SUPPLEMENT

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Retrospective air bone gap evaluation of patients with tympanic membrane central perforation

Abstract

Purpose: The purpose of this study was to evaluate hearing recovery and air-bone gap (ABG) before and after tympanoplasty surgery in patients with tympanic membrane central perforation.

Methods: Histories and audiological assessments of 160 cases (total of 26 ears from 22 patients; 11 men and 11 women) from patients who had undergone tympanoplasty surgery and hearing reconstruction due to tympanic membrane central perforation were evaluated. Pre-postoperative audiograms and the pure tone, air-bone hearing thresholds and ABG gains were evaluated.

Results: The mean age of the patients was 38.6 years (± 16.04). The mean postoperative follow-up period was 13.4 months (± 15.5). The mean preoperative ABG was 25.36 dB (± 9.9) and postoperative ABG was 17.36 dB (± 11.68) ($p = 0.001$). When four groups were compared before surgery and after surgery period as 0-6 months, 6-12 months, 1-2 years and 2 years in terms of pre- and postoperative ABG values, no statistically significant difference was observed ($p > 0.05$). All patients were divided into three groups: < 20 years of age; between the ages of 21-40; and, > 41 years of age, and no statistically significant difference were found between the groups ($p > 0.05$). Surgeries of the patients 21-40 years of age were more successful (ABG gain) than other age groups. No statistically significant gender differences were found in ABG averages ($p = 0.33$), but clinical results were significantly better in women as compared with men.

Conclusion: In patients with central tympanic membrane perforation, tympanoplasty surgery with temporal fascia is beneficial in terms of hearing recovery.

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The purpose of tympanoplasty is to eradicate the tympanum disease, provide ventilation, reconstruct conducting mechanism of sound and build a self-cleaning dry cavity [1]. This surgery should be performed if there is no discharge in the ear at least for 6 months [2].

Tympanoplasty consists of myringoplasty and/or ossiculoplasty steps. Myringoplasty is the process of closing tympanic membrane perforation and creating a vibrating membrane. For this surgery, the bony chain is robust and ossiculoplasty is not performed. Several graft materials can be used for myringoplasty, and they can be arranged in different ways to close the perforation (e.g., overlay, underlay, over-under.) [1]. In contrast, ossiculoplasty is bony chain reconstruction. Stapedotomy for otosclerosis treatment is excluded from this group [1, 3].

According to Wulstein classification, tympanoplasty surgeries are determined as Type I, Type II, Type III, Type IV, Type V, Type Va, Type Vb, although Type V tympanoplasty is rarely used now [3, 4]. Central perforation refers to a perforation with a residual membrane not involving annulus but continuing to annulus, marginal perforation is a perforation without a residual membrane but involving annulus. Subtotal perforation means if almost all tympanic membrane is absent, total perforation means if all tympanic membrane was absent. The localizations of smaller perforations are described by the four quadrants of the tympanic membrane [3, 5].

In the normal ear, the gain in the middle ear is achieved by the surface ratio; the tympanic membrane collects power on the surface and conducts the power to the footplate smaller than stapes. The gain in normal human ear ranges between 250 and 1000 Hz, and only about 20 dB, and reduces 6-8 dB per octave at frequencies above 1000 Hz [6].

In a mechanically mobile but suboptimal tympanoplasty, optimal middle ear ventilation and circular window protection with middle ear gain may not be achieved, but a patients may still achieve relatively good hearing; for example, a tympanoplasty providing 5 dB middle ear gain, but allowing for middle ear ventilation and circular window mobility only results in 15 dB air-bone gap (ABG) [7]. Since the cochlea responds the sound pressure difference between oval and round windows, it is important to understand how this difference is connected to the relative magnitude and phase between the two sound pressures. In a normal ear, after a successful tympanoplasty, the magnitude of the sound pressure in oval window is significantly larger than that from a round window and the effect of phase difference on window pressure is low under these conditions [6, 7]. The purpose of

tympanoplasty, regardless of the phase, is to maintain the sound pressure magnitude higher in oval window than round window [7].

The aim of this study is to determine the extent of hearing recovery and to evaluate ABG retrospectively before and after tympanoplasty surgery in the patients with tympanic membrane central perforation.

Materials and Methods

The cases from patients undergoing tympanoplasty surgery and hearing reconstruction due to tympanic membrane central perforation at Turgut Ozal University Hospital ENT clinic between December 2010-2015 were assessed. The study protocol was approved by Turgut Özal University Ethics Committee (Approval No:99950669/237). The patients with ear discharge within the last month were excluded from the study. The audiological results were evaluated retrospectively and the outpatients followed-up regularly were included in the study. Pre-postoperative audiograms were evaluated air-bone conduction hearing thresholds at 0.5-1-2-4 kHz and ABG gain were executed.

IBM SPSS Statistics 21 program (SPSS Inc., IBM, Somers, NY) was used for statistical evaluation. Paired Samples t-Test, Independent Samples Test and Oneway Anova were done in order to obtain p values.

Pre-postoperative ABG mean values were compared in all patient groups. Pre-postoperative ABG measurement times were analysed in four groups: 0-6 months; 6-11 months; 1-2 years and 2 years. Success for age factor was studied in three groups: <20 years, 21-40 years and >41 years. Gender factor was also examined. Pre-postoperative ABG gain values were compared between groups and statistical analyses was performed. $p < 0.05$ value was considered significant.

Results

The histories of 160 tympanoplasty cases were evaluated and a total of 26 ears from 22 patients followed-up regularly (11 men and 11 women) were included in the study. Temporal fascia was used as graft material in all patients under general anesthesia. The mean age of the individuals in the study was 39 years (± 16.04). The mean postoperative follow-up period was 13.3 (± 15.5) months. The mean pre-postoperative ABG gains are presented in Table 1.

The mean preoperative ABG was 25.36 dB and the mean postoperative ABG was 17.36 dB. The pre/postoperative difference in audiometric evaluation was found to be statistically significant ($p = 0.001$) (Table 2).

TABLE 1. Pre-postoperative ABG gain range

ABG range	≤10 dB	11-24 dB	≥25 dB	Worsened	Unchanged
N	9	9	1	6	1

TABLE 2. Comparison of pre-postoperative ABG values

Measurement time	N	Mean	SS	Sd	t*	P*
Pre-op ABG	26	24.34	9.90	25	3.76	0.001
Post-op ABG	26	16.84	11.68			

TABLE 3. Comparison of ABG gain by pre-postoperative measurement period

Pre-Post Measurement period	N	Mean	Sd	*F	*p
< 6 months	14	5.71	3	0.272	0.845
6-12 months	5	10.4			
1-2 years	2	6			
2 years	5	8.2			

*Oneway ANOVA

TABLE 4. Comparison of pre-postoperative ABG gains by age groups

Age (years)	N	Pre-op ABG Mean	Post-Op ABG Mean	Sd	*F	*p
<20	5	24.4	25.4	2	3.033	0.068
20-40	14	23.64	12.93			
>40	7	25.71	20			

*Oneway ANOVA

TABLE 5. Comparison of pre-postoperative ABG mean values by gender

Gender	N	Mean	Sd	*Df	*F	*p
Male	13	4.69	10.9	24	0.987	0.33
Female	13	9.53	8.7	22.8		

*Independent Samples Test

Four groups were formed by means of before and after surgery measurement period of time as 0-6 months, 6-12 months, 1-2 years and 2 years. In terms of ABG gain, statistically significant differences were not observed ($p=0.845$) (Table 3).

All patients were divided into three groups with regard to age (<20, 21-40, >41 years), ABG gains were compared and no statistically significant difference were seen between the groups ($p=0.68$) (Table 4).

When ABG gains were compared between female and male patients, although no statistically significant difference was attained, as seen in Table 5, the difference was clinically significant.

Discussion

ABG results in tympanoplasty surgeries were analyzed as a success evaluation in several studies [8, 9, 10]. Demirci *et al.*, in their pediatric study, found that preoperative ABG was 28.2 ± 10.1 dB and postoperative ABG was 15.1 ± 10.2 dB, and pre-postoperative gain was 13.1 ± 9.6 dB in the fascia group [8]. In a study performed by Elaso *et al.*, preoperative ABG was 25.8 ± 07.5 dB and postoperative ABG was 13.1 ± 06.3 dB. [9]. Palva reported that 69% of Type 1 tympanoplasty cases had ABG of <20 dB and TM (tympanic membrane) regeneration success was 97%. [10]. In our study, when pre-postoperative ABG were compared in tympanoplasties with temporal fascia, statistically significant results were obtained, and mean ABG values were consistent with other studies (Table 2).

In the study performed by Vrabec *et al.* with 30 cases, young age is the only factor that showed poor results - no significant relationship was found between surgical success and other factors [11]. In our study, three age groups (<20, 21-40 and >41 years) were evaluated, and pre-postoperative ABG values were compared among the age groups. No statistically significant differences were found among three age groups ($p=0.68$); however, mean pre-postoperative ABG gain showed clinically significant differences in patients between 20-40 years of age (Table 4).

Emir *et al.* reported that the correlation between success rate and male gender was statistically significant [12]. In their study looking at temporal fascia (45 cases) and cartilage graft (63 cases), Callioglu *et al.* reported that age, gender and addition of mastoidectomy procedure were not significantly associated with ABG gain and success among two groups [13]. Similarly, Dornhoffer reported that age and gender did not play a role in operation success [14]; however, in our study, although no statistically significant difference in age and

gender was found for tympanoplasty surgeries, the differences between mean values were clinically significant (Table 5).

Batna and Goyal evaluated graft status and hearing results at 3, 6 months and 1 year in 100 cases with Type I tympanoplasty, temporal fascia graft and tympanic membrane reconstruction, and found that the success rate of fully recovered intact graft was 88% at one year post-operative. The hearing gain was 14.55 dB and mean ABG decrease was 11.94 dB. ABG gain was statistically significant [15]. In their study, Lyons *et al.* (2015) reported that a minimum 3 months follow-up period was required to observe postoperative hearing recovery [16]. In our study, when pre-postoperative ABG measurements were compared by months in four groups (first 6 months, 6-12 months, 1-2 years and 2 years), no statistically significant difference was observed ($p=0.845$).

Conclusion

The results of the patients with central tympanic membrane perforation showed that tympanoplasty surgery with temporal fascia is generally favorable in terms of hearing recovery. In addition, pre-postoperative ABG mean gain in 20-40 years old patients was higher as compared with lower and upper age groups. No difference in recovery rate was found after the 6 months follow-up period. There were significant differences in terms of gender.

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