Boomerang-Shaped Chondro-Perichondral Graft Versus Temporalis Muscle Fascia Graft: Which One is to be Trusted?

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Received: 21 November 2014 / Accepted: 15 January 2015 / Published online: 25 January 2015
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The aim of this study was to compare anatomical and audiological results of boomerang-shaped chondroperichondrial graft (BSCPG) with temporal muscle fascia in type 1 tympanoplasties. Sixty-eight patients in BSCPG group and 54 patients in fascia group were evaluated. Otomicroscopic examination was done periodically till 24 months as for graft perforation, lateralization and retraction and mean air conduction threshold and airbone gap values were measured. At long term controls, in BSCPG group, rates of neomembrane, perforation, retraction and lateralization were 91.17 % ($n = 62$), 8.82 % ($n = 6$), 4.41 % ($n = 3$) and 0 % ($n = 0$), respectively. In fascia group, the corresponding rates were 79.62 % ($n = 43$), 20.37 % ($n = 11$), 12.96 % ($n = 7$) and 3.7 % ($n = 2$), respectively. In both groups, mean postoperative PTA and ABG values were significantly better while postoperative same values were significantly different between groups ($p = 0.044$ and 0.032 , respectively). Compared to

fascia, BSCPG is an ideal grafting technique in the repair of tympanic membrane perforations.

Keywords Tympanoplasty ·
Boomerang-shaped chondroperichondrial graft ·
Perforation

Introduction

The aim in tympanoplasty is to achieve a healthy ear with reconstructed tympanic membrane, which is well aerated and has a good hearing function. Since Zollner and Wulstein defined reconstruction with fascia in 1952, various graft materials and different techniques have been described up to now [1, 2]. Primary materials used for this purpose include skin, fascia lata, temporalis muscle fascia, adipose tissue and perichondrium. Reconstruction of the tympanic membrane using cartilage was originally realized by Salen and Jansen in 1963 and this method has been performed up to now with developments in the technique [3, 4].

Cartilage is more resistant to deformation, which might occur because of the effects of the negative pressure than temporalis muscle fascia. Indorewala et al. indicated that temporalis muscle fascia can shrink at an unpredictable extent after it is retracted and create problems in type 1 tympanoplasties reconstructed with fascia [5]. Cartilage tissue is nourished by diffusion of nutrients and adapts better to focal nutritional disorders, which occurs during healing of the tympanic membrane [6]. Since it is relatively thicker, it is more resistant to anatomic deformations, which may occur under negative pressure [7]. Because cartilage is thick and rigid, some authors have advocated that marked hearing loss can be experienced by some

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patients who had cartilage tympanoplasty. However in cases where tympanic membrane is thinner than 0.5 mm, hearing outcomes comparable to normal tympanic membrane have been achieved [8]. In conclusion, use of cartilage or fascia do not lead to conspicuous changes in hearing outcomes. Both materials are well tolerated by middle ear and retain their vitality for longer times [9]. In an experimental study, Zahnert et al. investigated acoustic conduction properties of cartilage grafts of various thickness and their mechanical deformations when exposed to fluctuations in atmospheric pressure [10]. In the same study, tragal and conchal cartilages were comparatively evaluated without obtaining any significant outcome. The authors indicated that cartilage grafts less than 0.5 mm in thickness would lead to acceptable conductive hearing loss when compared with the tympanic membrane.

In addition, Mauri et al. preferred local anesthesia for transcanal butterfly cartilage tympanoplasty [11]. This method has been found to be at least as effective as temporalis fascia tympanoplasty, which apparently decreased operative time, expenditures and hospital stay. In conclusion, superiority of cartilage tympanoplasty over fascia tympanoplasty in various aspects has been indicated.

In the light of this information, popularity of remodelled cartilage–perichondrium grafts, which may incorporate durability of cartilage graft with thinness of fascia has increased with time. An example of this type of graft is boomerang-shaped chondro-perichondral graft (BSCPG), which has currently gained acceptance in the literature. This method has been described in this article by us [12]. In this method, cartilage tissue was left only in the anterior and lower quadrants for the stabilization of the graft. It prevents perforation of the tympanic membrane at the anterior quadrant and avoids graft lateralization due to placement of the graft under the manubrium mallei. The part of the graft which plays an important role in the auditory function which also comes in contact with the manubrium demonstrates acoustic properties comparable to temporalis muscle fascia thanks to thinness of perichondrium.

In our study, our aim was to compare BSCPG technique, which we recently described and applied in adult patients to temporalis muscle fascia technique in our patients who underwent tympanic membrane reconstruction and also reveal graft and audiometric success rates of both techniques.

Materials and Methods

Study Design

A total of 153 patients who underwent type I TPL using two different methods of reconstruction with the indication of chronic otitis in Mardin State Hospital between March

2010 and March 2014 were included in the study. Sixty-eight patients who underwent TwBSCPG reconstruction (Group 1) and 54 patients in whom temporalis fascia reconstruction (Group 3) was applied were evaluated. Eighteen patients who lost to follow-up and 13 patients with cholesteatoma were excluded from the study. The study was approved by the ethics committee.

Patients between 18 and 65 years of age with otorrhea persisting for at least 3 months and previously unoperated cases with healthy middle ear mucosa as observed on otomicroscopic examination without any preoperative or perioperative cholesteatoma during at least 24 months of follow-up were included in the study. All patients were subjected to preoperative otomicroscopic, radiological and audiological investigations. The patients were otomicroscopically examined at postoperative 3, 6, 9, 12 and 24 months and mean air conduction threshold and air-bone gap values were measured at 0.5, 1, 2 and 4 kHz. The patients were evaluated in the postoperative period as for the presence of graft perforation, lateralization and retraction.

Surgical Technique

All patients were operated under general anaesthesia. Tympanic membrane was repaired using graft material harvested from tragal cartilage, boomerang-shaped chondro-perichondral graft previously described in the literature or temporalis muscle fascia graft. In all patients, tympanoplasty was performed through endaural approach. After endaural incision, tympanomeatal flap was elevated. Middle ear was entered and intact and mobile ossicular system was detected. Chondro-perichondral graft prepared with a piece of SpongostanTM (Sponstan Standard, Ferrosan Inc., Copenhagen, Denmark) placed both on the posterosuperior quadrant and promontorium or a temporalis muscle fascia was implanted as an underlay graft medial to the malleus and underneath the annulus. Tympanomeatal flap was spread in situ and supported externally by pieces of SpongostanTM.

Outcome Parameters

Pre- and postoperative audiograms of all patients were evaluated according to the criteria proposed by 1995 American Academy of Otolaryngology–Head and Neck Surgery guidelines. Pure-tone averages 160 (PTA) were calculated by averaging the hearing thresholds for 0.5, 1.0 and 2.0 kHz. Preoperative and postoperative air-bone gaps were also calculated according to the pure-tone averages of the patients.

Statistical Analysis

The data obtained were analyzed with the aid of *SPSS 16.0 Evaluation for Windows* (SPSS Inc. Chicago, Illinois)

package program. PTA-ABG for each audiogram was evaluated by calculating the mean air-bone gap at 500, 1000, 2000 and 4000 Hz¹⁵. Pre- and post-operative PTA-ABG values were compared using Student's *t* test. $p < 0.05$ accepted as significant.

Results

Mean age of the patients was 29.2 ± 12.1 (range, 18–65) years. Study population consisted of 75 (61.47 %) female and 47 (38.53 %) male patients. Mean follow-up period was 28.45 ± 2.84 months. The demographic and comorbidity characteristics are shown in Table 1. No significant correlation was observed between other parameters and any demographic features.

The postoperative status of the grafts in patients who underwent tympanoplasty using BSCPG technique was evaluated in Table 2. At 3. month controls performed in Group 1, any sign of perforation, retraction or lateralization was not observed, while in Group 2, among 54 grafts, cases with perforation ($n = 2$) and lateralization ($n = 2$) were observed.

At 6 month controls, in Group 1, signs of perforation ($n = 3$) and retraction in the posterior quadrant ($n = 1$) and immediately inferior to the malleus ($n = 1$) were observed. In Group 2, at 3 month controls, 2 additional cases with perforation and areas of retraction in 4 grafts 2 of them being in the antero-inferior quadrant and 2 in the

posterior quadrant extending to fossa incudis were detected. Besides lateralization was seen in two cases.

In Group 1, at 9 month controls, decrease was observed in the dimensions of one of three perforated grafts detected at 6 months. However, perforation in additional two grafts was noted and also retraction at posterior quadrant was found in one graft in addition to two retracted grafts detected in the previous control visit. In Group 2, perforation detected in one case at 3 month control was later closed, while perforation was noted in additional two cases amounting to a total of five cases in Group 1 and 5 cases in Group 2. One case in addition to previously detected four retractions, in one case retraction was observed in the attic area, amounting to a total of 5 retracted grafts. Any difference in the number of lateralizations was not observed when compared with previous controls.

In Group 1 at 12 month controls, any change in the dimensions of the perforations in the grafts relative to previous controls was not detected. Besides, perforation was seen in one additional case. Any change was not observed as for retraction and lateralization. In Group 2, any change in the dimensions of previously observed cases with perforation was not detected, while in additional six cases central perforations were detected. In this group, any change was not noted as for retraction and lateralization.

In Group 1, at 24 month controls, any finding different from that of controls was not detected. In Group 2, the number of perforations and lateralizations did not change and additionally areas of retraction in one case extending

Table 1 Comparison of two groups in demographic and clinical characteristics ($n = 122$)

Variables	Group 1 ($n = 68$)	Group 2 ($n = 54$)	<i>p</i> value
Age (mean $\pm$ SD)	30.45 ± 12.25	28.56 ± 11.48	0.452
Gender			
Female	36 (52.9 %)	39 (72.2 %)	0.645
Male	32 (47.1 %)	15 (27.8 %)	
Period of education (years)	11.25 ± 2.85	10.42 ± 2.86	0.418
Annual income			
0-10,000\$	22	23	0.236
10,001–20,000\$	32	19	
20,001–30,000\$	14	8	
>30,001\$	4	4	
Postoperative perforated graft number (one year)	9 (13.2 %)	15 (27.7 %)	0.876
Last infection (mean/month)	6.25 ± 3.15	8.48 ± 3.44	0.442
Smoking (pack/day)			
Present	25 (0.7 ± 0.26)	32 (1.05 ± 0.82)	0.098
Absent	43	22	
Alcohol (gram/week)			
Present	7 (10.42 ± 7.12)	9 (13.28 ± 5.02)	0.882
Absent	61	45	
Duration of surgery (min)	52.4 ± 10.25	72.6 ± 12.22	0.105
Duration of follow-up (month)	27.25 ± 2.8	30.08 ± 3.15	0.624

Group 1 = chondroperichondrial graft; group 2 = temporal fascia graft

$p < 0.05$ is statistically significant

Table 2 Graft status in patients (n = 122)

	3rd month		6th month		9th month		12th month		24th month	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Neotympanum	68 (100 %)	52 (96.2 %)	65 (95.5 %)	50 (92.5 %)	63 (92.6 %)	49 (90.7 %)	62 (91.1 %)	43 (79.6 %)	62 (91.1 %)	43 (79.6 %)
Perforation	0	2 (3.8 %)	3 (4.5 %)	4 (7.5 %)	5 (7.4 %)	5 (9.3 %)	6 (3.8 %)	11 (20.4 %)	6 (8.9 %)	11 (20.4 %)
Retraction	0	0	2 (2.9 %)	4 (7.5 %)	3 (4.5 %)	5 (9.3 %)	3 (4.5 %)	5 (9.3 %)	3 (4.5 %)	7 (12.9 %)
Lateralisation	0	2 (3.8 %)	0	2 (3.8 %)	0	2 (3.8 %)	0	2 (3.8 %)	0	2 (3.8 %)

medial to manubrium and in another case to fossa incudis in the vicinity of external auditory canal were observed. When all cases of retraction were evaluated according to Sade classification [13], in Group 1, 3 cases of retraction were of grade 1 and in Group 2, grade 2 (n = 2) and grade 1 (n = 5) retractions were observed.

At 24 month controls, in Group 1, rates of development of neomembrane, perforation, retraction and lateralization were 91.17 % (n = 62), 8.82 % (n = 6), 4.41 % (n = 3) and 0 % (n = 0), respectively. In Group 2, the corresponding rates were detected to be 79.62 % (n = 43), 20.37 % (n = 11), 12.96 % (n = 7) and 3.7 % (n = 2), respectively (Table 2; Fig. 1).

Preoperative mean pure tone audiometry (PTA) and ABG values were 26.42 ± 8.15 , 19.46 ± 9.82 in Group 1 and 29.75 ± 8.65 , 18.64 ± 10.42 in Group 2, while 1 year post-operative corresponding values for PTA and ABG in Groups 1 and 2 were 12.24 ± 4.92 and 11.45 ± 4.75 versus 17.6 ± 4.7 and 14.42 ± 7.08 , respectively. In both groups, mean post-operative PTA and ABG values were significantly better than corresponding preoperative values. Still, postoperative PTA and ABG values were significantly different between groups ($p = 0.044$ and 0.032 , respectively) (Table 3).

Changes in mean pure tone audiometry results and ABGs of the patients through follow-up time were given in Table 4 and Fig. 2. According to this table, mean PTA and ABG values did not demonstrate any intergroup change, while from 12 months on available values were significantly better in Group 1.

Fig. 1 Graft status BSCPG 24th month

Discussion

The success of tympanoplasty depends on eradication of middle ear infection and the presence of fairly well aerated ear. Up to now many graft materials and techniques have been described for the repairment of the tympanic membrane perforation. Salen et al. and Jansen et al. used cartilage successfully in the middle ear surgery previously [3, 4]. In recent years, some autologists believe that cartilage is a reliable graft material resistant to reperforations, which can be easily placed under malleus because of its stable nature. Clinical and experimental studies cited in the literature have revealed that cartilage is very well tolerated with better auditory outcomes and minimal resorption [14].

In the literature, different cartilage tympanoplasty techniques have been defined and generally as a prevalent thought, in adults cartilage tympanoplasty is relatively more successful. In a series of 223 patients operated by Mubarak et al. the authors found graft success rate of 98.03 % at the end of 2 years of follow-up period [15]. Sozen et al. in a series of 246 patients compared choncal cartilage, tragal cartilage and temporalis muscle fascia and found corresponding graft success rates of 100, 88.5 and 80.5 %, respectively [16]. However Mukherje et al. reported success rates for fascia and cartilage as 68 and 64 %, which may infer that general preference for cartilage grafts will increase cartilage graft success rate when compared with that of the temporalis muscle fascia graft [17]. On the other side of the medallion, it should be kept in mind that increased thickness of the cartilage will decrease compliance and affect the functional result adversely. Zahnert et al. conducted experiments on cadavers and indicated acoustic outcomes similar to tympanic membrane could be obtained with the use of cartilage grafts thinner than 0.5 mm [10]. Based on this fact, in order to ensure stabilization and prevent development of perforation without impairing acoustic properties, recently chondro-perichondral grafts have been defined and used with increasing popularity up to now. As examples for these graft types, Triple C technique chondro-perichondral graft, Mercedes-Benz graft and boomerang-shaped chondro-perichondral graft recently described by us can be enumerated. In our study, we detected 1-year graft success

Table 3 The mean pre- and post-operative (first year) pure tone average and air-bone gap of the patients

	Preoperative			Postoperative		
	Group 1	Group 2	<i>p</i> value	Group 1	Group 2	<i>p</i> value
Pure tone average	26.42 ± 8.15	29.75 ± 8.65	0.722	12.24 ± 4.92	17.6 ± 4.7	0.044
Air-bone gap	19.46 ± 9.82	18.64 ± 10.42	0.553	11.45 ± 4.75	14.42 ± 7.08	0.032

Group 1 = chondroperichondrial graft; group 2 = temporal fascia graft

p < 0.05 is statistically significant; statistically significant values were shown in bold

Table 4 Pure tone average air-bone gap at different follow-up times

	Group 1	Group 2	<i>p</i> value
3rd month	8.35 ± 3.25	11.5 ± 2.85	0.242
6th month	9.4 ± 4.15	12.8 ± 4.55	0.044
9th month	11.05 ± 5.26	13.1 ± 5.12	0.458
12th month	11.45 ± 4.75	14.42 ± 7.08	0.032
24th month	13.8 ± 4.64	16.45 ± 6.38	0.022

Group 1 = chondroperichondrial graft; group 2 = temporal fascia graft

p < 0.05 is statistically significant; statistically significant values were shown in bold

Fig. 2 Type I tympanoplasty pure-tone average air-bone gap at different follow-up times (Group 1, blue; group 2, brown)

rate of 91.1 % (62/68) for this new BSCPG technique in tympanoplasty patients.

Postoperative hearing gain of the patients who underwent tympanoplasty operations is an important indicator of surgical success. Many studies reported relevant successful results. In a series of 132 patients operated by Chhapola et al. at the end of 2 years of follow-up, ABG value was lower than 10 dB in 82 % of the cases in the fascia group and in 78 % of the patients who received choncal cartilage grafts thinner than 5 mm [18]. Still Mohamad et al. could not observe a significant difference between fascia and cartilage grafts as for ABG gain [19]. In our study, in both groups, postoperative mean PTA and ABG values were found to be significantly improved relative to corresponding preoperative values. A significant intergroup difference

was found as for postoperative PTA and ABG values (*p* = 0.044 and 0.032, respectively).

The most important difference between fascia and cartilage graft is that with time cartilage or chondro-perichondral graft lead a stable course, while unexpected perforations can emerge on the fascia grafts. For example, in a study performed by Chhapola et al. the rate of perforation in temporalis muscle fascia grafts at 6. months was 4.2 %, while at 2 year controls, it increased 2-fold up to 9.85 % [18]. In the same study, rates of perforation in the cartilage graft at 6 month and 1-year controls did not change. In our study, in the chondro-perichondral and fascial graft groups 6 month and 2 year- perforation rates were 4.5 and 7.5 % versus 8.9 and 20.4 %, respectively. In long-term follow-ups of the cases constructed with fascia, relatively worse PTA and ABG values were observed due to potential perforation and retraction, however in the cases with cartilage and chondro-perichondral grafts these adverse changes have not been noted thanks to higher stabilization rates. In our study, mean 6 month ABG values were 12.8 ± 4.55 in the fascia and 9.4 ± 4.15 in the chondro-perichondral graft groups, while at 12 month controls the corresponding values were observed to be 16.45 ± 6.38 and 13.8 ± 4.64, respectively. The changes in ABG with time are presented in graphics and figures.

Conclusion

When BSCPG and temporalis muscle fascia techniques were compared, in the long-term follow-ups, anatomical

and functional outcomes of both groups were adequately good in accordance with the literature findings, BSCPG has yielded more successful outcomes. We think that this recently described technique minimizes anterior quadrant problems with minimal probability of graft lateralization and it will be an ideal grafting technique in the repair of tympanic membrane perforations.

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