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Bone-anchored hearing aids in patients with sensorineural hearing loss and persistent otitis externa

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A bone-conduction hearing aid is suitable for patients with a conductive or mixed hearing loss who cannot be fitted with air-conduction hearing aids because of chronic otorhoea or anomalies of the ear canal and/or pinna. In the past decade, bone-conduction hearing aids have gained increased interest because of the introduction of new types of bone-conduction hearing aids, such as the Swedish Bone-Anchored Hearing Aid (BAHA). The BAHA has been fitted successfully in patients with a conductive or mixed hearing loss and several studies have shown that the audiological results with the BAHA were comparable or better than those obtained with conventional bone-conduction hearing aids.

A second category of potential candidates for the BAHA are patients with sensorineural hearing loss who cannot be fitted with an air-conduction hearing aid owing to persistent otitis externa.

We present the results in three patients with a predominant sensorineural hearing loss who were fitted with a BAHA. They were suffering from persistent otitis externa which prevented the use of an earmould; a conventional bone-conduction hearing aid had also been unsuccessful for several reasons.

Patients

The first patient was a 46-year-old man with a bilateral sensorineural hearing loss of 20 dB at 500 Hz which increased to 35 dB at 4 kHz. He had a history of recurrent otitis media with effusion (OME). Otoscopy showed no abnormalities in the right ear and a ventilation tube in the left ear. Besides the sensorineural hearing loss, an air-bone gap of 13 dB was found. Before fitting the BAHA, the patient had used air-conduction hearing aids with earmoulds with large vents and several different anti-allergic coatings but the skin reactions persisted. Conventional bone-conduction hearing aids were subsequently fitted, mounted in a spectacle frame (Viennatone AN) but the patient could use them only for a few hours a day because of skin irritation at the site of the transducers. As a solution he was fitted with a BAHA which he has been using for more than 4 years.

Patient 2 was a 14-year-old girl with one deaf ear and an ear with a high frequency sensorineural hearing loss of 15 dB at 1 kHz increasing to 45 dB at 4 kHz. In addition, she had an air-bone gap of 10 dB and a history of recurrent OME. Otoscopy did not reveal abnormalities. In the past, an air-conduction hearing aid had been tried but rejected because of allergic reactions. For 3 years prior to entering the BAHA implant programme, she had been using a conventional bone-
conduction hearing aid (Philips S1594 with bone conductor) but she experienced pain after a few hours of use. Implantation was uneventful and she has been using the BAHA for more than 2 years without problems.

Patient 3 was a 39-year-old woman with bilateral pure sensorineural hearing loss of 40 dB HL; above 1 kHz, the hearing thresholds improved to about 25 dB. Otoscopy showed no abnormalities. Several attempts at fitting her with air-conduction hearing aids had been unsuccessful because of almost instantaneous allergic reactions of the skin in the ear canal and, in the case of a behind-the-ear hearing aid, also behind the ear. A bone-conduction hearing aid was tried but rejected by the patient because of insufficient help compared with no hearing aid at all. Owing to these problems, she was not using a hearing aid. Now she has a percutaneous titanium implant with a BAHA which she has been using for 2 years without any problem.

All three patients received the BAHA HC200, monaurally. For Patient 3 who had a predominantly low frequency hearing loss, we chose the HC200 BL, with enhanced output in the low frequency range.

Methods
To make a comparison, the patients participated in audiological tests with the BAHA and, separately, with their previous hearing aid. As Patient 3 did not have a previous hearing aid, her results with the BAHA were compared with unaided test results and to the results obtained with a conventional bone-conduction hearing aid from our stock (Philips S1594 with bone conduction transducer). The tests were performed after at least a 4-week period of daily use and comprised free-field tone and speech audiometry and a speech-in-noise test. All the hearing aids were checked for normal function and during all the tests they were used at the normal daily volume.

Audiometry was performed using standard procedures and equipment (Interacoustics AC5 audiometer, calibrated according to ISO 389). The free-field thresholds were obtained with warble tones, generated by the audiometer and presented via a loudspeaker at 0 azimuth. Calibration of the free-field set-up was performed with the aid of a group of patients as described by Stream and Dirks.

The free-field phoneme recognition score was performed at a presentation level of 60 dB (comfortable listening level for subjects with normal hearing) and is further referred to as the PS60. If the score was below 100%, phoneme scores were also obtained at 70 and 80 dB. The maximum phoneme score (MPS) was the maximum score thus determined. It should be noted that the PS60 depends on the gain setting of the hearing aid while the MPS does not. To quantify speech recognition when competing sounds were present, the sentence recognition test in noise, as described by Plomp and Mimpen, was used. The noise level was fixed at 65 dB. The difference between the noise level and the presentation level of the sentences at which 50% were repeated correctly, is the signal-to-noise ratio (S/N ratio). The speech recognition tests were performed at least twice to increase the reliability. Mean values are presented.

The data on the patients' opinion about their previous hearing aid and the BAHA were obtained by means of a questionnaire. The questionnaire was filled out for the previous hearing aid before fitting the BAHA and for the BAHA after at least a 5-month period of use. The questions concerned four categories viz. the recognition of speech in quiet and noisy situations, the perceived quality of several everyday sounds and whether the device was comfortable to use. The patients were asked to rate their answer on a scale from 1 (very poor) to 10 (excellent).

Results and discussion
No serious problems occurred with the percutaneous titanium implant in our three patients. This is in accordance with our general experience and with that of other authors who have reported that the titanium implant forms a stable percutaneous connection for the BAHA.

Figure 1 depicts the free-field thresholds (expressed in dB HL), obtained with the previous hearing aid and with the BAHA, as well as the unaided audiograms. Only the unaided free-field thresholds and the aided thresholds with the BAHA are presented for Patient 3 who had not been using a hearing aid regularly prior to the BAHA. The free-field thresholds were only slightly better than the unaided thresholds. In Patients 1 and 2, the aided thresholds were close to the (not shown) sensorineural thresholds. These two patients were using their BAHA at a gain setting just high enough to compensate for the air-bone gap. This is in line with our previous results with the BAHA HC200 in patients with a mixed hearing loss; on average, these patients used their BAHA to compensate for the air-bone gap only and not to compensate for any sensorineural hearing loss. This is surprising because generally patients with a pure sensorineural hearing loss (using air-conduction hearing aids) choose a gain level which compensates for about half of their hearing loss.

The speech recognition test results (PS60, MPS, S/N) with the previous hearing aid and the BAHA are presented in Table 1. The mean scores for the four categories of questions in the questionnaire are also presented in Table 1. As Patient 3 did not have a previous hearing aid, the questionnaire results with the BAHA were compared with her scores without a hearing aid. The results of the three patients are discussed below.

Patient 1 had used his previous hearing aid only occasionally, whereas he was using his BAHA all day. He experienced a significant improvement in speech recognition in quiet but not in noisy surroundings. The sound quality of both hearing aids was found to be comparable and he reported that the
Figure 1. The free field unaided and aided audiograms of the three patients. The continuous line connects the unaided thresholds and the broken line connects the aided thresholds using the BAHA: • - • connects the aided thresholds using the conventional bone-conduction hearing aid. (a) Patient 1; (b) Patient 2; (c) Patient 3.
Conduction hearing aids has often been debated owing to the acknowledged that it is difficult to fit patients with low-frequency hearing loss successfully with hearing aids. In accord-

ance with the other two patients, the S/N ratio with the BAHA may have played a part. Generally, pr

of little use. Therefore, she only used the BAHA for a few hours a day. The speech recognition scores did not improve with the BAHA. The S/N ratio with the BAHA was even poorer than that without a hearing aid. This may explain her disappointing answer to the question on speech recognition in noisy surroundings, although the monaural fitting of the BAHA may also have played a part. Generally, problems in noisy surroundings are encountered by patients with bilateral hearing loss but monaural amplification. Another explanation may lie in the shape of the hearing loss because it is generally acknowledged that it is difficult to fit patients with low-frequency hearing loss successfully with hearing aids. In accordance with the other two patients, the S/N ratio with the BAHA was better than that with a conventional bone-conduction hearing aid.

Patients 1 and 3 may have benefited from a binaural fitting of the BAHA, but the virtue of binaural application of bone-conduction hearing aids has often been debated owing to the small attenuation of sound vibrations in the skull leading to simultaneous stimulation of both cochleas.

It can be concluded that all three patients benefitted to some extent from the BAHA which was reflected for instance in the (increased) number of hours of daily use. Nevertheless, the use of a BAHA in this subgroup of patients should be approached with caution. In audiological terms and according to the questionnaire, the BAHA was comparable to or better than a conventional bone-conduction hearing aid. Therefore, if a bone-conduction hearing aid has to be used, the BAHA seems to be the best choice.

If a patient with (predominant) bilateral sensorineural hearing loss cannot be fitted with air-conduction hearing aids and a BAHA is being considered, the imbalance owing to the monaural application of a BAHA should be discussed with the patient beforehand. In our view, it is always essential to introduce the patient to a conventional bone-conduction hearing aid for at least a 4-week period prior to the fitting of a BAHA to help shape his or her expectations.

### Table 1. Results of the free-field speech recognition tests and the questionnaire with the previous hearing aid (CHA) and with the bone-anchored hearing aid (BAHA)

<table>
<thead>
<tr>
<th>Patient</th>
<th>PS60 (%)</th>
<th>MPS (%)</th>
<th>S/N (dBA)</th>
<th>SQ</th>
<th>SN</th>
<th>QS</th>
<th>COM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CHA</td>
<td>90</td>
<td>100</td>
<td>-2.7</td>
<td>7.0</td>
<td>6.0</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>BAHA</td>
<td>95</td>
<td>100</td>
<td>-4.0</td>
<td>9.2</td>
<td>6.2</td>
<td>6.3</td>
</tr>
<tr>
<td>2</td>
<td>CHA</td>
<td>20</td>
<td>90</td>
<td>5.6</td>
<td>6.0</td>
<td>2.1</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>BAHA</td>
<td>45</td>
<td>90</td>
<td>4.5</td>
<td>6.2</td>
<td>2.1</td>
<td>2.7</td>
</tr>
<tr>
<td>3</td>
<td>No HA</td>
<td>97</td>
<td>100</td>
<td>-4.4</td>
<td>6.0</td>
<td>3.6</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>CHA</td>
<td>93</td>
<td>100</td>
<td>-2.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BAHA</td>
<td>100</td>
<td>100</td>
<td>-3.2</td>
<td>7.3</td>
<td>3.8</td>
<td>7.0</td>
</tr>
</tbody>
</table>

PS60, phoneme score at 60 dB; MPS, maximum phoneme score; S/N, speech-to-noise ratio; SQ, speech recognition score in quiet surroundings; and SN in noisy surroundings; QS, quality of sound score; COM, comfort score.

BAHA was more comfortable to use. The audiological test results showed minor improvements in phoneme recognition in quiet but a 1.3 dB improvement in the S/N ratio, which is equal to a 22% improvement in the recognition of sentences. This advantage was not reflected in the questionnaire score which was most probably due to the fact that the patient had been using his previous hearing aid binaurally whereas the BAHA was fitted monaurally. In quiet surroundings, the BAHA was preferred.

Patient 2 rated the BAHA and her previous bone-conduction hearing aid as being equal, except on the comfort score. She used the BAHA and the previous hearing aid all day. The low scores for the speech recognition in noisy surroundings were in agreement with the very poor S/N ratios found in this patient. The speech recognition scores (PS60, S/N ratio) with the BAHA were nevertheless better than those with the conventional bone-conduction hearing aid.

Patient 3 only experienced a positive effect with the BAHA in quiet surroundings. In noisy surroundings, the hearing aid was of little use. Therefore, she only used the BAHA for a few hours a day. The speech recognition scores did not improve with the BAHA. The S/N ratio with the BAHA was even poorer than that without a hearing aid. This may explain her disappointing answer to the question on speech recognition in noisy surroundings, although the monaural fitting of the BAHA may also have played a part. Generally, problems in noisy surroundings are encountered by patients with bilateral hearing loss but monaural amplification. Another explanation may lie in the shape of the hearing loss because it is generally acknowledged that it is difficult to fit patients with low-frequency hearing loss successfully with hearing aids. In accordance with the other two patients, the S/N ratio with the BAHA was better than that with a conventional bone-conduction hearing aid.

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