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Main Article

The Bradford bone-anchored hearing aid programme: impact of the multidisciplinary team

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Abstract

Objectives: The aim of this study was to assess the impact on implant survival, abutment skin reaction and patient satisfaction in patients implanted with a bone-anchored hearing aid (BAHA), following the introduction of a multidisciplinary team (MDT) in 1997.

Design and methods: Part prospective and retrospective analysis. Implant survival and cause of failures were recorded along with abutment skin reaction (graded as none, mild, moderate and severe, according to the amount of wound care required). Patient satisfaction and quality of life were assessed using a questionnaire enquiring about several aspects of the use and benefits of their BAHA.

Setting and participants: Eighty patients treated at the Bradford Royal Infirmary between 1991 and 2005. The unit is a recognized tertiary referral centre.

Results and conclusions: Twelve out of 80 implants failed, giving an overall failure rate of 15 per cent. Kaplan–Meier survival curves show a steady decrease in implant survival. The MDT had a positive effect on implant survival and adverse skin reactions, with a higher proportion of patients experiencing no reaction after its introduction. There was a 92.5 per cent response rate to the questionnaire. Overall patient satisfaction was high, both before and after the introduction of the MDT.

Key words: Hearing Aids; Implants; Titanium; Otologic Surgical Procedures; Quality of Life

Introduction

Conventional bone conduction hearing devices have long been used in patients with anomalies or disease of the external or middle ear. Tjellström developed the bone-anchored hearing aid (BAHA) in Goteburg, Sweden, in 1977.[1] It now has an established role in the management and rehabilitation of patients with conductive hearing loss caused by congenital atresia, chronic active otitis media, otosclerosis and single-sided deafness.

The overall aim of BAHA surgery is to achieve a stable, integrated abutment surrounded by thin, hairless skin around the implant site. Implant skin reaction causes significant morbidity, such as infection, over-granulation and, in some cases, implant loss. It is often the standard of soft tissue work that varies among different surgeons.[1] Causes of implant failure vary, but they are generally due to primary failure to integrate; late failures are due to poor abutment hygiene, infection and direct trauma.[1–9]

Data published from the largest series of patients in the UK have come from the Birmingham team.[2–4] Their series of 188 patients had a fixture failure rate of 10.1 per cent,[2] with only two cases of failure related to direct trauma. Seventy-nine per cent of patients had no adverse skin reactions, although these were not reported in any detail. This group have emphasized the importance of the multidisciplinary team (MDT). Proops[2] believed that using the MDT approach in rehabilitation promotes shared clinical responsibility and gives patients a sense of long-term commitment.

Evidence suggests that the BAHA is a safe, effective device for the treatment of conductive hearing loss, a device with which patients are highly satisfied. Questionnaires providing additional information about the performance of the aid in real life situations have also been very useful. Bone-anchored hearing aid users have been reported to be very satisfied with their new aids compared with their previous conventional aid, with 78–95 per cent[3,5,7,8,10–12] wearing their new aid for more than eight hours per day. Cooper *et al.*[3] hypothesized that the aetiology of conductive hearing loss and the type of aid used previously would affect patients' levels of satisfaction with their BAHA. These authors concluded that the majority of patients with both congenital and acquired conductive hearing loss were satisfied with their new aid, but

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all patients with congenital loss and a previous air-conduction device reported a significant improvement. A later study[11] reported that the BAHA was significantly superior to prior, conventional hearing aids in all respects.

Other studies from the UK also reported the subjective benefit patients experience from a BAHA.[13,14] Almost all patients fitted with a BAHA experienced an improvement in their quality of life, as measured by the Glasgow Benefit Inventory.[13] Stephens *et al.*[14] reported the benefits and shortcomings of BAHAs in 40 patients. The main benefits listed were better hearing, ease of use, better clarity, less conspicuousness, increased confidence, increased comfort and fewer infections. The main problems listed were poor telephone use, wind noise, poor speech discrimination in noisy environments and, finally, the device being easily dislodged and too bulky. European and North American studies also support this high level of patient satisfaction.[5,7,8,10,12]

The first BAHA surgery was performed at Bradford Royal Infirmary in 1991. From 1991 to 1996, patients were selected for a BAHA by the individual surgeon on the basis of clinical and audiological data available to them. In 1997, an MDT approach was introduced. The MDT consisted of two otologists, a dedicated audiologist and a nurse specialist, each with defined and specific roles in the management of BAHA patients.

The patient plays a central role in modern clinical practice, and, in the context of optimizing clinical services for patients, subjective outcome measures such as patient satisfaction and quality of life are very important in demonstrating the effectiveness of any given clinical intervention. Those responsible for funding and distributing clinical resources recognize the importance of this type of research in making such decisions.

The MDT approach to the management of BAHA patients was introduced at the Bradford Royal Infirmary in 1997, six years into an already established implantation programme.

Materials and methods

All patients fitted with a BAHA at the Bradford Royal Infirmary between July 1991 and August 2005 were included in the study.

Patient selection

The Bradford Royal Infirmary offers a tertiary referral service for Yorkshire. From 1991 to 1996, patients were selected for a BAHA by one of five consultants. After 1997, patients underwent a more formal otological assessment by one of two surgeons. All patients had a pure tone audiogram, with air and bone thresholds at 0.5, 1.0, 2.0 and 3.0 kHz. Free field thresholds were also tested, with the patient's current hearing aid or no aid and the BAHA testband. Patients were considered suitable for a Compact 300™ BAHA (Entific Medical Systems, Wilmslow, Cheshire, UK) if the average bone conduction thresholds were better than 45 dB. If the average bone conduction thresholds were 45–63 dB, patients were considered suitable for the body-worn Cordelle™ BAHA. Bone-anchored hearing aid implantation side was decided based on the side of the existing aid, handedness and patient choice.

Surgical techniques

A two-stage procedure was initially used. The first stage involved choosing a position for the titanium fixture in the temporal bone. One or two fixtures were then implanted. A 4 mm fixture was used whenever possible. A second fixture was used whenever the temporal bone was considered thin or of poor quality. The second stage was performed two to three months later, with soft tissue reduction and either a local or distant split skin graft. Subsequently, a one stage procedure was performed, the same as that described by Tjellström in 1990.[14,15]

A variety of dressings were used, including proflavine-impregnated wool, Inadine® (Johnson & Johnson Medical Ltd, Maidenhead, Berkshire, UK) and Mepilex® (Molnlycke Ltd, Dunstable, Bedfordshire, UK), secured by a healing cap. Postoperative care involved a dressing change after seven days and then regular weekly reviews by a nurse specialist, with advice on wound cleaning, until the graft had taken and the wound was clean. A formal review by the operating surgeon and audiologist was conducted at three months for fitting of the sound processor. The importance of a continued daily cleaning routine was stressed whenever the patient was seen. Subsequent formal reviews were at six and 12 months, with patients having access to members of the MDT as required.

Data collection

Data were recorded retrospectively from individual case notes prior to 1997 and prospectively thereafter. Information recorded included: basic demographics; referral centre; indication for BAHA; audiological assessment; operative details; and follow up and complications, including implant skin reactions.

Surgical data collected for analysis included: surgeon; type of anaesthetic; number of fixtures implanted; size of fixture implanted; one- or two-stage procedure; and time between stages.

Adverse skin reactions were recorded as none, mild (defined as requiring wound care one to three times per year), moderate (defined as requiring wound care four to six times per year) or severe (defined as requiring monthly or more frequent wound care). An abnormal wound was defined as one with signs of infection, i.e. erythema, swelling, wound breakdown and over-granulation. Wound care was defined as daily wound cleaning and dressing by the BAHA nurse specialist, minor debridement and topical antibiotics.

Fixture failure was classified into groups according to cause, as follows: primary failure to integrate, late failure and direct trauma.

Time to fixture failure was calculated from the date of implantation to the date of failure from any cause. Data on patients who were lost to follow up or on

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implants that had not failed were censored in the survival analysis at the date of last follow up. Survival curves were constructed using Kaplan–Meier survival estimates.

Patient satisfaction questionnaire

Patients fitted with a BAHA after 1997 were routinely given a post-operative satisfaction questionnaire three months after their BAHA was fitted. Patients fitted with a BAHA prior to 1997 were asked to complete the questionnaire retrospectively. Patient satisfaction data were analysed inclusively to 2004. The design of the patient satisfaction questionnaire was based on the original subjective outcome questions used by Tjellström and his collegues.[1,16]

The post-operative questionnaire (Appendix 1) consisted of questions one to four relating to overall use of the BAHA, quality of life and overall satisfaction. Question five covered the use of the BAHA in different situations, and question six compared the BAHA with the patient's old device. Questions seven and eight related to the reliability of the device and abutment care.

The responses to the post-operative satisfaction questions were scored out of a possible total of 70; this was then converted to a percentage to give the satisfaction score.

Results and analysis

Between 1991 and 2005, 80 patients were fitted with a BAHA at the Bradford Royal Infirmary. There were 31 males and 49 females. The mean age at operation was 39.5 years (range, nine to 79 years), with mean follow up of 31 months (range, three to 101 months).

The indications for fitting a BAHA are shown in Table I.

Surgical details

The surgical details of all 80 patients with completed BAHAs are highlighted in Table II.

Implant survival

As of August 2005, 12 of the 80 implants had failed, giving an overall implant failure rate of 15 per cent. The median survival time of the implants was 122 months; a 95 per cent confidence interval (CI) could not be calculated due to the low number of failures. The main cause of overall implant failure was late failure due to infection and poor hygiene, followed by primary failure to integrate and two cases of direct trauma. Figure 1 highlights the causes and frequency of implant failures ($n = 12$).

A Kaplan–Meier survival curve for the whole series (Figure 2) shows that there was a steady decrease in implant survival over time, with no sudden failures at any one particular time point. Kaplan-Meier survival graphs of implant survival before and after the introduction of the MDT approach (Figure 3) show that patients had a higher probability of implant survival following the introduction of the MDT.

Patients treated before MDT introduction were followed up for a mean of 70 months (range, 34 to 101 months) and post-MDT patients for a mean of 39 months (range, three to 81 months). Formal statistical comparisons were not carried out due to the low number of events, resulting in insufficient power to detect a meaningful difference between the two groups. Survival probabilities (i.e. the probability of surviving one, two and three years) and 95 per cent CIs were calculated for both groups and are displayed in Table III.

TABLE I

INDICATIONS FOR BAHA IMPLANTATION

Indication	*n* (%)
Acquired	
Chronic otitis media	63 (78.75)
Chronic otitis externa	6 (7.5)
Single-sided deafness	2 (2.5)
Otosclerosis	2 (2.5)
Congenital	
Absent external auditory meatus	5 (6.25)
Treacher–Collins syndrome	1 (1.25)
Goldenhaars syndrome	1 (1.25)

BAHA = bone-anchored hearing aid

TABLE II

BAHA IMPLANTATION: PATIENTS' SURGICAL DETAILS

Surgical factor	1991–1996 (*n*)	1997–2005 (*n*)	Total (*n*)
Anaesthetic			
GA	18	56	74
LA	0	6	6
Fixtures used (n)			
1	15	53	68
2	3	9	12
Fixture size (mm)			
3	6	13	19
4	12	49	61
Surgical stages (n)			
1	1	45	46
2	17	17	34
Graft site			
Local	10	53	63
Distant	8	9	17

BAHA = bone-anchored hearing aid; GA = general anaesthetic; LA = local anaesthetic

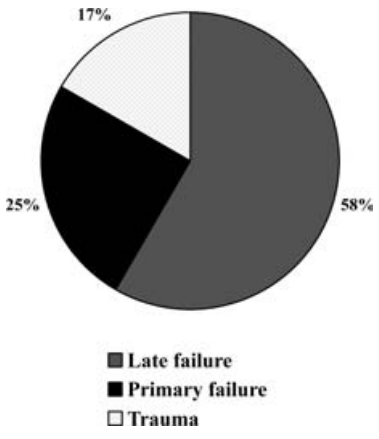

FIG. 1

Causes of implant failure ($n = 12$).

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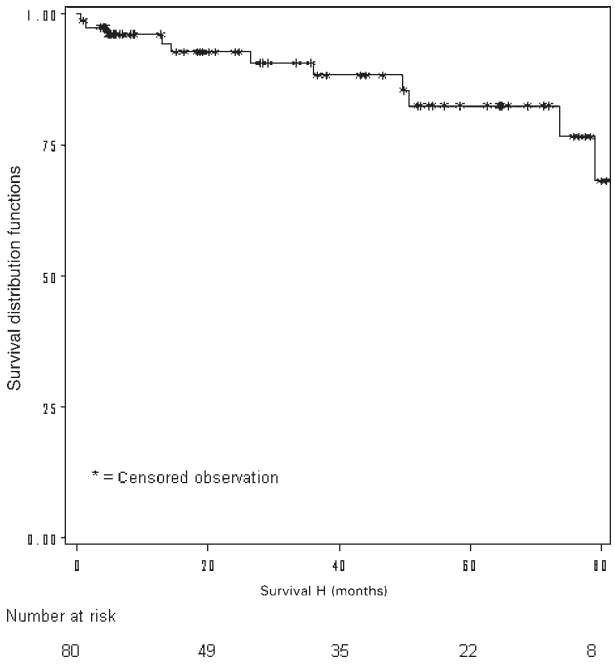

FIG. 2
Implant survival curve for the whole series ($n = 80$).

Skin reaction

Seven patients in the whole series had no recorded data on wound care, two in the pre-MDT group and five in the post-MDT group. In the whole series, 43.3 per cent of patients had no adverse skin reaction, 33.3 per cent had a minor skin reaction, 20 per cent had a moderate skin reaction and 3.3 per cent had a severe skin reaction. As shown in Figure 4, 18.8 per cent of patients had no adverse skin reaction before introduction of the MDT, compared with 52.3 per cent after MDT introduction.

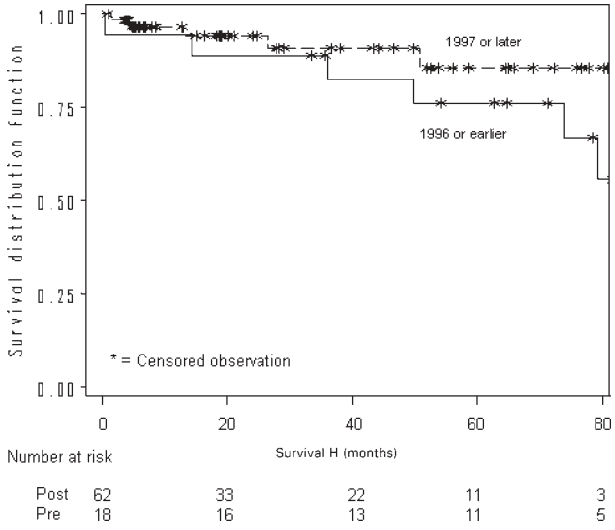

FIG. 3
Effect of introduction of the multidisciplinary team (MDT) on bone-anchored hearing aid survival. Pre = before MDT introduction (1996 or earlier); post = after MDT introduction (1997 or later)

TABLE III
BAHA SURVIVAL ESTIMATES AT 1, 2 AND 3 YEARS

Survival (years)	1991–1996 Probability (95%CI)	1997–2005 Probability (95%CI)
1	0.94 (0.84, 1)	0.97 (0.92, 1)
2	0.89 (0.74, 1)	0.94 (0.87, 1)
3	0.83 (0.64, 1)	0.91 (0.82, 1)

BAHA = bone-anchored hearing aid; CI = confidence intervals

Minor skin reactions occurred in 37.5 per cent and 31.8 per cent of patients and moderate skin reactions in 43.8 per cent and 11.4 per cent, before and after MDT introduction, respectively. No patients in the pre-MDT group suffered a severe skin reaction, compared with 4.5 per cent of patients in the post-MDT group.

Patient satisfaction

Five patients did not answer the patient satisfaction questionnaire, giving an overall response rate of 92.5 per cent, adding weight to the results. These patients were excluded from the analysis of results. All questions were answered by the responders. The statistical significance of the results was not tested due to the low power of the study.

The mean patient satisfaction score for the whole series was 87.1 (range, 59–97); the scores before and after the introduction of the MDT were 86.4 and 83.6, respectively. Thus, there was very little difference in patient satisfaction scores before and after the introduction of the MDT.

Responses to individual questions

Table IV shows the number of patient responses to the individual questions in the questionnaire.

Questions 1 and 2 – BAHA use. The majority of patients used their BAHA all seven, or at least five to six, days a week [61 (98.4 per cent)]. One (1.6 per cent) patient did not use their BAHA at all. There was no obvious difference seen pre- and post-MDT introduction. All patients used their

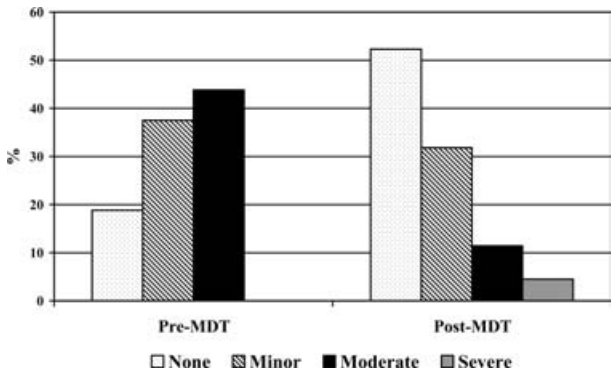

FIG. 4
Effect of introduction of the multidisciplinary team (MDT) on patients' rates of adverse skin reactions.

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BAHA either every day or most days pre-MDT, compared with 44 (97.8 per cent) post-MDT.

Fifty-three (85.5 per cent) patients in the whole series used their BAHA for more than eight hours per day, compared with a higher percentage of 94.1 per cent pre-MDT and a slightly lower percentage of 82.2 per cent post-MDT. This indicates that, when patients did wear their BAHA, they tended to wear it for most of the day.

Questions 3 and 4 – quality of life and satisfaction. In the whole series, 83.9 per cent of patients felt that their BAHA had improved their overall quality of life. Similar figures were seen before and after the introduction of the MDT, at 88.2 per cent and 82.2 per cent, respectively. No patient said that their quality of life was worse after BAHA implantation.

When asked to score their satisfaction with their BAHA on a visual analogue scale of one to 10, with 10 being very satisfied, 87.1 per cent of all patients expressed a high level of satisfaction, with scores of eight or more. Both pre- and post-MDT groups were very clearly satisfied with their BAHA.

Question 5 – value of device in different listening situations. When in one-to-one conversation, 95.2 per cent of the whole series found their new device excellent or very good. In the pre- and post-MDT groups, the figures were 94.1 and 95.6 per cent, respectively. When using the device when talking in a group of people, the results were not as good; only 54.1 per cent of all patients thought the device was excellent or good in this situation, and four patients felt the device was poor or useless in this situation (three of these patients were in the post-MDT group).

Question 6 – new device compared with old device. Patients generally found their new BAHA to be superior to their previous hearing aid in terms of reduced ear infections, improved speech understanding, sound quality, aesthetics, comfort and handling. In the whole series, 8.1 per cent of patients found the sound quality of the BAHA to be worse than that of their old device. This figure was slightly higher in the post-MDT subgroup, at 8.8 per cent. Patients also found their BAHA inferior in terms of wearing comfort; 12.9 per cent of all patients found their new device to be worse, and similar figures were seen in the pre- and post-MDT subgroups, at 11.7 and 13.3 per cent, respectively.

Questions 7 and 8 – service issues and abutment cleaning. In the whole series, 75.8 per cent of patients had never had their BAHA repaired. In the pre-MDT group, 17.6 per cent of patients had had their BAHA repaired three or more times, compared with only 2.2 per cent in the post-MDT group. In the whole series, most patients found their abutment site very easy or easy to clean; this figure was lower in the pre-MDT group, at 64.7 per cent, compared with 75.6 per cent in the post-MDT group. A greater proportion of patients (11.8 per cent) found their abutment difficult to clean before the introduction of the MDT. This may have been due to the introduction of a new, conical abutment in 1999.

Discussion

The BAHA has had over 25 years of clinical use throughout Europe and North America.[1] It is widely accepted that bone-anchored hearing aids are safe, effective devices with which patients are highly satisfied. This series is the second largest published in the UK.

Several studies have reported long term follow-up results. Hakansson *et al*.[5] published 10 years of experience with the Swedish bone-anchored hearing system. These authors reported a fixture failure rate of 9.5 per cent, with only 2.7 per cent of patients having a moderate to severe skin reaction around the abutment site. They concluded that the procedure was virtually risk free.

Later studies from Sweden addressing separately results in adults and children, showed similar fixture failure rates. Tjellström and Granstrom[6] reported that 10 per cent of implants were lost, half of these due to direct trauma. They also found that 3.4 per cent of abutment observations showed moderate to severe skin reactions and that 21 per cent of patients had experienced two or more adverse skin reactions. The results for the study by Cooper *et al*.[3] on osseointegration of BAHAs and external ear prostheses were slightly better, with a 5.8 per cent fixture failure rate, but 9.1 per cent of patients experienced adverse skin reactions. This may reflect increased difficulties with abutment hygiene in children. Studies from Canada,[7] the USA[8] and the Netherlands[9] reported fixture failure rates of 0–8 per cent. However, this USA study, with no failures, was a very small series. Another multi-centre study from the US, of 40 patients, showed a fixture failure rate of 2.5 per cent and adverse skin reactions in 7.5 per cent, although the severity of these reactions was not specified.[17]

There were 12 fixture failures in the current series, giving an overall fixture failure rate of 15 per cent, which is slightly higher than previously published data. There is no immediate, obvious explanation for this, as this series had a similar age range and case mix to previously reported series from Europe and North America.[3,5,6–8] One explanation could be the learning curve experienced by any surgeon performing a new procedure. At the Bradford Royal Infirmary, BAHA surgery was initially performed by one of five surgeons. From 1997 onwards, only two surgeons performed the procedure, thereby gaining more expertise. Wade *et al*.[7] also recognized the importance of this learning curve when starting to perform a new surgical technique. The period of follow up must also be considered when comparing results from different centres. Failure rates published from Birmingham,[3] the USA[8] and the Netherlands[9] had follow ups of seven, three and seven years, respectively. At three and seven years, the failure rate in our current

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TABLE IV

BAHA PATIENTS' RESPONSES TO INDIVIDUAL QUESTIONS

Question response	Total *n* (%)	Pre-MDT* *n* (%)	Post-MDT† *n* (%)	Question response	Total *n* (%)	Pre-MDT* *n* (%)	Post-MDT† *n* (%)
Question 1				*Question 6.1*			
Every day (7 days)	54 (87.1)	15 (88.2)	39 (86.7)	Better	46 (74.2)	12 (70.5)	34 (75.6)
Most days (5–6 days)	7 (11.3)	2 (11.8)	5 (11.1)	No difference	7 (11.3)	1 (5.8)	6 (13.3)
Occasionally (3–4 days)	0	0	0	Worse	3 (4.8)	1 (5.8)	2 (4.4)
Sometimes (1–2 days)	0	0	0	I do not have an infection	6 (9.7)	3 (17.6)	3 (6.7)
Not at all	1 (1.6)	0	1 (2.2)				
Question 2				*Question 6.2*			
More than 8 hours	53 (85.5)	16 (94.1)	37 (82.2)	Better	46 (74.2)	15 (88.2)	31 (68.9)
4–8 hours	6 (9.7)	0	6 (13.3)	No difference	15 (24.2)	2 (11.8)	13 (28.9)
2–4 hours	3 (4.8)	1 (5.9)	2 (4.4)	Worse	1 (1.6)	0	1 (2.2)
Less than 2 hours	0	0	0				
Question 3				*Question 6.3*			
Yes	52 (83.9)	15 (88.2)	37 (82.2)	Better	49 (79.4)	15 (88.2)	34 (75.6)
Both yes and no	7 (11.3)	2 (11.8)	5 (11.1)	No difference	8 (12.9)	1 (5.9)	7 (15.6)
No difference	3 (4.8)	0	3 (6.7)	Worse	5 (8.1)	1 (5.9)	4 (8.8)
Worse	0	0	0				
Question 4				*Question 6.4*			
10 Very satisfied	31 (50)	9 (52.9)	22 (48.9)	Better	45 (72.6)	14 (82.3)	31 (68.9)
9	17 (27.4)	4 (23.5)	13 (28.9)	No difference	13 (16.1)	2 (11.8)	11 (24.4)
8	6 (9.7)	2 (11.8)	4 (8.9)	Worse	4 (6.5)	1 (5.9)	3 (6.7)
7	5 (8.1)	2 (11.8)	3 (6.7)				
6	1 (1.6)	0	1 (2.2)				
5 No difference	0	0	0				
4	1 (1.6)	0	1 (2.2)				
3	0	0	0				

2	0	0	0				
1 Unsatisfied	1 (1.6)	0	1 (2.2)				
Question 5.1				*Question 6.5*			
Excellent	36 (58.1)	10 (58.8)	25 (55.6)	Better	40 (64.5)	11 (64.7)	29 (64.4)
Very good	23 (37.1)	6 (35.3)	18 (40.0)	No difference	14 (22.6)	4 (23.5)	9 (20.0)
Moderate	3 (4.8)	1 (5.9)	2 (4.4)	Worse	8 (12.9)	2 (11.7)	6 (13.3)
Poor	0	0	0				
Useless	0	0	0				
Question 5.2				*Question 6.6*			
Excellent	11 (17.7)	1 (5.9)	10 (22.2)	Better	47 (75.8)	15 (88.2)	32 (71.1)
Very good	23 (37.1)	7 (41.2)	16 (35.6)	No difference	11 (17.7)	0	11 (24.4)
Moderate	24 (38.7)	8 (47.1)	16 (35.6)	Worse	4 (6.5)	2 (11.8)	2 (4.4)
Poor	3 (4.8)	1 (5.9)	2 (4.4)				
Useless	1 (1.6)	0	1 (2.2)				
Question 5.3				*Question 7*			
Excellent	17 (27.4)	2 (11.8)	15 (35.6)	No	47 (75.8)	9 (53.0)	38 (84.5)
Very good	34 (54.8)	12 (70.6)	22 (48.9)	Once	7 (11.2)	2 (11.8)	5 (11.1)
Moderate	10 (16.1)	3 (17.6)	7 (15.6)	Twice	4 (6.5)	3 (17.6)	1 (2.2)
Poor	0	0	0	Three or more	4 (6.5)	3 (17.6)	1 (2.2)
Useless	1 (1.6)	0	1 (2.2)				
Question 5.4				*Question 8*			
Excellent	19 (30.6)	7 (41.2)	13 (28.9)	Very easy	21 (33.9)	5 (29.4)	16 (35.6)
Very good	25 (40.3)	3 (17.6)	22 (48.9)	Easy	24 (38.7)	6 (35.3)	18 (40.0)
Moderate	18 (29.1)	7 (41.2)	10 (22.2)	Acceptable	10 (16.1)	4 (23.5)	6 (13.3)
Poor	0	0	0	Difficult	5 (8.1)	2 (11.8)	3 (6.7)
Useless	0	0	0	Very difficult	2 (3.2)	0	2 (4.4)

*$n = 17$; †$n = 45$. See Appendix for question content. BAHA = bone-anchored hearing aid; MDT = multidisciplinary team

series was zero and 10.8 per cent, respectively, i.e. much more consistent with published data.

An implant failure rate of 25 per cent was reported in a paediatric series.[18] All procedures were two-stage, with a 3 mm implant. Paediatric patients pose a problem due to thinner skull bone and excessive bony growth around the BAHA implant.

The introduction of the MDT had a positive effect on implant survival. Interestingly, seven of the 12 BAHAs that failed were implanted in the pre-MDT group, giving a failure rate of 39 per cent, compared with a failure rate of 8 per cent in the post-MDT group. The positive effect of the MDT could also be confirmed by the increased implant survival probabilities after the introduction of the MDT (Table III). Patients in the post-MDT group may have had a slightly higher probability of the implant surviving, but more follow up is required in order to test this hypothesis. The size of the difference in survival that would translate into a clinically meaningful difference between the groups also needs to be considered.

There was an obvious improvement in the incidence of adverse skin reactions following the introduction of the MDT, although the statistical significance of this result could not be tested due to the low power of the study. Before MDT introduction, 56 per cent of patients had no or only minor skin reactions, compared with 84 per cent of post-MDT patients.

Most papers have described adverse skin reactions according to the classification proposed by Holgers *et al.*,[19] but we found it difficult to describe skin reactions retrospectively according to this classification as these data were often not available in the patient records.

Reyes *et al.*[20] studied implant skin reactions in 146 BAHA patients over eight years. These authors compared adverse skin reactions during the first four years with those during the next four years and found that the degree and frequency of adverse skin reactions showed a decreasing trend with time. The authors hypothesized that better patient education, with increased skin care and implant handling, might be the cause of this decreasing trend; patients would become more aware of adverse skin reactions over time and seek medical help earlier, therefore reducing the severity of the reaction.

Improved surgical technique in later implants, with better soft tissue reduction, may also be a relevant factor. The phased introduction of a new, conical, snap-on coupling which was easier to clean was thought to have had a positive effect on adverse skin reactions,[7] but there was little evidence to substantiate this.

While it may be assumed that most of the large BAHA centres use an MDT approach, there is little published data on the role MDTs play in patient management. Cooper *et al.*[3] described a multidisciplinary osseointegration team for the care of BAHA and facial prosthesis patients, and concluded that BAHA application by an MDT is a successful development in audiological rehabilitation.

The current study demonstrated a high level of patient satisfaction with their BAHA, and this correlates well with data published by other centres;[3,5,7,8,10–13] a response rate of 92.5 per cent adds value to these results.

Using modifications of validated questionnaires (such as the Glasgow Benefit Inventory,[21] the Nijmegen group questionniare[11] and the Entific medical systems questionnaire)[22] to assess BAHA patients' satisfaction and quality of life, a series of studies has shown very positive results.

The Glasgow Benefit Inventory has been used by two centres in the UK to assess quality of life issues in BAHA patients.[13,21] The earlier study[13] had a response rate of 85 per cent and found that patients fitted with a BAHA for congenital ear conditions such as atresia gained the most benefit, compared with patients fitted for discharging mastoid cavities or chronic otitis media. Cooper *et al.*[3] hypothesized that the aetiology of conductive hearing loss and the type of hearing aids used before BAHA implantation would have a significant effect on patient satisfaction after BAHA fitting. They found that patients with congenital abnormalities obtained the greatest benefit from their BAHA. This can in part be accounted for by the larger air–bone gaps found in these patients; hence, they have more to gain. In our study, there was a slightly higher satisfaction score in the pre-MDT group, reflecting the greater proportion of congenital patients treated in this time period.

The same centre[4] also used a modified Glasgow Benefit Inventory to assess satisfaction in adult and paediatric patients. The authors commented that patients who had worn their BAHA for many years may have poor recall or faded memories of the problems experienced before their BAHA was fitted. This may also explain why patients' overall satisfaction was higher in the pre-MDT group in our study, as these patients were given the satisfaction questionnaire many years after their BAHA fitting.

As regards overall BAHA use, 86 per cent of patients used it for more than eight hours a day. This compares favourably with other reported series, as shown in Table V.

Interestingly, the only other centre that has reported their use of an MDT[3] has the highest reported percentage of patients using their BAHA for more than eight hours per day. In our pre-MDT patient subgroup, 94.1 per cent of patients wore their BAHA for more than eight hours per day. This may reflect a period of adjustment when first using the BAHA; patients fitted early may increase their use over time.

As regards the other areas of the questionnaire, responses from both groups were generally similar; however, some responses from the pre-MDT group were more positive than comparable post-MDT group results. A greater proportion of the pre-MDT group felt that their quality of life had improved; the only patient who was completely dissatisfied with their BAHA was in the post-MDT group. Closer inspection of this patient's questionnaire responses revealed that: their implant had not

TABLE V
PUBLISHED BAHA RESULTS IN OTHER CENTRES

Centre	Authors	Patients wearing BAHA >8 hours/day (%)
Birmingham (UK)	Cooper *et al.*[3]	96
Gotenburg (Sweden)	Hakansson *et al.*[5]	90
Nijmegen (Netherlands)	Mylanus *et al.*[10]	90
Ontario (Canada)	Wade *et al.*[7]	78
New York (USA)	Wazen *et al.*[8]	77

BAHA = bone-anchored hearing aid

failed and was worn seven days a week for up to four hours; it was of moderate value in different listening situations (although the quality of the amplified sound was found to be no different); it had never been repaired; and the abutment skin was reported to be easy to clean. These responses are inconsistent with the patient being dissatisfied with the device. Other negative questionnaire responses tended to be isolated to one particular aspect of BAHA use. Generally, most patients found their device excellent when talking to one person, and only post-MDT patients found their device very poor when talking in a group situation. Again, a higher proportion of the post-MDT group found the wearing comfort of their BAHA to be worse than that of their old device.

Patients' responses to abutment cleaning questions support the hypothesis that the MDT improved patient satisfaction; more patients found their abutment easier to clean after the introduction of the MDT. This reflects the increased patient education given by all members of the team. Interestingly, two patients in the post-MDT group found the abutment very difficult to clean.

Due to the smaller number of patients in the pre-MDT group compared with the post-MDT group, statistical comparison between the two was not possible.

- **This study of patients implanted with a bone-anchored hearing aid assessed the impact of the introduction of a multidisciplinary team on implant survival, abutment skin reaction and patient satisfaction**
- **The study investigated 80 patients treated at a recognized tertiary referral centre**
- **Twelve implants failed, giving an overall failure rate of 15 per cent. Kaplan–Meier survival curves showed a steady decrease in implant survival. Introduction of the multidisciplinary team had a positive effect on implant survival and on adverse skin reactions**

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Appendix 1. Post-operative patient satisfaction questionnaire

(1) How many days per week do you use your new device?

Every day (7 days)	5
Most days (5–6 days)	4
Occasionally (3–4 days)	3
Sometimes (1–2 days)	2
Not at all	1

(2) How many hours per day do you use your new device?

More than 8 hours	4
4–8 hours	3
2–4 hours	2
Less than 2 hours	1

(3) Has your quality of life improved due to the new device?

Yes	4
Both yes and no	3
No difference	2
Worse	1

(4) How satisfied are you with your new device? Use the 10 point scale.

Very satisfied	10
	9
	8
	7
	6
No difference	5
	4
	3
	2
Unsatisfied	1

(5) How do you assess the value of your new device in the following situations?

5.1. Talking to one person:

Excellent	5
Very good	4
Moderate	3
Poor	2
Useless	1

5.2. Talking in a group of people:

Excellent	5
Very good	4
Moderate	3
Poor	2
Useless	1

5.3. Listening to music:

Excellent	5
Very good	4
Moderate	3
Poor	2
Useless	1

5.4. Listening to TV/radio:

Excellent	5
Very good	4
Moderate	3
Poor	2
Useless	1

(6) Please compare your new device with your old device in the following aspects.

6.1. How has your new device affected your ear infection?

Better	3
No difference	2
Worse	1
I do not have an infection	0

6.2. How has your speech understanding changed since you obtained the new device?

Better	3
No difference	2
Worse	1

6.3. How has the sound quality of amplified sound changed with the new device?

Better	3
No difference	2
Worse	1

6.4. How do you compare the aesthetics and cosmetics of your new device with the old device?

Better	3
No difference	2
Worse	1

6.5. Has the wearing comfort in terms of headache, pressure or skin irritations changed since you obtained the new device?

Better	3
No difference	2
Worse	1

6.6. How is the new device to handle compared with the old device?

Better	3
No difference	2
Worse	1

(7) Has the new device, which you presently wear, been repaired?

No	4
Once	3
Twice	2
Three or more	1

(8) How easy/difficult do you find it to clean the skin around the abutment?

Very easy	5
Easy	4
Acceptable	3
Difficult	2
Very difficult	1

Total 70

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