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Main Articles

Laser stapedotomy

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Abstract
Thirty-four ears with conductive hearing loss due to otosclerosis were operated upon using the laser stapedotomy technique. Audiological results were compared with the results of 316 non-laser stapedotomies. The post-operative air-bone gap, calculated as the difference between the post-operative air and bone conduction levels, was smaller with the laser stapedotomy group. Also, the bone conduction showed significant improvement with the use of laser.

Significant sensorineural hearing loss was not found in any of the laser-treated patients. According to our results, we concluded that laser is of benefit in stapes surgery for improving the hearing results and minimizing the inner ear trauma.

Key words: Otosclerosis; Surgery, operative; Laser surgery

Introduction

The advantages of stapedotomy over stapedectomy have been demonstrated frequently. Several series demonstrated that stapedotomy produces less post-operative sensorineural hearing loss and dizziness in comparison with standard stapedectomy (Smyth, 1978; Fisch, 1982; Causse, 1985; Marquet, 1985). However, in some cases, it is difficult to obtain a round, precise stapedotomy opening by mechanical means (drill or trocar): a partially fixed stapes can mobilize, a thin footplate can fracture, drilling a thick obliterative footplate can produce significant vibratory trauma to the inner ear (Lesinski and Newrock, 1993).

Laser stapedotomy, if performed with appropriate wavelengths and energy parameters, could permit the surgeon to vaporize a precisely round stapedotomy opening in the centre of the stapes footplate regardless of its thickness or fixation and without mechanical trauma to the inner ear (Lesinski and Newrock, 1993). Schuknecht (1993) enumerated the advantages of laser stapedectomy: 1) a bloodless field can be maintained, 2) the posterior crus can be vaporized, which reduces the risk of a floating footplate during removal of the crura, 3) an opening of accurate dimensions can be made without creating excessive footplate or perilymph movement, thus minimizing the risk of acoustic trauma, and 4) an opening can be made in a mobile footplate without risk of pushing the footplate into the vestibule.

The aim of this study was to evaluate the hearing results obtained with the use of laser in stapes surgery.

Material and methods

In the period from 1994 to 1997 a total of 159 stapedotomies were performed at the Otorhinolaryngology Department, Aarhus University Hospital. At irregular times a CO_2 laser with micromanipulator was available for laser stapedotomy. A total of 34 ears with otosclerosis, 21 females and 13 males, were operated by the laser technique. The selection of patients for laser stapedotomy was random as it was determined by the accessibility of the laser equipment.

The mean age at stapedotomy was 42 years (range between 26–58 years). Twenty-nine patients had bilateral otosclerosis and five patients had unilateral otosclerosis. The operations were performed in the right ear in half of the patients and in the left ear in the other half. The follow-up period ranged from one month to 45 months with an average of 12 months.

Audiological results are compared with the audiological results of 316 non-laser stapedotomies (randomly selected) operated upon at the Otorhinolaryngology Departments, Aarhus University Hospital, Denmark (116 stapedotomies) and

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TABLE I
DEMOGRAPHICAL DATA

	Laser group	Non-laser group
Number of patients	34	316
	Females = 21 (60%)	Females = 207 (65%)
	Males = 13 (40%)	Males = 109 (35%)
Age	42 years (26–58 years)	39 years (12–70 years)
Side of operation	Right = 17 (50%)	Right = 164 (52%)
	Left = 17 (50%)	Left = 152 (48%)
Anaesthesia	Local = 32 (94.1%)	Local = 309 (97.8%)
	General = 2 (5.9%)	General = 7 (2.2%)
Follow up	12 months (1–45 months)	17 months (1–183 months)

Mansoura University Hospital, Egypt (200 stapedotomies, operated from 1980–1996). The demographic data of both group are shown in Table I.

Surgical technique

All operations were performed by the senior authors (CBP) and (HA). The majority of cases were performed under local anaesthesia with adequate pre-operative sedation. Local anaesthesia allows immediate intra-operative and post-operative assessment of hearing function as well as any evidence of balance disturbance. Local anaesthesia with noradrenaline was used also in cases carried out under general anaesthesia to minimize bleeding.

A classic endomeatal approach was used to perform the small fenestra technique (stapedotomy). After adequate exposure of the oval window, all anatomical landmarks were inspected and the ossicular chain was tested for mobility. With the CO_2 laser beam, the fenestra was created in the centre of the footplate. Then, a Fisch prosthesis with a diameter of 0.4 mm was inserted to the oval window and crimped on the long process of the incus. This was followed by vaporization of the stapedial tendon and the posterior crus. Then the incudostapedial joint was separated and the anterior crus was fractured towards the promontory. Suction is necessary to keep the field free of vapours. To achieve a good seal of the fenestrated footplate, a drop of the patient's blood was placed in the oval window niche. The mobility of the prosthesis was checked by applying gentle pressure to the under surface of the manubrum before the tympanomeatal flap was returned to its original position. The patient was then checked for subjective improvement in hearing and for any feeling of vestibular disturbance. A small pad of gelfoam was placed over the flap and the incision line.

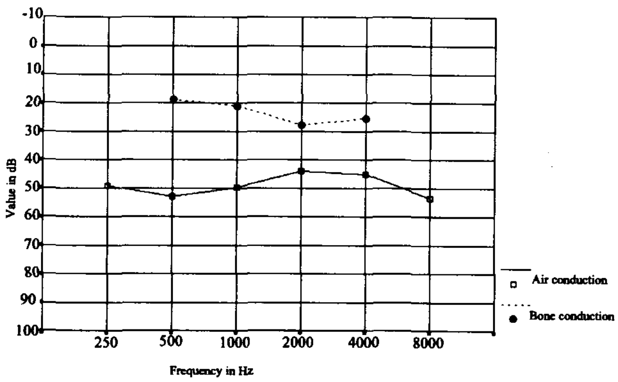

FIG. 1a
Pre-operative hearing thresholds (laser group).

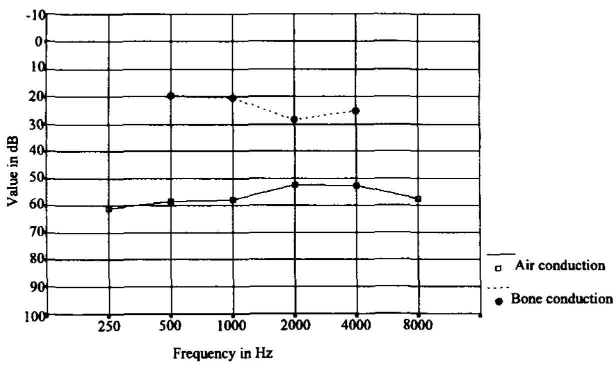

FIG. 1b
Pre-operative hearing thresholds (non-laser group).

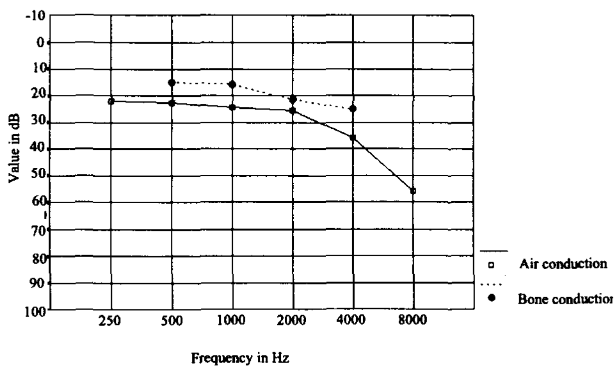

FIG. 1c
Post-operative hearing thresholds (laser group).

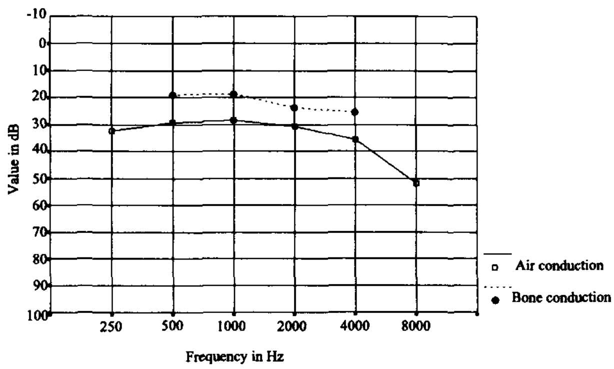

FIG. 1d
Post-operative hearing thresholds (non-laser group).

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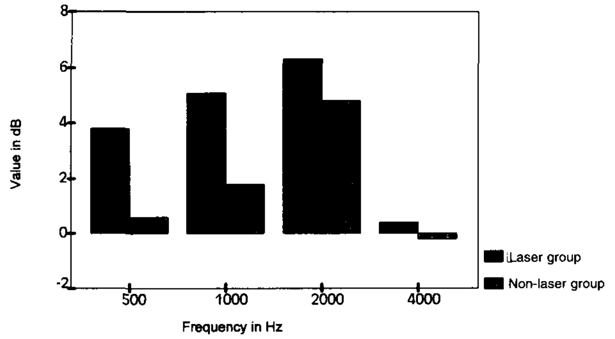

FIG. 2

Bone conduction changes.

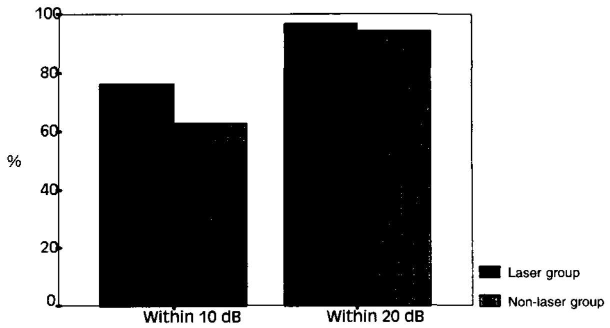

FIG. 4

Percentage of ABG closure.

Results

The mean pre-operative air-conduction threshold (250–8000 Hz) was 49 dB for the laser group and 56.6 dB for the non-laser group and the mean pre-operative bone conduction threshold (500–4000 HZ) was 23.2 dB for the laser group and 23.4 for the non-laser group. The mean post-operative air conduction was 31.1 dB for the laser group and 34.7 dB for the non-laser group and the mean post-operative bone conduction was 19.3 dB for the laser group and 21.7 dB for the non-laser group. Pre- and post-operative hearing thresholds are shown in Figure 1(a–d).

The mean post-operative bone conduction improvement was 3.9 dB in the laser group compared to 1.7 dB in the non-laser group. This difference was statistically significant ($p<0.05$). Changes of bone conduction after the operation are shown in Figure 2. Greater improvements were found in the laser group at all frequencies. A statistically significant advantage was demonstrated by the laser group at 1000 Hz ($p<0.05$) while at 500 Hz there was a trend towards significance.

The post-operative air-bone gap, calculated as the difference between the post-operative air and bone conduction thresholds, as figured at 500–4000 Hz was smaller in the laser group for all frequencies except at 4000 Hz (Figure 3). The difference was statistically significant at 2000 Hz ($p<0.05$).

The mean post-operative air-bone gap (500–4000 Hz) was 7.8 dB and 9.3 dB for the laser and non-laser group, respectively, which was statistically insignificant.

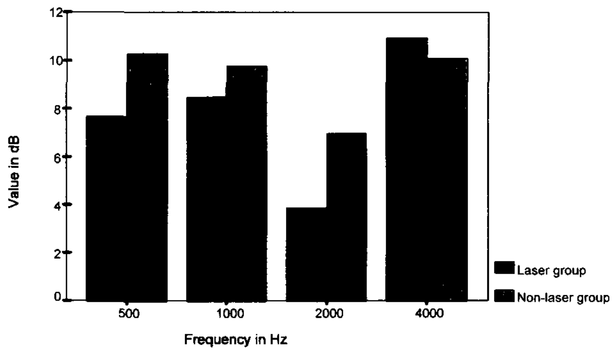

FIG. 3

ABG at each frequency.

Closure of the air-bone gap to within 10 dB was achieved in 76.5 per cent of laser patients compared to 62.7 per cent of non-laser patients and closure of the air-bone gap to within 20 dB was achieved in 97.1 per cent of laser patients compared to 94.6 per cent of non-laser patients (Figure 4).

Speech reception threshold (SRT) showed improvement from 42.2 dB to 20.2 dB in the laser group and from 52.7 dB to 27.7 dB in the non-laser group. Also, SDS improved from 98.8 per cent to 99.5 per cent in laser group and from 97.1 per cent to 98.4 per cent in non-laser group. SRT and SDS changes are shown in Table II.

No patients of the laser group showed significant sensorineural hearing loss (loss of more than 20 dB of the pre-operative bone conduction threshold) compared to 0.9 per cent of patients in the non-laser group.

Discussion

The first significant application of laser in ear surgery was the laser stapedotomy introduced in 1979 (Palva, 1979). Many reports stated that laser stapedotomy appears to have an advantage over total stapedectomy and manual small fenestration surgery (Perkins, 1980).

Analysis of our results revealed that although the demographical data of both groups are very similar, the pre-operative air conduction threshold was found to be larger in the non-laser group. The pre-operative air conduction threshold was larger in the Egyptian patients than the Danish patients. This may be due to delayed seeking of medical advice among these patients who usually presented with the severe form of the disease. This could explain the difference in the pre-operative air conduction as most of the non-laser patients are Egyptian.

The pre-operative air-bone gap was larger in the non-laser group, indicating that such patients had a better chance potentially to improve the air-bone

TABLE II

PRE- AND POST-OPERATIVE SRT AND SDS

	Pre-operative	Post-operative
SRT (laser)	42.2 dB	20.2 dB
SRT (non-laser)	52.7 dB	27.7 dB
SDS (laser)	98.8%	99.5%
SDS (non-laser)	97.1%	98.4%

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gap with stapedotomy. However, comparison of the post-operative results revealed greater improvement in the laser group which showed also greater incidence of gap closure compared to the non-laser group.

Our results also revealed better improvement of bone conduction with no incidence of significant sensorineural hearing loss among patients in the laser group. This is believed to be the result of a more precise technique with less trauma to the inner ear.

In the literature, closure of the air-bone gap to within 10 dB was achieved in more than 85 per cent of patients treated by laser stapedotomy (McGee, 1983; Horn *et al.*, 1990; Lesinski, 1990; Vernick, 1996 and Beatty *et al.*, 1997) and the complications rate was less with the use of laser (Rauch and Bartly, 1992). Our results support these published data.

Contrary to our observations, Sedwick *et al.* (1997) reported that there was no significant difference in neither the post-operative air-bone gap nor the post-operative sensorineural hearing loss. Time did not allow for estimation of the occurrence of late complications that may be seen in all techniques of surgery for otosclerosis as reported by Pedersen (1996).

In conclusion, laser stapedotomy appears to have advantages over traditional small fenestra stapedotomy technique: by vaporizing the posterior crus and creating the hole in the footplate, the operation is less likely to produce inner ear trauma.

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