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# *Bone and air conduction after stapedectomy*

Otosclerosis causes loss of air conduction (AC) but also bone conduction (BC) may be deteriorated. The aim of surgical treatment of otosclerosis is to replace the immobile stapes with the prosthesis and to improve AC. It is reported that also BC may improve after surgical treatment of otosclerosis (1,2,3). Results published by Carhart (1) were derived from patients who had undergone fenestration surgery. Ginsberg (2) included only patients with BC improvement greater than 10 dB, which probably leads to overestimated results. Łukowski (3) assessed all operated patients. Patients with good and bad hearing results were included to the study. Gatehouse (4) proposed criteria for assessing the Carhart effect. Factors affecting BC improvement were assessed by Awengen (5). He found that postoperative change of BC is related to age.

The aim of this study was to evaluate if the BC improvement depended on BC threshold before the operation and how big the improvement was in our group of patients. AC after the surgery was also assessed.

## MATERIAL AND METHODS

The investigation was carried out in a group of 50 patients treated due to otosclerosis in our institution. The group included 34 women and 16 men, at the age 24 to 55 years. Partial stapedectomy was performed under local anaesthesia with the following premedication: atropine 0.5 mg, atarax (hydroxyzine) 50 mg and fortral (pentazocine) 30 mg. One experienced surgeon performed all the stapedectomies with endoaural approach and with the same technique. Posterior part of footplate was removed using perforator and ossicular reconstruction was done using Teflon piston prosthesis of 0.6 mm diameter made in Poland. The hole in the footplate was sealed with pieces of fat. Only patients with air-bone gap closed to less than 10 dB, which is considered as surgical success, were included in the study. Patients with deterioration of BC after stapedectomy suggesting inner ear impairment were excluded from the study. One patient with floating footplate and three patients with oval window obliteration were excluded from the studies.

Pure-tone audiometry for bone and air conduction threshold was performed in all the patients at the frequencies 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, 4 kHz. Audiometer type was AUG-80 and it was calibrated regularly. Hearing tests were carried out before and 2–4 months after the operation by the same technician.

The mean change of hearing threshold after the operation was assessed in the whole group of 50 patients and in two subgroups with different BC thresholds before the operation. In the

group of 36 patients the BC threshold before the operation at all the frequencies was ≥ 30 dB. The other group of 14 patients had BC threshold at all the frequencies < 30 dB. The mean changes of BC and AC thresholds at different frequencies after the operation were analysed statistically, using t-Student test. The value at $p < 0.05$ was considered statistically significant.

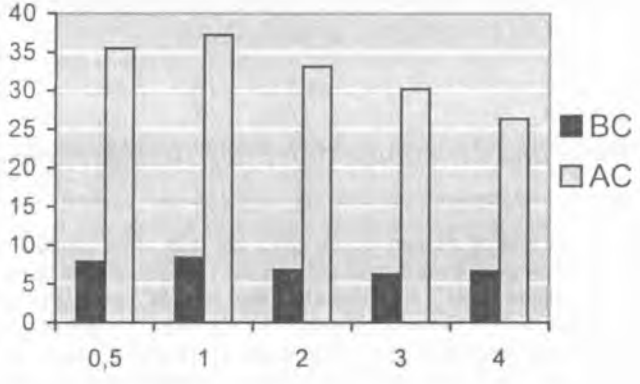


Fig. 1. Change of bone conduction (BC) and air conduction (AC) threshold after stapedectomy. Sign means statistical significance

## RESULTS

In all the patients the improvement of BC threshold after stapedectomy was highly significant ($p < 0.001$) at all the frequencies. The improvement of mean BC threshold is shown in Table 1 and Figure I. The group of patients with BC threshold ≥ 30 dB before stapedectomy demonstrated significant ($p < 0.001$) improvement of BC after the operation from 9.58 to 11.57 dB at all the frequencies (Tab. 2). In the group of patients with BC threshold < 30 dB before the operation, changes of BC after surgery were small and not significant (Tab. 3).

Table 1. Change of bone conduction (BC) threshold after stapedectomy in the whole group of 50 patients

| Frequency kHz | Mean x | Standard deviation SD | t-value | P |
|---|---|---|---|---|
| 0.5 | 7.85 | 12.62 | 4.36 | P<0.001 |
| 1 | 8.36 | 12.84 | 4.69 | P<0.001 |
| 2 | 6.80 | 14.68 | 3.17 | P<0.001 |
| 3 | 6.27 | 17.14 | 2.50 | P<0.001 |
| 4 | 6.16 | 15.61 | 2.58 | P<0.001 |

The whole group of patients after stapedectomy showed highly significant improvement of air conduction at all the frequencies (Tab. 4).

Table 2. Change of bone conduction (BC) threshold after stapedectomy in a group of 36 patients with BC level before surgery ≥ 30 dB

| Frequency kHz | Mean x | Standard deviation SD | t-value | P |
|---|---|---|---|---|
| 0.5 | 9.58 | 12.09 | 4.76 | P<0.001 |
| 1 | 11.57 | 11.29 | 6.08 | P<0.001 |
| 2 | 11.06 | 12.60 | 5.05 | P<0.001 |
| 3 | 11.36 | 15.67 | 4.17 | P<0.001 |
| 4 | 9.66 | 15.75 | 3.36 | P<0.001 |

Table 3. Change of bone conduction (BC) threshold after stapedectomy in a group of 14 patients with BC level before surgery < 30 dB

| Frequency kHz | Mean x | Standard deviation SD | t-value | P |
|---|---|---|---|---|
| 0.5 | 1.78 | 14.22 | 0.46 | NS |
| 1 | 0.35 | 13.36 | 0.10 | NS |
| 2 | -3.21 | 14.75 | -0.81 | NS |
| 3 | -5.71 | 16.65 | -1.46 | NS |
| 4 | -1.92 | 12.33 | -0.56 | NS |

Table 4. Change of air conduction (AC) threshold after stapedectomy in the whole group of 50 patients

| Frequency kHz | Mean x | Standard deviation SD | t-value | P |
|---|---|---|---|---|
| 0.5 | 35.5 | 13.43 | 18.66 | P<0.001 |
| 1 | 37.2 | 12.46 | 21.11 | P<0.001 |
| 2 | 33.1 | 12.97 | 18.04 | P<0.001 |
| 3 | 30.2 | 16.41 | 13.01 | P<0.001 |
| 4 | 26.3 | 19.13 | 9.70 | P<0.001 |

## DISCUSSION

It is well known that otosclerosis can impair not only stapes mobility but is also manifested by elevation of BC threshold. There is also a very rare risk of further inner ear injury during stapedectomy. It was Carhart (1) who first described improvement of BC after fenestration in otosclerosis. The average improvement he measured was 5 dB at 0.5 kHz, 10 dB at 1 kHz, 15 dB at 2 kHz, and 5 dB at 4 kHz. Awengen (5) reported the BC improvement of 5–6 dB. Łukowski and Białaczewski (3) showed improvement of BC from 1.4 to 9.5 dB at frequencies 0.5–2 kHz, but they noticed a decrease of 0.1 dB at 4 kHz.

In our study a significant improvement of bone conduction after stapedectomy occurred and it depended on BC threshold before the operation. If BC loss before the operation is small, the change of BC after stapedectomy is not significant. According to Awengen (5) the improvement of BC after stapedectomy is correlated to the age of patients and the improvement is bigger in younger patients.

Carhart's effect was explained by Tonndorf (6). There are three ways of bone conduction: 1) vibration of the skull and the petrous bone stimulates directly the inner ear perilymph and endolymph, 2) vibration of the skull and the walls of the tympanic cavity is transmitted via ossicles to the inner ear, 3) vibration of the skull and of the bony external auditory canal is transmitted via the tympanic membrane and the ossicles to the inner ear.

According to Tonndorf (6), the ways number 2 and 3 are impaired by disconnected or stiff ossicular chain and these results in a false BC loss in middle ear diseases. This BC loss equivalent to Carhart's effect is not a true loss because it does not result from damage to the inner ear and because BC loss improves after successful middle ear reconstruction. The successful middle ear reconstruction improves BC threshold thanks to restoration of impaired indirect ways of BC transmission. Marked improvement of air conduction in our patients after surgery meant successful reconstruction of middle ear transmission and this resulted also in improvement of bone conduction.

## CONCLUSION

Successful stapedectomy improves bone conduction by about 6.2–8.4 dB depending on frequency. It means that in patients with otosclerosis there is a reversible BC pseudo hearing loss of that level, apart from true BC loss resulting from cochlea impairment. The BC after stapedectomy improves in patients with BC threshold before surgery $\geq$ 30 dB. In patients with BC threshold before stapedectomy < 30 dB BC did not change significantly.

## REFERENCES

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## SUMMARY

Otosclerosis causes loss of air conduction (AC) but also bone conduction (BC) may be deteriorated. It is reported that also BC may improve after surgical treatment of otosclerosis. The investigation was carried out in a group of 50 patients treated due to otosclerosis in our institution. The group included 34 women and 16 men, at the age 24 to 55 years. Pure-tone audiometry for bone and air conduction threshold was performed in all the patients. Hearing tests were carried out before and 2-4 months after the operation by the same technician Partial. Only patients with air-bone gap closure were included in the study. Sapedectomy was performed under local anaesthesia. Results: Significant improvement of AC was obtained after stapedectomy. There was also significant improvement of BC at all the frequencies examined of

6–12 dB and it depended on BC threshold before surgery. In the group of 37 patients with BC threshold before surgery ≥ 30 dB a significant improvement of BC after stapedectomy developed. In the group of 14 patients with BC threshold before surgery < 30 dB the change of BC after stapedectomy was not significant. Successful stapedectomy improves bone conduction. It means that in patients with otosclerosis there is a reversible BC pseudo hearing loss and it is related to BC threshold before the operation.

Przewodnictwo powietrzne i kostne po stapedektomii

Celem pracy była ocena progu przewodnictwa powietrznego (PP) i kostnego (PK) po leczeniu operacyjnym 50 chorych na otosklerozę. Po stapedektomii uzyskano istotną poprawę PP we wszystkich częstotliwościach ze zmniejszeniem rezerwy ślimakowej. Po operacji wystąpiła również istotna poprawa progu PK przed operacją. W grupie 37 chorych z progiem PK przed operacją ≥ 30 dB wystąpiła istotna poprawa PK po stapedektomii we wszystkich częstotliwościach. Natomiast w grupie 14 chorych z progiem PK przed operacją < 30 dB zmiany PK po stapedektomii były nieistotne.