Analysis of Factors Predicting the Success of the Bone Conduction Device Headband Trial in Patients With Single-Sided Deafness

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**Objective:** To determine factors predicting whether patients with single-sided deafness (SSD) opt for a bone conduction device (BCD) for the contralateral routing of sound (CROS) after a regular trial with a BCD on a headband.

**Results:** Fourteen patients (47%) chose a percutaneous BCD application after the BCD headband trial. Hearing loss of the contralateral ear at 4.0 kHz was significantly larger in the BCD+ group for bone and air conduction (P=.05 and P=.02, respectively). Patients in the BCD+ group experienced more problems in several listening situations and used the BCD headband more frequently than patients did in the BCD− group.

**Conclusions:** Several individual factors influence the decision of patients with SSD to opt for a BCD. Hearing loss in the contralateral ear at high frequencies seems to be a relevant factor to predict the success of the BCD headband trial. It is advisable to offer all patients with SSD the option to participate in the BCD headband trial for at least 1 week and create a realistic expectation for patients based on their unaided subjective hearing handicaps.


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The determinants might serve as an alternative for the counseling of the patient following a headband trial. These determinants can lead to an assessment of the benefit of a BCD CROS after a trial with a BCD headband. These determinants to predict whether patients would opt for a BCD after a BCD headband trial as part of their workup for the treatment of SSD. The aim of this study is to find more precise determinants to predict whether patients would opt for a BCD CROS after a trial with a BCD headband. These determinants can lead to an assessment of the benefit of a BCD in the counseling of the patient following a headband trial. The determinants might serve as an alternative for the headband trial for selected patient groups.

METHODS

PATIENTS

Thirty consecutive patients with SSD were included in this study from May 2009 to August 2010. All of the patients received a BCD headband trial as part of their workup for the treatment of SSD. The inclusion criteria were profound or total unilateral sensorineural hearing loss, pure-tone bone conduction threshold on the contralateral side of 25 dB or lower and an air-bone gap of 20 dB or lower averaged over 0.5, 1, and 2 kHz. An air-bone gap of 25 dB was allowed if the bone-conduction threshold was lower than 5 dB; the trial with the BCD headband lasted at least 1 week.

QUESTIONNAIRE

The questionnaire administered for this study was derived from elements of validated questionnaires to answer the research question. These questionnaires were the APHAB, the Glasgow Hearing Aid Benefit Profile (GHABP), and the SSD questionnaire and Speech Spatial Qualities of Hearing scale (SSQ). The APHAB consists of 4 subdomains: ease of communication, background noise, reverberation, and aversiveness of sounds. The APHAB gives an indication of the improvement achieved with a hearing aid by comparing baseline and postintervention outcomes. The GHABP measures initial disability, handicap, hearing aid use, hearing aid benefit, residual disability, and patient satisfaction. The SSD questionnaire concerns use, aesthetics, handling of the BCD, satisfaction, and several listening situations. The SSQ measures disabilities of speech hearing in different listening situations, disabilities of spatial hearing, and quality of hearing. The questionnaire used in the current study was completed with a number of other questions based on clinical experience and contained questions about satisfaction, patient-related factors (duration of deafness, fear of operation, cosmetics, visibility of deafness), BCD-related factors (sound quality, intensity of the BCD, annoyance in use), and listening situations in an unaided situation and with the BCD headband. The patients were also asked if they wanted to proceed to placement of a BCD and to explain their choice.

STATISTICAL ANALYSIS

The χ² test or Fisher exact test, in cases of small subgroups, was applied to compare the determinants for both groups. P < .05 was considered to be significant. Owing to the small group of patients, the 5-point scales were converted to 3-point scales for analysis, except for the listening situations. This 3-point scale represents a confirming answer, neutral answer, and denying answer. The results were computed using version 16 of the SPSS software package (SPSS Inc).

RESULTS

After the BCD headband trial, the group of 30 patients was divided into 2 groups based on the patients’ decision to choose a BCD CROS (BCD+ group) or not (BCD− group). The BCD+ group consisted of 14 patients (47%), including 9 men and 5 women, with a mean age of 51.6 years (range, 23-72 years). The BCD− group consisted of 16 patients (53%), including 9 men and 7 women, with a mean age of 44.8 years (range, 19-77 years). Table 1 gives an overview of the etiologies of hearing loss. Twenty-two patients (74%) were provided with a BAHA Intenso, 3 patients (10%) with a BAHA Classic, and 1 patient (3%) with a BAHA Divino during this trial with the headband (all, Cochear Ltd). In 4 cases (13%), the type of BCD was not registered.

All of the patients received the questionnaire at the time of the headband trial. Nine patients fully completed the questionnaire at once; 6 patients completed a part of the questionnaire and were asked to complete it at a later stage. Another 15 patients who had tried the BCD headband without answering the questionnaire were phoned in September 2010 to participate in our study. These patients all agreed to participate and received the questionnaire by mail. All patients returned the questionnaire, resulting in a response rate of 100%.

As described herein, the time between BCD headband trial and questionnaire varied per patient. The mean time difference was 27.1 weeks (range, 2-73 weeks) in the BCD+ group and 20.6 weeks (range, 2-59 weeks) in the BCD− group (P = .42). As a result of the time that elapsed between the headband trial and questionnaire, not all questions could be answered by some patients. Other questions were not applicable to all patients because they did not have a job or had not tested all listening situations. The minimum number of patients who were applicable for analysis was 23.

Eight patients (57%) in the BCD+ group were satisfied with the BCD headband compared with 3 (19%) in the BCD− group (Figure 1). Four patients from the BCD+ group (29%) were dissatisfied with the BCD headband but chose a BCD. Patients in the BCD+ group used the BCD headband in the trial period more often than did patients in the BCD− group. In the BCD+ group, 10 patients (71%) used the headband every day, and 8 patients (57%) used it for more than 7 hours a day. In the BCD− group, 11 patients used the BCD headband 1 to 4
hours a day (69%), and no patient used it for more than 7 hours a day (Figure 2).

Patients with congenital deafness were more common in the BCD− group. Eleven of 30 patients (37%) were diagnosed as having congenital SSD; 7 of these patients (64%) did not select a BCD after the headband trial, while 4 (36%) did so. Of the remaining 19 patients (63%) with acquired deafness, 9 patients (47%) did not choose a BCD (H9273 test; \( P = .39 \)). In the small subgroup of patients with acoustic neuroma or other tumors in the cerebellopontine region, 3 of 6 patients opted for a BCD (50%).

Comparing the mean air conduction and bone conduction thresholds at 1, 2, and 4 kHz of the contralateral ear of both groups, there was no difference for the frequencies of 1 and 2 kHz. However, the mean hearing loss at 4 kHz was significantly greater in the BCD+ group. The mean air conduction threshold was 31.2 dB (range, 0-55 dB) in the BCD+ group compared with 16.9 dB (range, 0-55 dB) in the BCD− group (\( P = .02 \)). The mean bone-conduction threshold was 22.4 dB (range, 0-55 dB) in the BCD+ group and 9.7 dB (range, 0-35 dB) in the BCD− group (\( P = .05 \)).

Patients were asked about their hearing abilities without the BCD headband in different listening situations. Answers were given on a 5-point Likert scale, which ranged from always to never. Table 2 shows the number of patients who answered the question with “always” in specific listening situations. Patients in the BCD− group scored their hearing abilities higher than patients in the BCD+ group for most of the listening situations. Significantly more patients in the BCD− group were always able to understand speech in a conversation with 1 (\( P = .05 \)) or several (\( P = .02 \)) people in a quiet environment. More patients in the BCD− group were able to have a conversation on the phone (\( P = .03 \)) and hear the doorbell or telephone when it rang (\( P = .007 \)). Regarding a conversation in noisy environments, there was no significant difference between groups. However, 10 patients (63%) in the BCD− group compared with 2 patients (14%) in the BCD+ group were almost always able to understand a conversation with 1 person in a noisy environment (Fisher exact test; \( P = .01 \)).
Table 3 shows possible factors explaining the choice to refrain from using a BCD. The cosmetic aspects of the BCD and the fact that patients have to wear a device behind the ear were both statistically significant reasons to refrain from using a BCD for 5 of 16 patients (31%) in the BCD− group compared with no patients in the BCD+ group (P = .02 and P = .01, respectively). The visible indication of deafness was not a relevant factor for 26 patients (13 in both groups). Surgery was not a reason to refrain from using a BCD in 13 patients (93%) of the BCD+ group. Four patients in the BCD− group (n = 16) refrained from using a BCD because surgery was required. There was no significant difference when comparing patients with congenital SSD and patients with acquired SSD for these factors. Of 5 patients who refrained from using a BCD because of the cosmetic aspects and the fact that they had to wear a device behind the ear, 2 patients had congenital SSD (18% of all patients had congenital SSD) and 3 patients had acquired SSD (16% of all patients had acquired SSD). The visible indication of deafness was not a reason to refrain from using a BCD in 1 patient with acquired SSD; no patients with congenital SSD mentioned it as a reason to refrain.

Before the BCD headband trial, 9 patients (64%) in the BCD+ group and 3 patients (19%) in the BCD− group experienced tinnitus at least half of the time from tinnitus. This difference was significant (P = .02). The tinnitus, if present, was not affected by wearing the BCD.

Most patients used the BCD headband on intensity 1 or 2. In the BCD+ group, more patients used the BCD headband on intensity 1, and, in the BCD− group, intensity 2 was used more often. This difference was not significant (P = .12). Only 2 patients in the BCD− group used intensity 3. Four of 30 patients (13%) could not remember which intensity they had used.

**COMMENT**

Most studies show a positive effect in satisfaction and improvement of quality of life in patients with SSD who use BCDs, formerly referred to as BAHAs, as a CROS system. These studies included only those patients who had chosen a BCD after a headband trial. The current study describes characteristics of patients with SSD in both groups, that is, those who elected to use a BCD and those who refrained from using a BCD. These characteristics included listening situations, reasons to refrain from using a BCD, such as wearing a device behind the ear or cosmetic aspects of the BCD, tinnitus before headband trial, and the etiology of SSD.

Without the BCD headband, more patients in the BCD− group compared with the BCD+ group were always able to hear in several listening situations, such as a conversation with 1 or more persons in a quiet environment (P = .05 and P = .02, respectively), during a phone call (P = .03), or when the doorbell or telephone is ringing (P = .01). This suggests that patients with subjectively good hearing abilities in the unaided situation are less likely to opt for a BCD. Therefore, it is important to be aware of a patient’s hearing capabilities and subjective handicap estimation in the counseling of patients with SSD to create a realistic expectation of the BCD headband test.

The mean hearing loss of the better-hearing contralateral ear at 4.0 kHz was significantly larger in the BCD+ group for both bone conduction (P = .05) and air conduction (P = .02). This result might suggest that patients with less function of the contralateral ear benefit more from the BCD headband. However, because 4 of 14 patients in the BCD+ group had pure-tone thresholds of 0 to 10 dB at a frequency of 4 kHz and 3 patients with hearing loss of 30 to 55 dB at 4.0 kHz did not choose a BCD, this is not a straightforward suggestion.

The cosmetic aspects of the BCD and the fact that patients have to wear a device behind the ear were both statistically significant reasons to refrain from using a BCD for 5 patients (31%) in the BCD− group compared with no patients in the BCD+ group (P = .02 and P = .01, respectively). A possible explanation might be that patients who experienced strong benefits from the BCD take the cosmetic aspects for granted. Patients with SSD who had already received a BCD were satisfied with the aesthetics of the BCD, reporting scores of 7.7 to 8.8 out of 10.

For 4 of 16 patients in the BCD− group, surgery was a reason to decline a BCD. All patients were informed about the option of conventional CROS hearing aids. These 4 patients declining a BCD were offered this trial period as well, and all of them declined. Patients in the BCD+ group (64%) experienced significantly (P = .02) more tinnitus than patients in the BCD− group (19%). Only 1 patient who had already received a percutaneous BCD experienced a reduction in tinnitus once she started using the BCD. The other patients in the BCD+ group who experienced tinnitus did not experience any reduction of tinnitus with the BCD headband or percutaneous BCD system. Holgers and Håkansson reported a reduction of tinnitus after a percutaneous BCD application in 9 of 47 patients (19%) with conductive or mixed hearing loss. To our knowledge, these data are not available for unilateral sensorineural hearing loss. These results indicate that tinnitus is not a predictor in the choice for a BCD. The severity of tinnitus was not a subject of this questionnaire; it can be speculated, how-
ever, that a high level of tinnitus might be a negative predictor. This could be an interesting option for further research.

In the current study population of with patients with SSD, almost half of the patients (47%) chose a BCD after the BCD headband trial compared with rates of 37.5% to 63.0% reported in the literature. The patients in the current study tried the headband because they experienced a handicap owing to their SSD. Probably most patients with SSD will never visit a physician because they are not aware of the opportunities of BCD application or are able to cope with the situation unaided. It is therefore important to realize that the current study reflects only the population visiting a physician with hearing-related difficulties owing to their SSD. In a pilot study by Hol et al, even 3 of 10 persons with SSD without complaints concerning their hearing loss did opt for a BCD after headband trial. Therefore, the fact remains that a great number of patients with SSD might benefit from a BCD.

Seven of 11 patients with congenital SSD (64%) refrained from using a BCD compared with 9 (47%) of 19 patients whose SSD had other causes. This outcome supports but cannot confirm the hypothesis that there is a difference between patients with congenital SSD and patients whose SSD has other causes as described by Hol et al. It is conceivable that patients who have been used to monaural hearing since birth and have never experienced binaural hearing develop better monaural hearing abilities than patients who become deaf after experiencing binaural hearing. Possibly, congenitally deaf patients might develop the ability to use spectral (pinna) cues for directional hearing in the horizontal plane. Slattery and Middelbrooks reported fairly good monaural sound localization abilities in patients with congenital SSD.

The time between the BCD headband trial and the time in which patients completed the questionnaire might have biased the results. However, a recall bias was not confirmed by the patients themselves; only a few questions could not be answered. Furthermore, there was no significant time difference between the groups; therefore, we assumed that the possible bias for both groups was comparable. By accepting the extension of time that elapsed between the trial and the questionnaire, 15 extra patients could be included.

Remarkably, 4 patients were dissatisfied with the headband but nevertheless chose a BCD. One of the patients did so only because his wife and children experienced a notable benefit when he was using the BCD headband. The 3 other patients, satisfied with most aspects of the BCD system, mentioned the pain caused by the headband as their main reason for dissatisfaction with the headband trial, though not with the device itself.

However, 3 patients refrained from using a BCD after the headband trial despite satisfaction with the headband trial. One patient mentioned the cosmetic aspects as a reason to refrain from using a BCD, and another patient experienced dizziness with the BCD headband. For the third patient, who has an acquired SSD, the vis-
might benefit more from a BCD. No other relevant factors were found to predict the success of the BCD headband. It is, therefore, advisable to continue offering all patients with SSD the BCD headband trial, which is proposed to last for at least 1 week, and create a realistic expectation for patients based on their unaided subjective hearing handicap.

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Conflict of Interest Disclosures: Dr Cremers is a part-time medical consultant for Oticon Medical.

Table 3. Possible Factors to Refrain From Using a Bone Conduction Device (BCD) in a Group of 30 Patients

<table>
<thead>
<tr>
<th>Reason to Refrain From Using a Definitive BCD</th>
<th>Yes (%)</th>
<th>Neutral (%)</th>
<th>No (%)</th>
<th>P Valuea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery required</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCD+</td>
<td>1 (7.0)</td>
<td>0</td>
<td>13 (93.0)</td>
<td>NA</td>
</tr>
<tr>
<td>BCD−</td>
<td>4 (25.0)</td>
<td>6 (37.0)</td>
<td>6 (37.0)</td>
<td></td>
</tr>
<tr>
<td>Wearing a device behind the ear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCD+</td>
<td>0</td>
<td>1 (7.0)</td>
<td>13 (93.0)</td>
<td>.01</td>
</tr>
<tr>
<td>BCD−</td>
<td>5 (31.0)</td>
<td>5 (31.0)</td>
<td>6 (38.0)</td>
<td></td>
</tr>
<tr>
<td>Cosmetic aspects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCD+</td>
<td>0.05 (0)</td>
<td>1 (7.1)</td>
<td>13 (92.9)</td>
<td>.02</td>
</tr>
<tr>
<td>BCD−</td>
<td>5 (31.0)</td>
<td>4 (25.0)</td>
<td>7 (44.0)</td>
<td></td>
</tr>
<tr>
<td>Visibility of deafness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCD+</td>
<td>0</td>
<td>1 (7.1)</td>
<td>13 (92.9)</td>
<td>.02</td>
</tr>
<tr>
<td>BCD−</td>
<td>1 (6.0)</td>
<td>2 (13.0)</td>
<td>13 (81.0)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: NA, not available; +, used a BCD headband; −, did not use a BCD headband.

aTwo-sided; Fisher exact test comparing BCD+/BCD− with yes/no.

References

4. Hol MKS, Bosman AJ, Snik AFM, Mylanus EAM, Cremers CWRJ. Bone-


