle ear recesses is more easily understood. To train the residents in ear surgery, endoscopes are widely used (9). Angled endoscopes are used to evaluate the middle ear and ossicle through the perforation. The endoscopic method can provide complete vision in some patients without needing canaloplasty and evaluate the perforation edges in patients with the external auditory canal exostoses (10).

The butterfly cartilage myringoplasty technique was performed in only small-sized perforations when Eavey first described this technique, but further studies indicated that the patients with near-total central perforations could undergo it (11). Furthermore, except for the size of perforation, the obtained hearing loss and hearing gain can also be determined according to the location of the perforation. However, according to the report of Mehta et al. ⁽¹²⁾, the hearing loss was not influenced by location of the perforation. Also,

Table 2. Mean hearing gain values and preoperative, and postoperative hearing results of the patients.

	Air conduction PTA (dB)	Bone conduction	Air-Bone gap (dB)	Air-Bone gap reduction
Preoperative inlay	36.3±13.7	12.1±6.3	22.1±8.4	
Preoperative underlay	35.6±13.3	12.3±5.8	23.2±8.9	
Postoperative month 6 inlay	25.4±12.3		12.5±5.8	11.2±5.3
Postoperative month 6 underlay	24.8±12.4		11.7±5.7	10.8±4.8
Postoperative month 12 inlay	22.5±10.5		11.6±5.7	
Postoperative month 12 underlay	22.7±9.7		11.4±5.8	

PTA; pure tone audiometry dB;decibel

according to Park et al. ⁽¹³⁾, there is no relationship between ABG and location of the perforation. The present study did not show any association among hearing gains, location of perforation, and ABG. (5-11)

Endoscopic inlay butterfly cartilage tympanoplasty is an efficient, and safe technique for graft placement without the need for tympanomeatal flap elevation. Average surgical time of 25.7 minutes, an ABG reduction of 9.4 dB and closure rate of 97.8% were reported during six months after surgery (14). Similar rates were also reported by many other studies (15, 16). The success rates of 93.3% (Bhattacharya et al. ⁽¹⁷⁾), and 88.2% (Mauri et al. ⁽¹⁶⁾) were also reported. In another study, authors operated 29 ears implementing inlay cartilage butterfly graft, and 28 cases showed sealed and dry tympanic membranes after six months (96.6%) (18). We observed graft failure in one of the cases with small-sized perforations, residual perforation in 4 cases with medium-sized perforations and graft resorption in three patients with large-sized perforations.

There was also an evaluation of the percentage of ears with ABG of below 10 dB. The percentages of respective ABGs before and after surgery for <20 dB and <10 dB were reported by Yu and Yoon⁽¹⁹⁾ as 76.5%, 88.2% and 29.4%, 70.6% and authors and authors indicated postoperative improvement in the mean ABG from 15.8 to 8.4 dB. Twenty-six patients (52 ears) underwent bilateral myringoplasty with the inlay or underlay technique, as reported by Caye-Thomasen et al.⁽²⁰⁾,

Table 3. Changes in hearing gains according to the size of perforations

	Inlay group (n:58)	Underlay group (n:65)
Perforation size ABG improvements (dB), mean ± SD		
Small	7.6±2.9	6.9±2.4
Medium	12.1±7.4	12.6±7.9
Large	12.9±4.7	13.1±5.2
Preoperative air conduction HL (dB), mean		
Small	37.4	36.9
Medium	39.7	39.3
Large	44.3	44.5
Postoperative 6. month air conduction HL (dB), mean		
Small	30.3	29.9
Medium	31.4	30.7
Large	35.2	33.6
Postoperative 12. month air conduction HL (dB), mean		
Small	29.1	28.3
Medium	27.9	29.1
Large	26.3	27.1

ABG; air bone gap, dB; decibel, HL; hearing loss

who found that ABG after surgery was close to 20 dB in 100% of the ears and 10 dB in 92% of ears. As shown by Daneshi et al.⁽²¹⁾, there was an improvement in the mean ABG after surgery from 13.88 dB to 9.16 dB. There was a change in the percentage of ABGs below 10 dB and 20 dB from 10.6% to 56% and from 40% to 95%, respectively, and there was an improvement in the mean ABG from 23.29 to 11.59 dB, after the surgery.

Kaya et al.⁽²²⁾ reported an improvement in the PTA average in hearing gains after surgery from 36.4 dB to 28.8 dB following small and medium perforations. Riss et al.⁽²³⁾, and Ulku et al.⁽²⁴⁾ reported postoperative hearing gains of 5.8 dB and 11.28 dB, respectively. Our study shows that the average air conductions (ACs) before and after the surgery for the inlay group were 36.3 ± 13.7 dB and 25.4 ± 12.3 dB 6 months after the surgery and 22.5 ± 10.5 dB 12 months after the surgery, respectively. In the underlay group, average ACs were found as 35.6 ± 13.3 dB and 24.8 ± 12.4 dB, 6 months and 22.7 ± 9.7 12 months after the surgery, respectively. Furthermore, we observed a difference in terms of hearing gains between one-year and six months after the surgery. Kaya et al.⁽²²⁾ explained that there was a reduction in thickness of the graft, which was fitted with the TM, leading to an increase in its elasticity. Due to this fact, the success of this method, which was assessed by performing the PTA during the late period, was more valuable than that in the early period.

One of the main limitations of the current study was that the study design was retrospective. Nevertheless, there were more patients in this study as compared with the previous studies. For this reason, the perforation size and localization could be studied with more credibility so as to compare the hearing gains achieved with the underlay and inlay technique. Furthermore, there is a need for further studies with late outcomes rather than early outcomes in the assessment of hearing gains.

In conclusion, endoscopic inlay cartilage tympanoplasty is becoming increasingly common among otorhinolaryngologists. This technique is

known to have at least similar results compared to other tympanoplasty techniques while reducing associated surgical morbidity. This technique can be used safely in small, moderate, and even large perforations, though performing this technique is challenging in some settings, successful closure rates, hearing outcomes and successful closure rates and hearing outcomes are comparable to those of the other surgical methods. The results of this study show that it is possible to say that the inlay method can be used with high graft success rate, low risk of complications and shorter operation time in appropriate patients, as a reliable surgical option for treatment.

Ethics Committee Approval: Ethics Committee approval was received for this study, Harran University Faculty of Medicine (09.09.2019/19/10/33).

Conflict of Interest: Authors declare that they have no conflict of interest, financial or otherwise.

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