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Investigation on bone conduction thresholds in otosclerosis

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Concept: The comparison of pure tone bone conduction thresholds before and after stapes surgery in most cases reveals a significant improvement of the preoperative bone conduction loss in addition to the expected closure of the air-bone-gap. This bone conduction effect not only occurs in the range around 2000 cycles per second, known as the Carhart notch, but in the entire range with maximum postoperative threshold rise in low and middle frequencies (500-3000Hz).

The present study was devised to determine if the opening of the oval window during surgery alone already improves bone conduction.

Methods: Stapedectomy under local anaesthesia was performed in 24 patients with stapes fixation due to otosclerosis. We compared the bone conduction from preoperative audiograms with intraoperative thresholds measured directly after removing the footplate using a bone conduction tansducer at test frequencies 0.5, 1, 2 and 4 kHz. The patients have given written consent for this intraoperative measurement.

Results: Our data showed a clear improvement at 0.5, 1 and 2 kHz, but not at 4 kHz. Corresponding to the Carhart notch threshold rise is best at 2000Hz. Pure-tone-averages (PTA) were calculated from the collected data and statistically analysed. The improvement was significant for PTA from 0.5-2 kHz. No significance was found for PTA from 0.5-4 kHz. To investigate the underlying cochlear mechanisms a finite element model of the cochlea was used. It suggests an increased amplitude of the basilar membrane movement with an open oval window due to a lower impendance compared to the situation with a fixed footplate.

Discussion: These results give evidence for the fact that optimal basilar membrane movement is depending on the integrity of the cochlear windows. In a cochlea with totally fixed stapes there is “captured energy“ which cannot properly act on the basilar membrane during bone conduction stimulation.

Conclusion: Therefore in otosclerosis the depression of bone conduction especially between 0,5 and 2 kHz is not a sensorineural but a mechanical deafness and can be surgical corrected. This is the first investigation where audiometry has been performed with opened oval window during stapedectomy. It directly explains the mechanical cause of parts of the depression of bone conduction in otosclerosis as already suspected by Carhart.