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Bone conduction variation poststapedotomy

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Abstract We evaluated the variation in bone conduction auditory thresholds in patients undergoing surgical intervention for otosclerosis as part of our report on the use of surgery in patients with a small air-bone gap. Of the 110 patients who underwent stapedotomy, 45 were treated by traditional surgery and 65 with carbon dioxide laser, with a follow-up of 3 years at 500-, 1000-, 2000-, and 3000-Hz frequencies. Both surgical techniques resulted in improvements in air conduction in more than 95% of cases; bone conduction improved more in patients treated with carbon dioxide laser (7.1 dB) compared to those treated with traditional surgery (4 dB) ($P < .01$). Furthermore, improvement in bone conduction was greater and more frequent in younger subjects (below 45 years) ($P < .05$). In conclusion, this study allows us to express a positive prognosis when considering otosclerotic patients with sensorineural hearing loss and small air-bone gap.

1. Introduction

Otosclerosis is a hereditary disease affecting the osseous tissue of the labyrinthic capsule. Disordered neoformation of osteoid material compromises the functionality of the ossicular chain (particularly the stapediovestibular joint) and of the sensorineural apparatus of the inner ear, determining stapes fixity with reduction of auditory capacity [1].

Liminal tonal audiometry shows, in the initial phase of the pathology, an exclusively transmissive hearing loss that becomes mixed and then purely sensorineural for a progressive bone conduction decay [2].

Anatomopathologic and epidemiologic studies reveal the presence of otosclerosis in 10% of the population [3], although it becomes clinically evident in only 1% as a consequence of stapes fixity. Women are more frequently affected by this pathology than men in, at a 2:1 ratio [4].

Otosclerosis is a hereditary autosomal dominant disease with incomplete penetrance.

So far, 3 gene loci have been identified [5]: OTSC 1, OTSC 2, and OTSC 3.

However, other researchers [6] suggest the possible presence of a fourth, as yet unidentified, locus.

Sensorineural hearing loss in the otosclerotic patient has been attributed over the years to different causes. Some authors believe it is caused by the presence of toxic substances in the labyrinthine fluids causing irreversible damage to the inner ear structures, in particular the hydrolytic enzymatic component [7]. Other authors contend it is a consequence of the effects of cochlear fluid hypertension affecting the organ of Corti [8].

The treatment of otosclerosis is exclusively surgical.

Stapes surgery gained its actual definition in the 1950s with the stapedectomy operation proposed by Rosen [9] in 1953 and the stapedotomy operation introduced by Shea [10] in 1958. Adequate bone conduction is a fundamental prerequisite for a successful outcome of a subsequent operation for otosclerotic disease. Surgery may be inadvisable in cases in which there is a preexisting bone conduction deficit [2]. It is therefore extremely useful to monitor the variation in bone conduction immediately postoperatively, and several years later to compare the results with the patient's opposite, nonoperated, otosclerotic ear.

The aim of the present study was to evaluate the variation in bone conduction auditory thresholds in patients undergoing surgical intervention for otosclerosis, comparing the

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Table 1
Patients treated via traditional surgery (group A) and carbon dioxide laser (group B)

	Male	Female
Group A		
No. of patients	13	32
Mean age (y)	35	38
Age range (y)	23–53	19–48
Group B		
No. of patients	45	20
Mean age (y)	38	43
Age range (y)	26–53	25–51

operated ear with the also-affected-by-otosclerotic-disease, nonoperated, contralateral ear, in relation to the surgical techniques applied.

2. Materials and methods

One hundred ten patients who underwent initial surgery for otosclerotic disease between 1998 and 2001 were studied. Surgery was always performed on the ear with the poorer air conduction threshold in the frequencies considered (0.5, 1, 2, and 3 kHz). Different surgical techniques were used: in 45 subjects, a microdriller was used and in 65 subjects carbon dioxide laser (Table 1). To avoid the influence of presbyacusia, patients older than 55 years were excluded from the study.

All surgical procedures were performed under intra-aural local anesthesia after sedation with midazolam (5 mg, IV, administered 10 minutes before the operation). In all cases a stapedotomy of 0.7 mm was performed. Ossicular continuity was reestablished with a “Richards Piston” prosthesis (Platinum Fluoroplastic type, 4.50 or 4.75 mm length, 0.6 mm diameter; Smith & Nephew Richards, Memphis, TN) positioned between the long process of the incus and the oval window. Preoperatively (1 day before surgery), all patients underwent impedenzometric examination with stapedial reflexes in ipsilateral and contralateral and liminal tonal audiometry.

The postoperative audiometric examination was conducted periodically (1 month after the operation and then every 6 months, for a minimum of 3 years postsurgery) with thresholds analyzed for variations of 1 dB. Based on recent international guidelines [11], we evaluated the closure of the cochlear reserve, expressed as the difference between the median of the postoperative air and bone-conduction thresholds, at 500, 1000, 2000, and 3000 Hz.

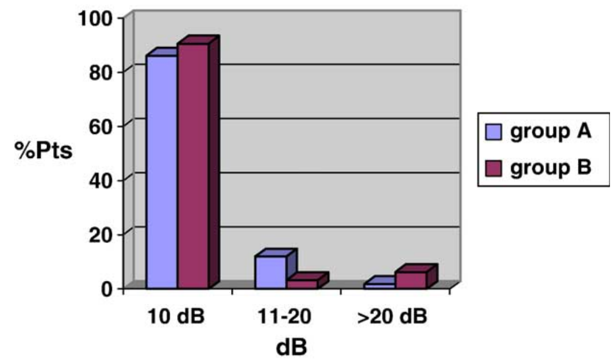

Fig. 1. Postoperative cochlear reserve closure at 500-, 1000-, 2000-, and 3000-Hz frequencies, at least 3 years after the operation, in 43 patients who were treated via traditional surgery (group A) and in 64 patients treated with carbon dioxide laser (group B) who did not report sensorineural hearing loss after the operation.

Statistical analysis of the results was performed using the Student t test.

3. Results

Preoperative audiometric data are presented in Table 2.

During audiometric postoperative follow-up, performed at a minimum of 3 years after the operation, we observed the following (Fig. 1):

(*a*) In 45 patients who underwent traditional surgery (group A): in 43 subjects (95.6%), a reduction of the transmissive gap; in 2 subjects (4.4%), a sensorineural hearing loss, concerning frequencies of 500, 1000, 2000, and 3000 Hz. Furthermore, in 43 cases in which bone conduction did not decrease, we found a closure of the cochlear reserve in the frequencies considered within 10 dB in 37 patients (86.2), between 11 and 20 dB in 5 (12%), and more than 20 dB in 1 (1.8%).

(*b*) In 65 cases treated with carbon dioxide laser (group B): an improvement of the cochlear reserve in 64 subjects (98.4%), whereas in 1 patient (1.6%) a sensorineural hearing loss. In 64 patients who did not report auditory bone conduction postoperative damage concerning the frequencies 500, 1000, 2000, and 3000 Hz, we found a closure of the postoperative air-bone gap as follows: within 10 dB in 58 (90.6%) patients, between 11 and 20 dB in 5 (3.2%) and more than 20 dB in 1 (6.2%).

(*c*) No case of anacousia in both groups of study.

Table 2
Mean preoperative air conduction and bone conduction values at 500, 1000, 2000, and 3000 Hz in group A and group B

Frequencies considered (Hz)	500		1000		2000		3000	
	Air conduction	Bone conduction	Air conduction	Bone conduction	Air conduction	Bone conduction	Air conduction	Bone conduction
Group A	60	18.5	55	22	70	32	70	26
Group B	55	19	60	21	65	34	70	26.5

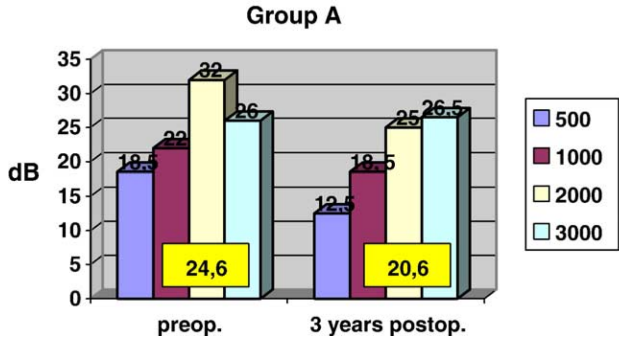

Fig. 2. Bone conduction threshold (in the operated ear), in the frequencies considered, before operation and at follow-up (at least 3 years after the operation) in group A.

Analysis of postoperative bone conductibility was performed at 500, 1000, 2000, and 3000 Hz (Figs. 2 and 3). One month after the operation, in group A (excluding 2 cases of sensorineural decrease) we found a median improvement of postoperative bone conduction of 4 dB compared with the preoperative level. In group B (excluding the single case of sensorineural decrease) the improvement was 7.1 dB. This difference is not statistically significant ($P < .01$) using Student t test. The observed improvement remained stable during subsequent postoperative assessments, as also reported by other authors [13].

There was no statistically significant difference ($P < .5$) concerning improved bone conductibility relating to patient sex. In relation to age, however, we observed greater improvement in bone conductibility in younger patients (<45 years) at 500-, 1000-, and 2000-Hz frequencies, with a statistically significant difference ($P < .05$). However, no difference was found at 3000 Hz.

4. Discussion

Analysis of functional results shows that most study patients achieved considerable auditory gain after surgical operation.

The closure of the cochlear reserve within 10 dB, in both subjects groups, overlapped without any significant statistical difference. Similarly, no statistically significant difference was observed between the 2 groups in relation to the incidence of sensorineural postoperative hearing loss. Irrespective of the surgical technique adopted, our data show the risk of postoperative sensorineural hearing loss to be extremely low. The greater improvement in bone conduction, which was not statistically significant ($P < .01$), observed with laser technique is due to the absence of the traumatic action of the microdriller on the inner ear structures. These findings agree with other results discussed by Motta and Moscillo [12].

Because no cases of anacousia were found, we considered this sample particularly useful for analyzing postoperative bone conduction auditory thresholds.

Previous reports [13,14] on improvement in bone conductibility after stapes surgery explain these outcomes by means of Carhart's [8] pathogenetic hypothesis, which correlates auditory gain with postoperative resolution of pressure imbalances existing in the cochlea of otosclerotic patients, with a consequent improvement in functionality of the organ of Corti. This hypothesis was subsequently confirmed by some electrophysiologic studies [15]. Analyzing the postoperative bone conduction improvement, Vartianen and Karjalainen [13,16] think it may be a demonstration of the presence of cochlear damage in otosclerotic patients, determined by reversible transitory conditions and resolved by the surgical intervention. Nevertheless, it is always necessary to consider the nonperfect reliability of preoperative bone conduction evaluation throughout tonal audiometry, particularly at 2000 Hz [17,18]; hence, the possibility that the "overclosure" found does not really occur, but, instead, represents a consequence of the inherent difficulties of bone conduction audiometry [18]. The presented data demonstrate a major improvement, at 500-, 1000-, and 2000-Hz frequencies, of postoperative bone conduction in younger patients (<45 years), as also reported by other authors [19], probably in relation to a reduced temporal exposition to endolabyrinthic pressure factors caused by otosclerosis itself. Thus, in younger patients, in consideration of the fact that an apparent mixed hearing loss could essentially be a conductive loss, surgical intervention may be considered even in the presence of a small cochlear reserve, as also advised by other authors [20].

5. Conclusions

This audiologic study on patients who underwent operation reveals that bone conduction hearing loss indicated by tonal audiometry may be overestimated in relation to the difficulties found in evaluating true bone conduction vs artifact. In fact, bone conductibility may improve in otosclerotic patients after the surgical operation. This result allows us to express a positive prognosis concerning surgical outcome when considering otosclerotic patients with sensorineural hearing loss and small air-bone gap. We

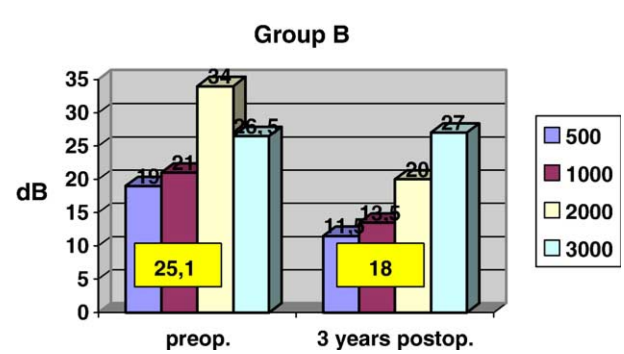

Fig. 3. Bone conduction threshold (in the operated ear), in the frequencies considered, before operation and at follow-up (at least 3 years after the operation) in group B.

believe that, particularly in patients younger than 45 years, the presence of a mean preoperative air-bone gap of 20 dB at 500, 1000, 2000, and 3000 Hz may be considered as an indication for surgical intervention (stapedotomy).

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