ORIGINAL ARTICLE

Ear surgery techniques results on hearing threshold improvement

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Background: Bone conduction (BC) threshold depression is not always by means of sensory neural hearing loss and sometimes it is an artifact caused by middle ear pathologies and ossicular chain problems. In this research, the influences of ear surgeries on bone conduction were evaluated. **Materials and Methods:** This study was conducted as a clinical trial study. The ear surgery performed on 83 patients classified in four categories: Stapedectomy, tympanomastoid surgery and ossicular reconstruction partially or totally; Partial Ossicular Replacement Prosthesis (PORP) and Total Ossicular Replacement Prosthesis (TORP). Bone conduction thresholds assessed in frequencies of 250, 500, 1000, 2000 and 4000 Hz pre and post the surgery. **Results:** In stapedectomy group, the average of BC threshold in all frequencies improved approximately 6 dB in frequency of 2000 Hz. In tympanomastoid group, BC threshold in the frequency of 500, 1000 and 2000 Hz changed 4 dB (P-value < 0.05). Moreover, In the PORP group, 5 dB enhancement was seen in 1000 and 2000 Hz. In TORP group, the results confirmed that BC threshold improved in all frequencies especially at 4000 Hz about 6.5 dB. **Conclusion:** In according to results of this study, BC threshold shift was seen after several ear surgeries such as stapedectomy, tympanoplasty, PORP and TORP. The average of BC improvement was approximately 5 dB. It must be considered that BC depression might happen because of ossicular chain problems. Therefore; by resolving middle ear pathologies, the better BC threshold was obtained, the less hearing problems would be faced.

Key words: Bone conduction, hearing threshold improvement, partial ossicular replacement prosthesis, stapedectomy, total ossicular replacement prosthesis, tympanoplasty

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INTRODUCTION

Sound is transmitted into the middle ear by air and bone conduction. Air conduction consists of external ear, tympanic membrane and ossicles of middle ear. As a matter of fact, three mechanisms have a noticeable role in this regard which include: Air conduction (AC), Sound induction in skull bone and Sound induction through the soft and hard tissue of body which is finally transmitted to the cochlea.[1-4] Five factors have been considered as effective parameters in bone conduction include: External auditory canal, Inertia of middle ear ossicle, Inertia of cochlear fluids, Changing in the cochlear space and transmitted pressure via Cerebrospinal fluid (CSF).[3,4] The role of external auditory canal is more obvious in the frequency below than 1000 Hz with occluded external auditory canal since bone conduction gets enhance in low frequency. Inertia of middle ear ossicles probably is more effective in high frequency, because bone conduction in frequencies of 200-1500 Hz is just 5-15 dB lower than air conduction. Moreover, it is more dependent to footplate vibration. Cochlear fluids inertia plays as an important factor in bone conduction (BC) below 4000 Hz.[5-8] Bone conduction thresholds have been used as a criteria for diagnosing of sensory-neural hearing loss. It means BC threshold depression is not only the sign of pathology of inner ear and cochlear nerve, but also the middle ear pathologies cause this changing in threshold (i.e. Carhart's notch).[9-12] In the previous studies BC threshold improvement was seen after stapedectomy.[13-15] In other pathologies of middle ear consist of ossicular chain problems and chronic disease of middle ear, BC threshold improvement was reported by removing middle ear pathology.[16, 17] In this study it was aimed to survey BC threshold improvement after ear surgeries (stapedectomy, tympanomastoid surgery, ossiculoplasty, Partial Ossicular Replacement Prosthesis (PORP) and Total Ossicular Replacement Prosthesis (TORP).

MATERIALS AND METHODS

This clinical trial study was approved by the Ethics Committee of Isfahan University of Medical Sciences (IRCT:387387). In this study, the selected intervention was the

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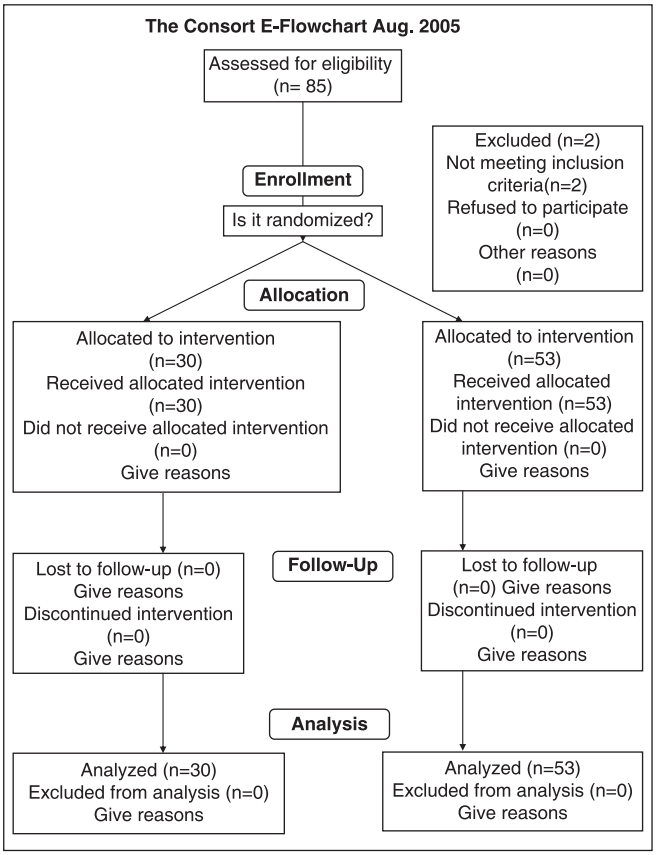
same as the performance of the surgery as seen in Flowchart 1. This study was carried out in 2007-2008 at Al-Zahra Hospital, Isfahan, Iran. 83 patients were selected as follows: 20 cases with stapedectomy, 27 cases with tympanoplasty or tymanoplasty mastoidectomy without ossicular problems and 14 cases with PORP and 18 cases with TORP surgery. There were 36 and have been diagnosed as otosclerosis, whom had been considered for stapedectomy and patients with the impression of Chronic Otitis Media (COM) have been candidate for tympanomastoid surgeries. The patients with ossicular problems had been selected for ossicular reconstruction surgery (TORP or PORP) with according to the condition of the ossicles. Preoperative BC threshold in frequencies of 250, 500, 1000, 2000, 4000 Hz had been assessed. Three months after surgery, the second audiometry tests were performed and the differences of BC thresholds before and after operations were analyzed. The normal distribution of the parameter was evaluated by use of Shapiro-Wilk test. As the parameter had an abnormal distribution, Wilcoxon test was used for final analysis. The significant point was 0.05. The statistical analysis was done by SPSS software; ver.11.5 (SPSS Inc., USA).

RESULTS

The mean (SD) age of participants in this study was 34.8 (±2.8) years. In the stapedectomy group, BC threshold improvement was significant only at 2000 Hz (P value = 0.013) as seen in Table 4. The patients in tympanoplasty group with/without mastoidectomy were divided in two categories. The first group were the patients with stiffness and tympanosclerosis in ossicular chain and BC threshold improvement was significant at 500 and 1000 Hz (P value = 0.028, P value = 0.007, respectively) as seen in Tables 2 and 3. However, in the second group; no ossicular chain problems, no significant difference was seen in all frequencies as seen in all tables. In PORP patients BC threshold improvement was noticeably significant except at 500 and 4000 Hz. (P value < 0.05) as seen in whole tables. In TORP patients group, BC threshold improvement was statistically significant in all frequencies. (P value < 0.05) as seen Tables 1-5.



Flowchart 1:

DISCUSSION

In otosclerosis, the otospongize process occurs in the middle ear and causes ossicular fixation.[4] audiological results shown a conductive hearing loss.[8] Maximum BC threshold depression was seen at 2000 Hz. In this study the BC threshold improvement after ear surgeries were detected in all frequencies (this improvement was significant at 2000 Hz). In the Awengen[15] *et al.* study, changes in BC after the stapedectomy showed that the average improvement in the frequencies of 500, 1000 and 2000 Hz was 5-6 dB and the best results were at 2000 Hz which is the same as the results of the current study. In Booncho[16] *et al.* study, in accordance with this study; BC threshold improvement was significant except for 4000 Hz. In Moscillo[11] *et al.* study, BC threshold changes was significant in all frequencies in younger cases that conforms results of this study. In Morshed[18] *et al.* study; BC threshold after stapedectomy surgery was improved 6-12 dB, which showed no significant difference with our results. In tympanoplasty group, significant difference was seen only at 1000 Hz (P value = 0.015). In abnormal ossicular chain group, BC threshold improvement was significant at 500 and 1000 Hz but there is no statistically significant difference in intact ossicular chain group, which it might be due to tympanic membrane pathologies. In Vartiainen[12] *et al.*, BC threshold changes in chronic ear pathologies group was 11-25 dB especially in tympanic membrane pathologies group as what seen in this study. In priede[14] *et al.* study, BC threshold improvement after ossiculoplasty surgery was seen in accordance with this study, in PORP and TORP surgery groups, significant difference was found in all frequencies except 4000 and 2000 Hz, respectively. In shrestha[18] *et al.*, BC threshold changes were significant (500 and 1000 Hz) in chronic otitis media group as what found in this study. Improvement of the ABG in almost of 66% of cases was found in Iñiguez-Cuadra[19] *et al.* study

Table 1: Pre/Post Hearing threshold at 250 Hz

Frequency 250 Hz	Stapedectomy N=20	Tympanomastoid N=31		PORP N=14	TORP N=18	
		With ossicular problems N=17	Without ossicular problem N=14		Appropriate hearing N=7	Inappropriate hearing N=11
Pre Op BC threshold	17	15.8	10.3	16.2	11.4	5.4
Post Op BC threshold	15	15	13.2	12.8	7.1	3.2
Mean	−2	−0.88	+2.8	−3.4	−4.2	−2.3
SD	6.7	5.9	8.7	6.6	5.5	7.1
P-value*:Significant	0.10	0.27	0.12	0.03*	0.11	0.04*

PORP=Partial ossicular replacement prosthesis; TORP=Total ossicular replacement prosthesis; BC=Bone conduction

Table 2: Pre/Post Hearing threshold at 500 Hz

Frequency 500 Hz	Stapedectomy N=20	Tympanomastoid N=31		PORP N=14	TORP N=18	
		With ossicular problems N=17	Without ossicular problem N=14		Appropriate hearing N=7	Inappropriate hearing N=11
Pre Op BC threshold	17.5	19.4	10.7	17.5	12.1	8.6
Post Op BC threshold	16.2	16.5	12.5	14.6	8.5	5
Mean	−1.2	−2.94	+1.8	−2.8	−3.6	−3.6
SD	8.4	5.9	7.7	8	8.5	7.5
P-value*:Significant	0.25	0.02*	0.2	0.1	0.05*	0.11

Table 3: Pre/Post Hearing threshold at 1000 Hz

Frequency 1000 Hz	Stapedectomy N=20	Tympanomastoid N=31		PORP N=14	TORP N=18	
		With ossicular problems N=17	Without ossicular problem N=14		Appropriate hearing N=7	Inappropriate hearing N=11
Pre Op BC threshold	19	18.8	12.8	16.4	12.1	10
Post Op BC threshold	17.5	14.7	12.5	11.4	6.4	7.3
Mean	−1.5	−4.1	−0.36	−5	−5.7	−2.7
SD	8.4	6.1	5.3	7.3	5.2	8.1
P-value*:Significant	0.21	0.007*	0.4	0.01*	0.08	0.05*

Table 4: Pre/Post Hearing threshold at 2000 Hz

Frequency 2000 Hz	Stapedectomy N=20	Tympanomastoid N=31		PORP N=14	TORP N=18	
		With ossicular problems N=17	Without ossicular problem N=14		Appropriate hearing N=7	Inappropriate hearing N=11
Pre Op BC threshold	25.5	22	16.4	19.6	20	19.1
Post Op BC threshold	19.2	23.2	14.3	14.6	10.7	20
Mean	−6.2	+1.2	−2.1	−5	−9.2	+0.9
SD	11.5	13.3	9.1	7.8	5.5	18
P-value*:Significant	0.01*	0.36	0.19	0.01*	0.01*	0.25

Table 5: Pre/Post Hearing threshold at 4000 Hz

Frequency 4000 Hz	Stapedectomy N=20	Tympanomastoid N=31		PORP N=14	TORP N=18	
		With ossicular problems N=17	Without ossicular problem N=14		Appropriate hearing N=7	Inappropriate hearing N=11
Pre Op BC threshold	23	24.7	17.5	20.7	24.3	21.3
Post Op BC threshold	24.7	26.9	18.9	17.1	19.3	15
Mean	+1.7	+2.2	+1.4	-3.5	−5	−6.4
SD	11.6	9.1	11.1	8.1	9.5	17.1
P-value*:Significant	0.25	0.17	0.32	0.06	0.1	0.005*

particularly at frequency of 4000 Hz, which is the same as the result of this study (TORP group). In Choi[20] *et al.*, significant changes of ABG, in the TORP group was seen rather than in the Long Columella group (30.8 ± 13.8 dB vs. 7.9 ± 9.4 dB). In Sazgar[21] *et al.*, partial stapedectomy group was better than stapedotomy group and hearing improvement was in 3 frequencies and improvement average was 15.6 dB. But in Kim[22] *et al.*, they found no preference of mastoid surgery procedures; Canal wall up mastoidectomy and canal wall down mastoidectomy

(CWUM and CWDM) on hearing improvement results; 10.9 dB vs. 13.5 dB, respectively. Nonetheless, researches with more cases and extended follow-up time are needed.

CONCLUSION

Bone conduction loss usually consider as a sign of sensory-neural hearing loss which is because of inner ear problem and cochlear nerve pathologies but sometimes it is an artifact because of middle ear problem and ossicles pathology which the commonest form is Carhart's notch in otosclerosis disease. In this study, BC threshold shift was found after ear surgeries such as Stapedectomy, tympanoplasty and ossicular reconstruction surgery i.e., PORP, TORP and so it must be considered other impressive factors might be addressed on BC depression and in this situation, hearing threshold of patients is improved by eliminating of middle ear and ossicles pathology

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