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The Effect of Mobility of Ossicles and Surgical Approach on Hearing Results in Patients with Tympanosclerosis

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OBJECTIVE: To evaluate involvement of ossicular chain with tympanosclerosis and their effects on hearing loss and to compare the results of mobilization or stapedectomy in stapes fixed tympanosclerosis.

MATERIAL AND METHODS: Seventy three patients operated for tympanosclerosis were retrospectively analyzed. Sixty-four ears with tympanosclerosis were mobilized with Type I tympanomastoidectomy and 9 ears were applied total stapedectomy in a two-stage surgery. Pre-and postoperative air-bone gap pure tone average and the average hearing gain were analyzed using a four frequency (500,1000,2000,and 3000Hz). Six months to 3 years of follow-up are provided.

RESULTS: Type III tympanosclerosis patients had the most severe hearing loss whereas type II tympanosclerosis patients had minimal hearing loss. With mobilization surgery preoperative air-bone gap of 23.5 dB in type II tympanosclerosis decreased to 12 dB postoperatively in 3 years whereas in type III and IV cases, preoperative air-bone gap of 34.5 and 28.2 dB decreased to 21.3 dB and 24 dB respectively. In 17 cases which their stapes were mobilized; preoperative air-bone gap of 29.7 decreased to 23.9 dB postoperatively in 2 years. In 9 cases which the stapedectomy was performed the air bone gap was decreased from 35.3 dB to 7.4 dB. Hearing gains among the cases which mobilization and stapedectomy were performed was found to be 7.2 dB and 25.3 dB respectively in 2 years.

CONCLUSION: Hearing results were negatively affected when stapes fixation in tympanosclerosis was treated by mobilization. The best hearing results in these cases were obtained in two conditions: (a) by applying total ossicular replacement prosthesis during stapedectomy in the second-stage surgery in case of attic fixation and incus-malleus could not be mobilized; and (b) by applying stapedectomy and inserting teflon piston in case of incus-malleus was managed to be mobilized.

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Tympanosclerosis (TS), an idiopathic chronic inflammatory processes of the middle ear, is a condition leading to a sclerotic or hyaline degeneration of the fibrous and elastic fibers in the lamina propria of the tympanic membrane and middle ear mucosa [1,2,3,4]. Calcifications usually occur in the lamina propria of the eardrum, under the mucoperiosteum of the middle ear, and around the ossicles. The calcification involving the ossicular chain results with conductive or mixed hearing loss [5]. There is a consensus in the literature on procedures to be applied with the involvement of incus and/or malleus. However the controversy arise in case of the involvement of stapes footplate with tympanosclerotic plaques.

With this study we retrospectively analyzed the clinical records and audiological data to explain if it could be possible to plan the type of surgery in regard to the degree and type of hearing loss. In case of incus or malleus fixation the mobilization procedures should be criticized in regard to the audiological output and, whether mobilization or stapedectomy could be the method of choice in case of stapes fixation.

MATERIALS AND METHODS

The records of 73 patients with middle ear tympanosclerosis, operated by two senior authors, during May 2004 and July 2007, were retrospectively reviewed. Myringosclerosis cases without tympanic cavity involvement; ears with cholesteatoma those who already received middle ear surgery, and revisions surgeries were not included into the study.

The cases were classified as suggested by Wielinga and Kerr [6].

Type I: involvement of the perforated or intact tympanic membrane.

Type II: Attic fixation of the malleus-incus complex with a mobile stapes.

Type III: A mobile malleus-incus complex associated with stapes footplate fixation. The stapes superstructure may be absent.

Type IV: fixation of both the stapes footplate and the malleus-incus complex.

This study involves type II TS (47 patients), type III TS (11 patients), and finally type IV TS (15 patients) cases.

The audiograms belonging to preoperative, 6 month, 1 year, 2 year, and 3 year postoperative periods were assessed. The pure-tone averages (PTA) were calculated by averaging the hearing levels in the frequencies of 500, 1000, 2000, and 3000 Hz.

An air-bone gap(ABG) closure to within 20 dB, considered a successful hearing result as suggested by the American Academy of Otolaryngology and Head and Neck Surgery.

Single-stage surgery is defined as exploration of the middle ear by creating and elevating the tympanomeatal flaps; mastoidectomy; removal of the hyaline plaques from the eardrum; checking the mobility of the ossicles and elimination of the tympanosclerotic plaques. In single stage surgeries extreme care was taken for not to overmobilize the stapes. The complete elimination of the hyaline deposits and mobilization of the ossicular chain has been accepted the rationale for completing the treatment in one stage. In cases which the stapes mobilization could not be achieved, a second stage was planned by only repairing the eardrum.

During the second stage the mobility of the ossicles were checked again and total stapedectomy was performed. The footplate was covered with vein graft and 0.6 mm teflon piston was applied in those cases with mobile incus. In case of incus fixation or erosion hydroxyapatite total ossicular replacement prosthesis (TORP) were used as columella.

The results were analyzed by using SPSS 11.0 with Wilcoxon test, Mann-Whitney test, oneway ANOVA and Kruskal-Wallis test.

RESULTS

The study group is formed by 22 males and 51 females having the mean age 28.7 ± 12.2 years (range

10-56 years). The follow-up period was 6- 36 months (mean 25 ± 11). Among them, seven patients having type III TS and two patients with type IV TS had stapedectomy in the second stage. Teflon piston has been used in 4 patients and and hydroxylapatite TORP prosthesis in the remaining cases. The remaining 64 patients received single-staged Type I tympanomastoidectomy with mobilization of the ossicular chain.

The distribution of the cases in regard to the type of tympanosclerosis is shown in Table 1. The preoperative air-bone gaps for the type II, III and type IV tympanosclerosis were 23.5 dB, 33.8 dB and 30.1 dB, respectively. The difference between these values were statistically significant (p = 0.03 for type II -type III and p = 0.04 for type II - type IV).

Preoperative and postoperative hearing levels of the patients that had single-staged tympanoplasty are shown in Table 2.

The postoperative air-bone gap values for type II tympanosclerosis during 6 month and three year postoperative period were 11 dB and 13 dB respectively. For type III the values were 23.5 dB and 21.3 dB and for type IV they were 23 dB and 24 dB, respectively.

The mean hearing gain for type II tympanosclerosis was 12 dB 6 months after the surgery and it was 13 dB three years later. Those values for type III were 11.5 dB and 14.3 dB and for type IV were 5.7 dB and 5 dB. The difference between the preoperative and postoperative air-bone gaps was statistically significant among type II tympanosclerosis cases (p=0.001). Due to the small number of cases statistical work could not be accomplished for III and type IV cases.

The results of single-stage tympanoplasty with mobilization of the ossicular chain and two-staged stapedectomies are presented in Table 3. The values for three years later couldn't be mentioned since these cases are still having less than 3 year follow-up. The air-bone gaps for single-stage operations were reduced by 6.9 dB six months later and 5.8 dB during 2 years postoperatively. The gains for two-staged mobilization were 20.4 dB six months after the surgery and 27.9 dB at the end of postoperative second year.

The gains in pure tone hearing thresholds for single stage operations were 7.1 and 7.2 dB six months and 2 years after the surgery respectively whereas those values were 20.4 dB and 25.3 dB respectively stapedectomy cases. The difference for single-staged operations was not significant (p > 0.05). In contrast, it was highly significant for cases with stapedectomies (p = 0,038).

2 cases who received stapes mobilization had sensorineural hearing loss (35.6 dB in average) presented itself within 4000 to 8000 Hz. None of patients had severe sensorineural hearing loss. No major complications such as floating footplate, perilymphatic fistula or facial paralysis were appeared in any of the procedures.

DISCUSSION

Tympanosclerosis is an important clinical disorder since it results in hearing loss due to fixation of the ossicles. The hearing loss in this disorder is mostly due to involvement of the stapes and its surroundings rather than involvement of the other ossicles[2,7,8,9].

Table-1: The effect of ossicle fixation on pre-operative hearing results in the cases with tympanpsclerosis.

	Type II TS	Type III TS	Type IV TS
N(%)	47 (64%)	11 (15%)	15 (21%)
Air PTA dB ±SD	42.7 ± 12.03	55.6 ± 9.98	52.4 ± 12.69
Bone PTA dB ±SD	19.2 ± 7.84	21.8 ± 8.20	22.3 ± 9.65
ABG PTA dB ±SD	23.5 ± 8.46	33.8 ± 9.64	30.1 ± 10.22

PTA:pure-tone average, n: numbers of patients, SD: standart deviation

Table-2: The hearing results in single-stage mobilization

		Type II TS	Type III TS	Type IV TS
	n	**47**	**4**	**13**
Preop	Air PTA dB ± SD	42.7 ± 12.03	56.8 ± 8.99	52.1± 13.67
	Bone PTA dB ± SD	19.2 ± 7.84	22.3 ± 10.24	23.9 ± 9.44
	ABG PTA dB ± SD	23.5 ±8.46	34.5 ± 10.72	28.2± 9.59
	n	**47**	**4**	**13**
	Air PTA dB ± SD	30 ± 14.01	45.3 ± 16.92	46 ± 14.25
Postop 6th month	Bone PTA dB ± SD	19 ± 8.49	21.8 ± 6.95	24 ± 10.7
	ABG PTA dB ± SD	11 ± 9.18	23.5± 11.09	23 ± 11.21
	Gain dB ± SD	2 ± 9.44	11.5± 15.84	5.7 ± 8.22
	n	**44**	**4**	**13**
Postop 1st year	Air PTA dB ± SD	32 ± 14.08	47.5 ± 19.94	49 ± 13.51
	Bone PTA dB ± SD	19 ± 8.47	22.5 ± 8.73	25± 10.33
	ABG PTA dB ± SD	12 ± 9.65	25 ± 11.22	24 ± 10.32
	Gain dB ± SD	12 ± 9.98	9.3 ± 19.41	2.8 ± 6.66
	n	**33**	**4**	**6**
	Air PTA dB ± SD	33 ± 16.7	46.8 ± 18.41	52 ± 19.72
Postop 2nd year	Bone PTA dB ± SD	19 ± 9.72	25 ± 10.28	26 ± 12.61
	ABG PTA dB ± SD	14 ± 10.48	23,3 ± 8.99	24 ± 7.50
	Gain dB ± SD	11± 10.91	10 ± 19.09	5 ± 5.04
	n	**23**	**3**	**5**
	Air PTA dB ± SD	32.4± 18.11	44.7 ± 21.59	53.6± 22.24
Postop 3rd year	Bone PTA dB ± SD	20 ± 10,96	23.7 ± 13.05	30 ± 15.07
	ABG PTA dB ± SD	12 ± 9.83	21.3 ± 9.01	24 ± 8.01
	Gain dB ± SD	13± 9.92	14.3 ±20.50	5 ± 5.83

PTA:pure-tone average, n: numbers of patients, SD: standart deviation

Preoperative air conduction levels give information concerning the mobility of the stapes and the prognosis of the disease in TS. Isolated stapes involvement (Type III TS) has been reported between 13-31.3% in different series[10,11]. Involvement of stapes alone was found to be 15% in our series. Stapes is rarely involved, however its involvement contributes more hearing loss than other ossicles, and its surgery is criticized more than the others.

Tsuzuki[5] reported preoperative hearing levels as 54.1 dB with mobile stapes and 62.4 dB with fixed stapes in patients with involvement of the ossicular chain with TS. Teufert[2] reported preoperative PTA as 53.5 dB in patients with fixed malleus, 52.3 dB in patients with fixed incus, and 60.4 dB in patients with fixed stapes due to TS. In our study, pure tone hearing level in patients was 42.7 dB with mobile stapes and 53.8 dB in patients with fixed stapes. We also investigated the impact of the stapes fixation alone or with the involvement of the other ossicles on the preoperative hearing. (Table 1) It was determined that the involvement of the stapes alone caused 26% loss in air conduction levels, 15% in bone conduction levels, and 35% air bone gap values when compared to involvement of the other ossicles. Those values were statistically significant.

There are controversies among the mobilization and stapedectomy operations to achieve a long lasting and stable hearing gain[3,12]. In literature many authors have reported that the best hearing results were obtained in patients with fixed malleus and mobile stapes[1,3]. Sometimes, both the head of malleus and

incus are involved in the attic. In the attic, the disease may also involve the suspensory ligaments and tendons of the incus and malleus. Removal of the calcified plaques around the ossicles cannot provide sufficient mobility in this case. Thus, careful examination and a meticulous removal of the plaques will influence the outcome of the surgery [9,12].

The postoperative air-bone gaps for mobilization in type II tympanosclerosis mentioned in several reports are shown in Table 4. Albu et al[3] reported preoperative air-bone gap values as 33.72 dB and postoperative air-bone gap values as 18 dB in type II tympanosclerosis patients with a fixed malleus and a mobile stapes. Preoperative and postoperative air-bone gap values were 29.6 and 12.2 dB respectively in the study of Teufert et al[2]. We found preoperative air-bone gap values as 23.5 dB and this value was 12 dB during the postoperative third year. These findings showed similarity with the others.

The results of the mobilization surgery were compared among the patients with type III and type IV tympanosclerosis. The results of mobilization were similar in both groups and the mean air-bone gap values did not meet the criteria for success (ABG PTA ≤ 20dB). There is a high incidence of re-fixation of the ossicular chain following mobilization procedures [7,8]. In case of removing all the plaques and fully

Table-3: Comparison of single- stage mobilization and two-stage stapedectomy results in stapes tympanosclerosis

		Single-stage stapes mobilization	**Two-stage stapedectomy**
	n	**17**	**9**
Preop	Air PTA dB ± SD	53.2 ± 12.62	53 ± 9.68
	Bone PTA dB ± SD	23.5 ± 9.32	19.6 ± 7.89
	ABG PTA dB ± SD	29.7 ± 9.90	35.3 ± 9.53
	n	17	9
Postop 6th month	Air PTA dB ± SD	46.1 ± 14.36	34.4 ± 7.24
	Bone PTA dB ± SD	23.4 ± 9.78	19.6 ± 6.80
	ABG PTA dB ± SD	22.8 ± 10.84	14.9 ± 7.30
	Gain dB ± SD	7.1 ± 10.20	20.4 ± 6.93
	n	17	9
Postop 1st year	Air PTA dB ± SD	48.8 ± 14.56	29.3 ± 6.24
	Bone PTA dB ± SD	24.2 ± 9.76	20.3 ± 7.69
	ABG PTA dB ± SD	24.6 ± 10.18	9 ± 4.58
	Gain dB ± SD	4.4 ± 10.57	25.5 ± 7.23
	n	10	7
Postop 2nd year	Air PTA dB ± SD	49.6 ± 18.30	28 ± 5.53
	Bone PTA dB ± SD	25.2 ± 11.21	19.6 ± 5.34
	ABG PTA dB ± SD	23.9 ± 7.65	7.4 ± 3.90
	Gain dB ± SD	7.2 ± 11.89	25.3 ± 7.22

PTA:pure-tone average, n: numbers of patients, SD: standart deviation

Table-4: The postoperative abg results of various authors for mobilization in type ii tympanosclerosis patients

Authors	n	Average postop ABG (dB)
Albu S, et al.3	10	18
Tos M, et al.13	9	5
Teufert KB, et al.2	65	12.2
Bayazıt YA, et al.1	–	18
Our study	23	12

ABG: air-bone gap, n: numbers of patients

Table-5: Different author's postopetarive abg results for post mobilization and stapedectomy in tympanosclerosis.

Authors	Postop Follow-up period	MOBILIZATION		STAPEDECTOMY	
		Postop ABG ≤ 20 dB	Average postop ABG (dB)	Postop ABG ≤ 20 dB	Average postop ABG (dB)
Teufert KB, et al.[2]	6 months	63 % (n=46)	20.6	60% (n=20)	16.4 dB (n=20)
	1 year			60% (n=20)	
Gormley PK.[7]	1 year			58 % (n=67)	18 dB (n=67)
	5 years			50 % (n=67)	23 dB (n=67)
Albu S, et al.[3]	2 years		24.33		18.23 dB (n=35)
Austin DF.[10]	15 years			100 % (n=3)	
Berenholz L, et al.[15]	17 months			60 % (n=6)	21.7 dB (n=10)
Vincent R, et al.[16]				70 % (n=65)	
Giddings NA, et al.[11]	2 years				17.0 dB (n=40)
	10 years				29.2 dB (n=?)
Bayazıt YA, et al.[1]	30.9 months			33 % (n=?)	
Our study	2 years	23 % (n=17)	23.9	100 % (n=7)	7.4 dB (n=7)

ABG: air-bone gap, n: numbers of patients

mobilizing the ossicles; deterioration of hearing may be due to adhesions because of mucosal damage, progression of the disease and relapse of the disease.

The worst hearing results in the literature were reported in patients with a fixed stapes and the trying to restore hearing with mobilization[1,3]. However, some authors claim that the long term results of stapes mobilization were better than those obtained by stapedectomy[7,13,14]. Many other studies favors stapedectomy with two staged surgery by reporting better and more stable long term results[7,13,15,16]. In our previous study[17], we performed stapedectomy in two stages in 25 patients with a fixed stapes due to tympanosclerosis. We reported successful long term (10 years) hearing results of those patients. The preoperative ABG PTA was 37.4 dB while the postoperative 10th year ABG PTA was 11.7 dB.

The mobilization and stapedectomy results of different authors for the cases with stapes fixation are shown in Table 5. In our study, the closure rate of air-bone gap values into 20 dB for the mobilization cases during the postoperative second year was 20% whereas this ratio was 100% in the two-staged stapedectomy.

Stapedectomy and teflon piston insertion may be planned in the second stage surgery if the stapes is fixed despite mobilization of the malleus and the incus. If the malleus and the incus are fixed, incus can be removed, and stapedectomy and total ossicular replacement prosthesis between the footplate and graft may be performed in the second stage[1,7,8,13,15].

CONCLUSION

1. The involvement of the ossicles towards the oval window causes to an increased hearing loss. Higher hearing loss indicates the involvement of the stapes footplate. This condition must be considered during planning the surgery.

2. We received good results with the mobilization surgery in cases the malleus and the incus were involved in the attic.

3. The crucial point lays on the involvement of stapes and the profound hearing loss it produces, postoperative hearing results, increased risks for surgery and its exciting surgery. The most significant

gain of the tympanosclerosis surgery is the great difference between the preoperative and postoperative hearing levels with stapedectomy after two-staged surgery in the ears with a fixed stapes.

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