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The bone anchored hearing aid—The third option for otosclerosis

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Abstract

The bone anchored hearing aid (BAHA) has mainly been used for the treatment of hearing loss in patients with congenital conductive problems or chronic suppurative otitis media.

In a five-year period, 32 otosclerotic patients have been referred to the Queen Elizabeth Hospital for consideration of a BAHA. Ten of these patients have been fitted and gained benefit compared to their previous hearing aid. The benefits are not necessarily those in hearing ability but in some cases relate to cosmetic or comfort improvements. This paper demonstrates that the BAHA offers a third treatment option for otosclerosis in patients who cannot or will not undergo stapedectomy and experience difficulty with conventional hearing aids.

Key words: Hearing aids, bone anchored; Otosclerosis; Stapedectomy

Introduction

The bone anchored hearing aid (BAHA) provides patients with direct bone conduction stimulation from a hearing aid attached by a titanium fixture implanted into the mastoid. This treatment was pioneered in Gothenburg, Sweden in the late 1970s (Hakansson *et al.*, 1990), and has been in use in the United Kingdom since the late 1980s. The device provides benefit to patients with bilateral conductive hearing loss and is generally prescribed for patients who are unable to wear air conduction aids because of chronic discharge from their ears or who have congenital malformations.

Theoretically, it would seem that a hearing aid offering direct bone conduction (a bone anchored hearing aid) could provide advantage in the treatment of patients with bilateral otosclerosis, most of whom have a primary conductive loss.

There are two methods of treating otosclerosis, either by stapedectomy or hearing aid rehabilitation (Zeitoun *et al.*, 1993). These are widely used and successful results are obtained with both methods. There are, however, certain disadvantages of both.

The results from stapedectomy are difficult to predict pre-operatively. Significant hearing improvements have been obtained and different studies conclude a variable rate from 68 to 85 per cent (Birt and Amitheringale, 1980; Beales, 1987; Leighton *et al.*, 1991) – significant improvement which is defined as a closure of the air bone gap to within 10 dB of the pre-operative bone conduction threshold.

There are risks of hearing thresholds declining as a result of surgery and in extreme cases profound sensorineural-neural loss occurs quoted as between two to four per cent (Beales, 1987; Leighton *et al.*, 1991). Long-term post-operative tinnitus and vertigo have also been reported (Beales, 1987; Leighton *et al.*, 1991). In addition, patients who gain only slight hearing improvement following stapedectomy and those with a mixed hearing loss may still need to rely on hearing aids.

Conventional air and bone conduction hearing aids continue to be a good treatment for otosclerosis, but some people find wearing aids uncomfortable, and/or cosmetically unacceptable and even with the very best hearing aids some patients report poor sound quality. It would seem, therefore, that the BAHA might offer certain advantages compared to the traditional treatments. These are: no risk of further hearing damage, tinnitus or vertigo occurring as a result of BAHA surgery; the surgery is reversible, and does not preclude patients from receiving a stapedectomy at a later stage. The comfort and appearance of the BAHA has advantages over conventional hearing aids and, because otosclerosis is most often a conductive problem, direct bone conduction should produce better sound quality.

Method

Thirty-two otosclerotic patients have been referred to the Birmingham osseointegration team for consideration for a bone anchored hearing aid

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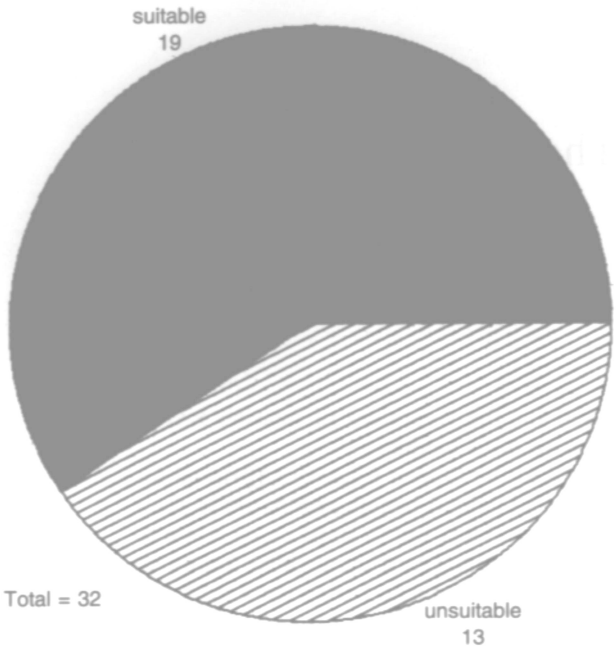

FIG. 1

Assessment of otosclerotics for suitability for BAHA.

over a five-year period. The audiological criteria for suitability were the same as for all other aetiologies referred to the programme:

Average bone conduction thresholds (0.5–4 KHz) less than 40 dB dBHL (ear level BAHA);

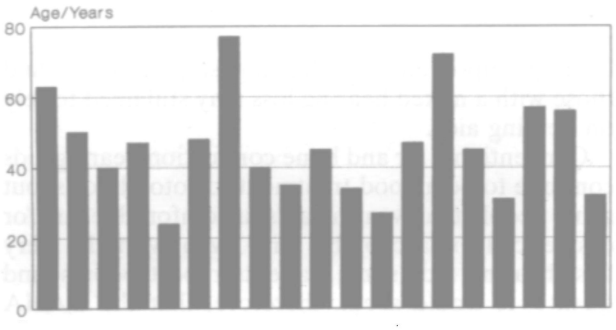

FIG. 2a

Age range – suitable patients.

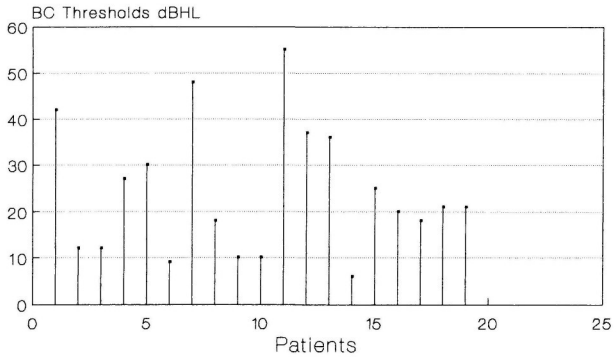

FIG. 2b

Average BC thresholds.

Average bone conduction thresholds less than 60 dB HL (bodyworn superbass);

Speech discrimination greater than 60 per cent (AB wordlists via headphones);

Realistic expectations;

Good support.

A proportion of these patients had been offered stapedectomy, and declined, whilst for others stapedectomy was either not indicated or they had experienced a previous failed surgery. Data was gathered of the hearing thresholds and the performance with any existing hearing aids; including subjective evaluation by questionnaire (Appendix 1). The final decision to proceed to a bone anchored hearing aid was taken by a multi-disciplinary team which included ENT surgeons, audiologists and a specialist speech therapist. For those patients meeting the audiological criteria, other factors such as expectations of outcome, and patients primary reason for choosing the BAHA were evaluated.

Post-operatively, results were collected on audiological performance, free-field warble tone and speech audiometry. Questionnaire results regarding subjective evaluation of the BAHA were also administered and the full post-operative protocol is given in Appendix 2. An analysis was also conducted of the reasons why patients had rejected stapedectomy as their preferred treatment.

Results

Thirty-two patients were assessed over a five year period, and 19 were found to be suitable and 13 unsuitable for a BAHA (Figure 1).

Of the 19 suitable patients the age range was from 25 to 76 years (mean 45.7) (Figure 2a). There were four males and 15 females, with average bone conduction thresholds (in the range 0.5 to 4 KHz)

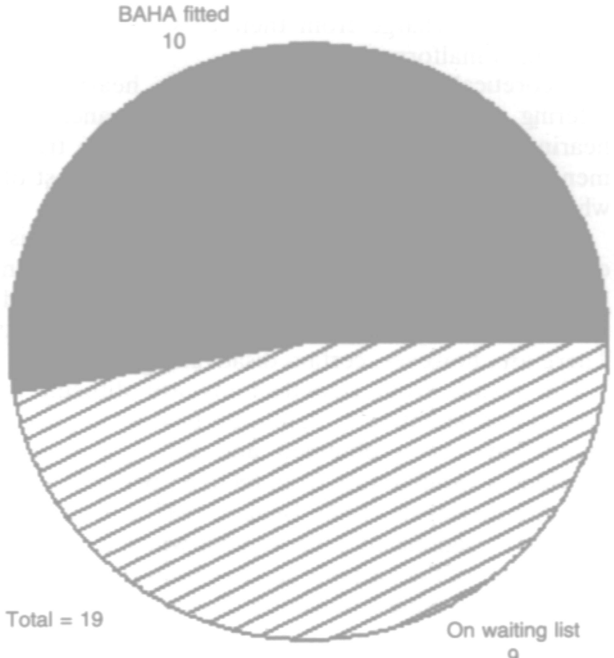

FIG. 3

BAHA fitted.

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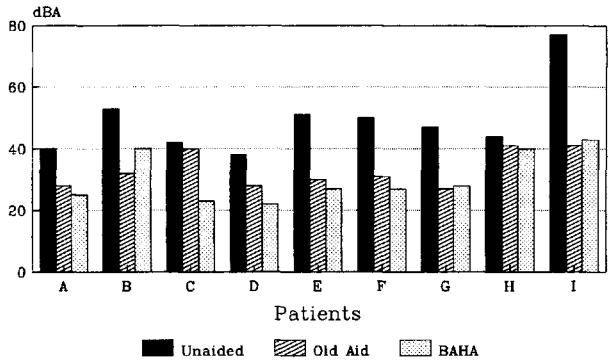

FIG. 4
Warbletone thresholds-freefield.

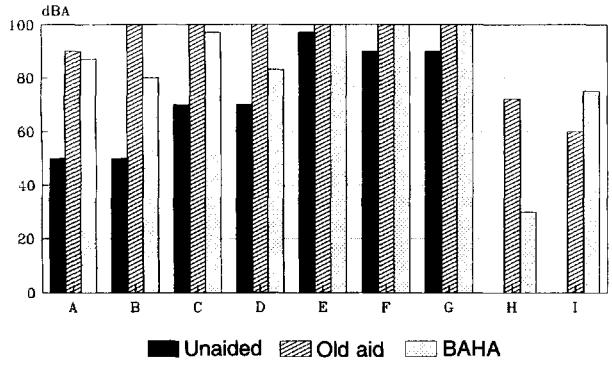

FIG. 5
Speech discrimination-freefield @ 63 dBA.

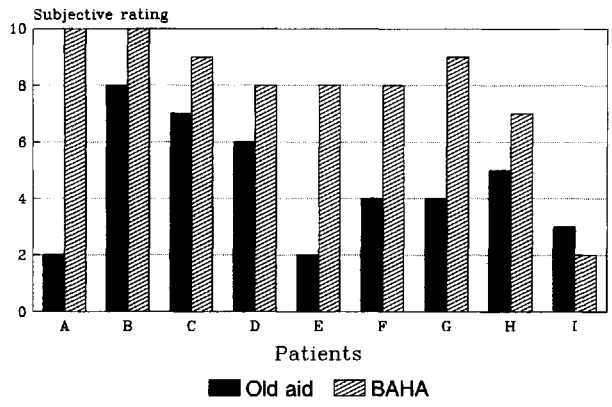

FIG. 6
Sound quality old *vs* BAHA.

of 24 dBHL (Figure 2b). Currently nine patients are waiting for surgery and 10 BAHA's are fitted (Figure 3).

A full set of post-operative data was available for nine patients and this is presented. Free-field warble tone audiometry is shown in Figure 4, combining an average threshold (0.5–4 KHz) for each patient in three conditions; unaided, with old aid and with BAHA. All patients gained improvements in threshold using their old hearing aids compared to the unaided condition. The results with the BAHA were comparable to the old aid, but significantly better in only one case. (*Case C*)

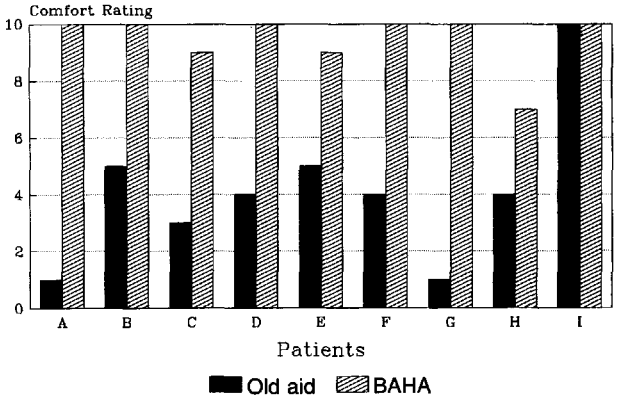

FIG. 7
Comfort old *vs* BAHA.

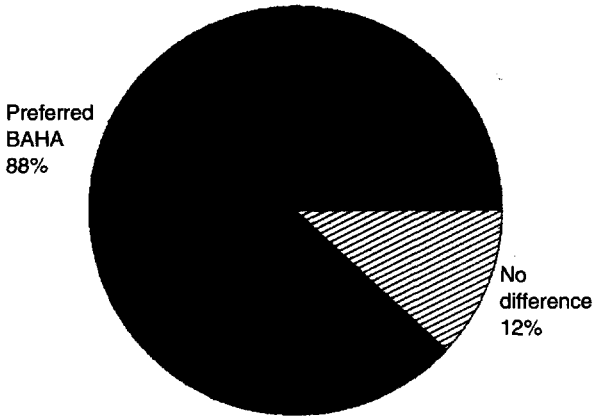

FIG. 8
Cosmetic preference BAHA *vs* conventional aid.

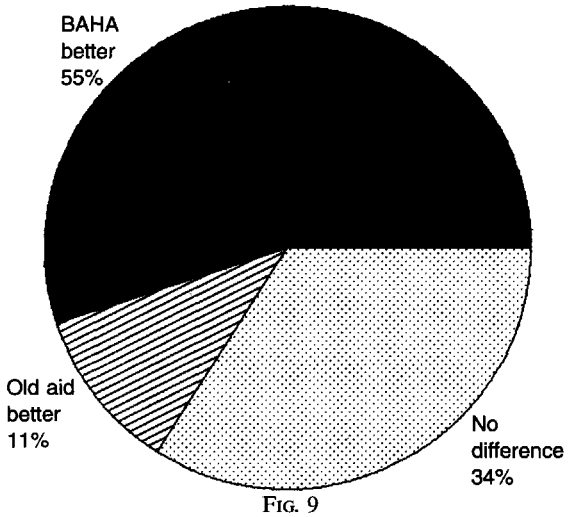

FIG. 9
Preference in background noise BAHA *vs* old aid.

Free-field speech discrimination at 63 dBA is summarised in Figure 5 combining the same three conditions; unaided, old hearing aid and BAHA. Once again, improvements were observed from unaided to old aid, however comparisons between old aid and BAHA showed no improvement.

In the questionnaire section, patients were asked to rate the sound quality of their existing hearing aid

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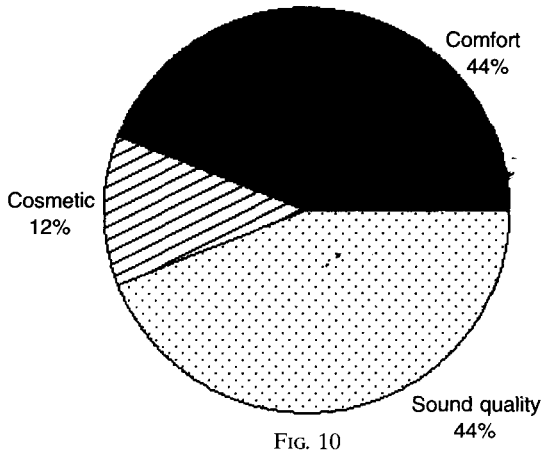

FIG. 10
Reason for choosing a BAHA.

on a scale of 1–10, with one being distorted and 10 being clear and natural. This was repeated post-operatively for the BAHA. Figure 6 clearly shows improvements for all patients in their subjective assessment of sound quality with the BAHA, with two patients scoring 10 out of 10.

A similar question was used to assess subjective feelings on the comfort of their BAHA compared to the previous aid. Patients were asked to rate the overall comfort on a scale of 1–10, 1 being very uncomfortable and 10 being extremely comfortable. Figure 7 shows significant improvement in comfort with the BAHA, with six patients scoring 10 out of 10.

Post-operatively, patients were asked to state their cosmetic preference between the old aid, BAHA and no difference. Figure 8 shows that 88 per cent (eight patients) found the BAHA cosmetically more acceptable, whilst 12 per cent (one patient) found no difference.

Hearing aid performance in background noise is an important factor and whilst this was not measured objectively, subjective responses were obtained by questionnaire. The results are summarised in Figure 9 and indicate that 55 per cent found the BAHA better, 11 per cent preferred the old aid and 34 per cent reported no difference.

Pre-operatively, patients were asked to state their main reason for wanting a BAHA and the results are illustrated in Figure 10. Four patients (44 per cent) expected improvement in comfort, one patient (12 per cent) felt the BAHA would be more cosmetically acceptable and four (44 per cent) wanted improvements in sound quality. For the nine patients currently fitted these expectations have been achieved, with all patients reporting that their primary reason for choosing a BAHA had been satisfied.

Unsuitable patients/Reasons for not choosing stapedectomy

Thirteen patients were found to be unsuitable for BAHA (Figure 11); eight had hearing which was either too bad (bone conduction thresholds in excess of 60 dB or in excess of 40 dB in patients unwilling to wear a body worn hearing aid), or had unilateral otosclerosis with normal hearing in the other ear. In one case the hearing was too good with thresholds within normal limits and four patients declined the bone anchored hearing aid when offered. All 32 patients referred to the programme were interviewed by questionnaire retrospectively about their reason for not choosing a stapedectomy. Twenty-six replies were received. In 12 cases a stapedectomy was not offered by the surgeon attending the patient due to a lack of expected successful outcome. The reasons include lack of an air bone gap, chronic otitis externa, unrealistic patient expectations and in one case the patient already had a dead ear since birth and surgery was not considered prudent on the only hearing ear.

Nine patients had had previous stapedectomy with unsatisfactory results, in seven cases they had gained no hearing improvement and in two cases the facial nerve was found exposed and surgery was technically not thought possible. Five patients decided that

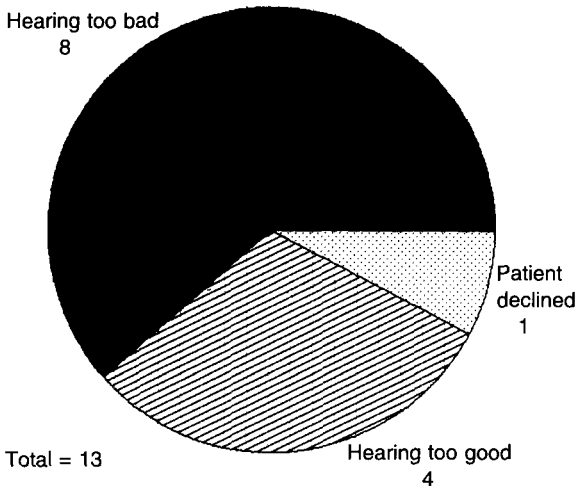

FIG. 11
Patients unsuitable for BAHA.

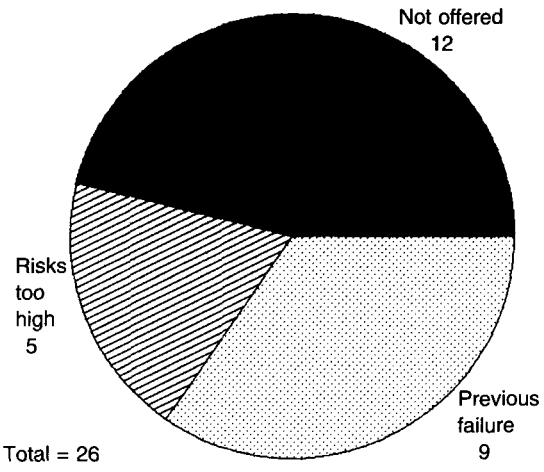

FIG. 12
Reason for not choosing stapedectomy.

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the explained risk associated with stapedectomy were too high.

Conclusions

In this series no significant disadvantages in using the BAHA for the treatment of otosclerosis were found. Indeed all patients gained some form of benefit, which were not necessarily improvements in hearing acuity and in cases were related to comfort or cosmetic acceptability.

There does appear to be a small discrepancy between patients' subjective reports of sound quality and the objective measures obtained. It may be that the measures used in this study are not sensitive enough to elicit meaningful comparisons between the BAHA and the old aid; formal speech in noise testing would be more revealing and this will be investigated in a subsequent study. It appears from this study, that patients with bilateral otosclerosis who need to wear hearing aids will receive improvement from a BAHA. It would be useful to compare the BAHA group with those patients who have obtained successful results with unilateral stapedectomy.

The BAHA does not offer a replacement for the existing treatments of otosclerosis, but may provide a third option for a group of patients who are unwilling or unable to benefit effectively from stapedectomy and/or conventional hearing aid rehabilitation.

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Appendix 1

Pre-operative BAHA evaluation

Audiological investigation

1. Pure tone audiogram
2. Headphone speech audiometry with Boothroyd wordlists
3. Loudness discomfort levels
4. Freefield warbletone audiometry—unaided and with any existing hearing aids
5. Freefield speech audiometry using Boothroyd lists—aided and unaided.

Questionnaire

1. How long have you worn a hearing aid?

>1 year
1–5 years
5–10 years
>10 years

Circle as appropriate

2. Do you find the hearing aid:

a. Uncomfortable to wear	Yes/No	*Circle as appropriate*
b. Cosmetically acceptable	Yes/No	
c. Causes ear infections/irritation	Yes/No	
d. Sounds muffled/distorted	Yes/No	

3. How many hours per day do you use your hearing aid?

Never
1–2 hours
2–5 hours
5–8 hours
>8 hours

4. Please rate the overall comfort of your hearing aid on a scale of 1–10, where 1 is so uncomfortable that the aid cannot be worn and 10 being so comfortable that you are unaware of its presence.

1 2 3 4 5 6 7 8 9 10

5. Please rate the overall sound quality of your hearing aid on a scale of 1–10, with 1 being no help and very distorted and 10 being completely clear and natural in all in all situations.

1 2 3 4 5 6 7 8 9 10

6. Please state your primary reason for wanting a bone anchored hearing aid (i.e. what main benefit do you hope to achieve).

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Appendix 2

Post-operative BAHA evaluation

Audiological investigation

1. Pure audiogram
2. Freefield warbletone audiometry—unaided and with BAHA
5. Freefield speech audiometry using Boothroyd lists—unaided and BAHA.

Questionnaire

3. How many hours per day do you use your BAHA?

Never
1–2 hours
2–5 hours
5–8 hours
>8 hours

4. Please rate the overall comfort of your BAHA on a scale of 1–10, where 1 is so uncomfortable that the aid cannot be worn and 10 being so comfortable that you are unaware of its presence

1 2 3 4 5 6 7 8 9 10

5. Please rate the overall sound quality of your BAHA on a scale of 1–10, with 1 being no help and very distorted and 10 being completely clear and natural in all situations.

1 2 3 4 5 6 7 8 9 10

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