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Main Article

Bone-anchored hearing aid modified with directional microphone: do patients benefit?

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Abstract

Background: Bone-anchored hearing aids are well established in the treatment of patients with a conductive or mixed hearing loss. However, one of the main problems is that of sound localisation. This can be improved with a directional microphone. This study compared the quality of life of bone-anchored hearing aid wearers before and after the use of a directional microphone.

Method: Eleven patients were included. They were required to wear the directional microphone for 12 weeks. Quality of life was measured using the Glasgow benefit inventory questionnaire, before and after the study period.

Results: The response rate was 82 per cent. The total benefit from the directional microphone was +49.7. The three components of the Glasgow benefit inventory were analysed separately, as follows: general subscale +57.4; physical health +42.6; and social scale +25.9.

Conclusion: This is the first study to demonstrate a significant improvement in quality of life from a directional microphone fitted to a bone-anchored hearing aid.

Key words: Hearing Aid; Sound Localisation; Quality of Life; Implants and Prostheses

Introduction

The bone-anchored hearing aid (BAHA) provides acoustic amplification, via an osseointegrated implant and bone-anchored sound processor, and has been in use since 1977. It is a well established mode of treatment for patients with a conductive or mixed hearing loss whose bone conduction thresholds are 45 dB hearing level or better within the speech frequencies. One of the main problems with omnidirectional aids (i.e. BAHA Classic and Compact, Entific Medical Systems, Göteberg, Sweden) is that of sound localisation.

This can be improved with the use of a directional microphone. A directional microphone system provides an output level that varies with the amplitude and direction of the sound source relative to the microphone. Within a hearing aid, it enables the wearer to differentiate between speech and background noise, by proper orientation of the microphone with respect to the sound source.

A BAHA fitted with a directional microphone changes the angle of maximum sensitivity from 90° to 45°, and when used in the right environment will improve speech recognition in noise.

This effect can be measured by evaluating the polar plot of the microphone, which describes the sensitivity to sound approaching the microphone from various angles. Traditionally, polar plots have been used to define the expectations of the manufacturer, professional and patient with regard to a given hearing aid's response to 360° sound, and therefore to indicate the directional emphasis of the hearing aid. This can be put into a more clinical context by the use of the House Institute's source azimuth identification in noise test.[1] The patient's sentence recognition threshold is obtained under four conditions that sample a range of binaural directional hearing abilities, i.e. speech in quiet, or with noise coming from different directions. The patient is required to identify the location of these sounds, which originate from different positions around the patient.

Whilst these tests give us an objective measurement of the benefit from an audiological viewpoint, it is important that we also address the patient's perspective and the effect on their quality of life. This reflects what the patient actually gains from the procedure rather than pure audiological data.

The Glasgow benefit inventory[2] is a validated questionnaire that provides a measure of patient benefit from otolaryngological procedures. It allows for comparison of benefit across different therapeutic or surgical interventions.

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The Glasgow benefit inventory consists of 18 questions, the responses to which are graded on a five-point Likert scale, ranging from a large improvement to a large deterioration in health status. Of these responses, one (−100) denotes the least favourable, five (+100) the most favourable and three (zero) no change. Quality of life is measured in three areas: general (12 questions), social (three questions) and physical (three questions).

The aim of this study was to compare the quality of life in BAHA wearers before and after the fitting of a directional microphone to the BAHA.

To date, this is the first study in which the Glasgow benefit inventory has been used to assess the benefit of a directional microphone used with a BAHA.

Materials and methods

The Freeman Hospital is a tertiary referral centre and leading teaching hospital in Newcastle upon Tyne. Each year, approximately 150 patients are fitted with a BAHA.

Eleven consecutive patients were recruited into this study. Inclusion required that the patient had been a BAHA user for more than three months. (A minimum of three months is needed for the patient to become comfortable with the aid and for any adjustments to be made.) There were no exclusion criteria. Following commencement of the study, the first eligible and agreeable patients were recruited. This resulted in a heterogeneous population, with regard to the patient's pathology, which minimised bias.

Despite the large number of BAHAs fitted each year at the Freeman Hospital, a small study size was used because of the high cost of the directional microphone.

All patients had a pure tone audiogram and patients also had a speech audiogram prior to the BAHA being fitted (see Table I).

The study required the patient to wear the directional microphone continuously for a 12-week period. This is the standard time needed for the patient to become familiar with the aid.

The patients were required to complete a Glasgow benefit inventory questionnaire before and 12 weeks after the fitting of the microphone. The questionnaire was sent to the patient by post, in an attempt to decrease the risk of bias often seen with interview techniques.

Results

Of the 11 patients recruited, there were seven women and four men, with an age range of 44–72 years (mean age 53.2 years). Nine had bilateral hearing impairment, two unilateral. The pathology on the side of the BAHA is presented in Table II. One patient had bilateral BAHAs.

The final response rate was 82 per cent. Two patients failed to return the postal questionnaire, and these results were excluded.

The total benefit of the directional microphone with the BAHA was +49.7. The three components of the Glasgow benefit inventory were analysed separately, and it was found that the general subscale score was highest, at +57.4, followed by physical

TABLE I

AUDIOGRAMS PRIOR TO BAHA FITTING

Patient	BAHA side	Ear	PTA AC (BC) thresholds (dB)				Speech audiogram (dB)	
			0.5 kHz	1 kHz	2 kHz	4 kHz	AC	BC
1	L	R	15 (0)	15 (5)	10 (5)	15 (0)	40	20
		L	70 (35)	70 (10)	65 (15)	80 (15)	90	40
2	Bilat	R	–	–	–	–	–	–
		L	40 (20)	30 (10)	50 (40)	80 (50)	80	60
3	R	R	50 (20)	50 (10)	40 (30)	60 (20)	–	–
		L	45 (10)	55 (10)	40 (20)	70 (35)	–	–
4	R	R	85 (45)	70 (45)	55 (50)	85 (40)	70	50
		L	25 (25)	20	20	45 (45)	40	40
5	L	R	70 (15)	45 (5)	50 (10)	55 (5)	100	50
		L	70 (15)	60 (10)	55 (10)	50 (5)	40	90
6	R	R	55 (5)	70 (15)	75 (55)	85 (45)	–	–
		L	70 (25)	65 (20)	90 (55)	90 (35)	–	–
7	R	R	65 (60)	60 (45)	65 (65)	85 (70)	90	90
		L	120 (60)	110 (70)	120 (70)	120 (70)	–	–
8	R	R	75 (15)	70 (5)	55 (20)	50 (20)	90	40
		L	70 (15)	70 (10)	60 (25)	70 (25)	90	50
9	R	R	55 (10)	50 (20)	45 (30)	60 (10)	80	60
		L	40 (20)	40 (20)	45 (30)	60 (20)	70	50
10	R	R	55 (20)	70 (35)	75 (50)	85 (45)	–	–
		L	30 (15)	50 (20)	45 (35)	40 (25)	–	–
11	L	R	–	–	–	–	–	–
		L	–	–	–	–	–	–

BAHA = bone-anchored heading aid; PTA = pure tone audiometry; AC = air conduction; BC = bone conduction; L = left; R = right; bilat = bilateral

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TABLE II

OTOLOGICAL PATHOLOGY ON SIDE OF BAHA

Pathology	*n*
CSOM	4
Otosclerosis	1
Cholesteatoma	3
Idiopathic SN loss	2
Dead ear following surgery	1
Unknown	1

CSOM = chronic suppurative otitis media; SN = sensorineural

health at +42.6 and finally social scale at +25.9. The pattern of these results correlates with those recorded using the BAHA alone, albeit on a higher scale (see Figure 1).

Overall, 66 per cent of the study group showed an improvement in their Glasgow benefit inventory scores following the addition of the directional microphone.

Discussion

Most microphones used in hearing aids are omnidirectional, so they are equally sensitive to sounds arising from all directions. This makes sound localisation extremely difficult for the wearer and may partly explain why so many users are not satisfied with their aid.[3]

The directional microphone aims to overcome this problem by altering the angle of maximum sensitivity and increasing the speech-to-noise ratio.

Our results are extremely encouraging. Although only a small study, the excellent response rate of 82 per cent validates our results and avoids bias.

The overall benefit of the directional aid, with respect to Glasgow benefit inventory score, was +49.7.

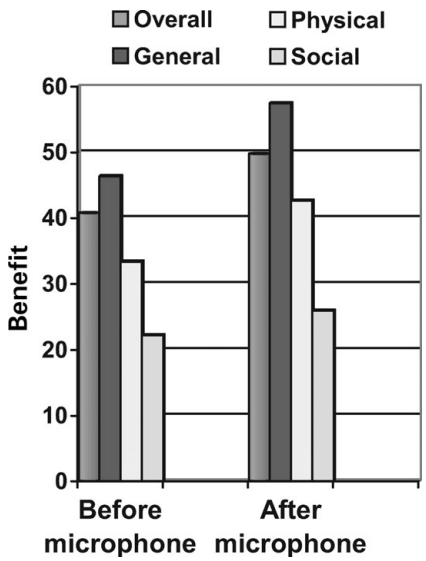

FIG. 1

GIBI scores before and after directional microphone fitting.

We can put this into perspective by comparing our results with a study which used the Glasgow benefit inventory questionnaire to assess quality of life in patients before and after being fitted with a BAHA alone. This study, by Arunachalam *et al.*,[4] assessed 60 patients 12 months after BAHA fitting and revealed an overall benefit of +31. Our results for the addition of the directional microphone are significantly higher.

- **Bone-anchored hearing aids (BAHAs) are well established in the treatment of patients with a conductive or mixed hearing loss, but one of the main problems is that of sound localisation**
- **This study compared BAHA wearers' quality of life before and after the use of a directional microphone, using the Glasgow benefit inventory questionnaire**
- **This is the first study to demonstrate a significant improvement in quality of life from a directional microphone fitted to the BAHA**
- ***The Journal of Laryngology & Otology* Editors and statistical advisor have some reservations concerning the use of the Glasgow benefit inventory in this study; however, a decision to publish was made on the basis of drawing readers' attention to this new development in BAHA technology**

Overall, 66 per cent of our study group showed an improvement in Glasgow benefit inventory score with the use of the directional microphone. This probably reflects the fact that not all patients feel comfortable with directional sound amplification. A proportion of patients prefer omnidirectional aids, as this provides a more naturalistic amplification.

The BAHA Divino (Cochlear Ltd, Weybridge, United Kingdom) was launched in January 2006 and will replace the Classic and Compact range. The Divino uses digital sound processing, has adjustable automatic gain control and output compression, and also has a built-in directional microphone. Whilst preliminary studies[5] have been performed on the directional microphone component, using the hearing in noise test and electromechanical testing, thus far no studies have assessed patient benefit.

Our results support the addition of a directional microphone to the BAHA. We feel that the significant increase in the Glasgow benefit inventory score, which equates to an improvement in patients' quality of life, justifies the increased cost of the new model.

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Miss K Blackmore takes responsibility for the integrity of the content of the paper.
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