Original Article

Cukurova Anestezi ve Cerrahi Bilimler Dergisi

Quality of Life and Audiological Results of Patients with Bone Anchored Hearing Aid

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Abstract

Aim: Conductive hearing loss effects quality of life in adults and children. BAHA is a treatment option. The aim of this study is to determine the audiological success and quality of life impact of BAHA in patients with conductive or mixed hearing loss. **Methods:** Patients rehabilitated with BAHA for conductive or mixed type hearing loss in Cukurova University between 2005 and 2013 were included in the study. The etiology was chronic suppurative otitis media or external auditory canal atresia. The sum of the patients was 23. Pure tone audiometry and free field audiometry were used for audiological evaluation. Functional gain was calculated by extraction of postoperative hearing threshold from preoperative air threshold. Glasgow Benefit Inventory (GBI) and International Outcome Inventory for Hearing Aids Turkish Version (IOI-HA-TR) were used for quality of life evaluation. **Results:** The sum of the patients was 23. Functional gain of patients with bone anchored hearing aid was 31.3 dB at 500 Hz. 45.5 dB at 1000 Hz, 44.5 dB at 2000 Hz and 44.3 dB at 4000. GBI score of adults with BAHA was 37.6. GBI score of children with BAHA was 41.6. IOI-HA-TR results were 25.22 in patients with BAHA. Two patients had (8.7%) had osseointegration problem. **Conclusion:** BAHA is effective in rehabilitation of conductive hearing loss. It has positive effect on quality of life.

Keywords: Bone Anchored Hearing Aid; quality of life; audiological result

1. Introduction

Medical use of titanium implants was first introduced in 1965[1]. They were used in dental region. Initial successful outcomes led the researchers to other areas. Tjellström et al.[1] reported the first use of titanium implants as bone-anchored hearing aid (Baha) in 1982. Since then, Baha became a widely accepted hearing rehabilitation method for patients with conductive or mixed hearing loss.

Currently indications for Baha are congenital malformations of the external and middle ear, chronic suppurative otitis media (CSOM), ossicular chain defects, single sided deafness (SDD) and unability to use conventional hearing aids.[2] Baha can be used safely in both adults and children unilaterally or bilaterally.[3]

The aim of this study is to reexamine our Baha experience with audiological results, quality of life measurement and complications.

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2. Materials and Methods

Patients who had Baha operation in Cukurova University, Otolaryngology Department between January 2005 and September 2013 were included in study. None of the patients had bilateral Baha system. This study was designed as a single-center, retrospective cross-sectional study.

Pure tone audiometry was used to determine the air and bone hearing thresholds without device. Free field audiometry was used to determine the hearing thresholds with Baha. Thresholds were measured at 500, 1000, 2000 and 4000 Hz. Functional gain was calculated with extracting postoperative threshold with Baha from preoperative air threshold of better ear.

Quality of life issue was evaluated with International Outcome Inventory for Hearing Aids Turkish Version (IOI-HA-TR), Glasgow Benefit Inventory (GBI) for adults and pediatric patients.

Glasgow Benefit Inventory is a validated method for comparing and quantifying changes in quality of life resulting from an otolaryngological procedure. The version for adults consists of 18 questions. Subscales of the test are general, social and physical health. Each of the questions has five answers with 5 likert type scale. The scores are averaged and plotted as a graph with 5 denoting +100 and 1 denoting -100.

International Outcome Inventory for Hearing Aids (IOI-HA) is a simple tool to assess hearing aid outcome. The questionnaire has seven questions targeting seven domains as daily use, benefit, residual activity limitations, satisfaction, residual participation restrictions, impact on others and quality of life. There were five options in response to each question, the minimum score of each question was one point and maximum was five points. The highest possible score was 35 points whereas the lowest possible score was 7. Mean scores below 3.5 in each domain indicate poor habilitation outcome.[3]

Patients were also asked if 'would you do it again?' and 'do you recommend to someone else?'. Also, they were evaluated for otorrhea and tinnitus condition related to surgery and complications were identified.

Ethical approval was obtained from the Ethics Committee of Cukurova University Faculty of Medicine, (Meeting No: 20, Decision No: 8, Date: June 6, 2013) and the study was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all adult participants and from the parents or legal guardians of pediatric participants prior to inclusion in the study.

2.1. Statistical Analysis

Statistical analyses were performed using SPSS software (version 22.0; IBM Corp., Armonk, NY, USA). Normality was assessed with the Shapiro–Wilk test. Preoperative air-conduction thresholds and postoperative free-field thresholds with BAHA were compared using the Wilcoxon signed-rank test. A p value < 0.05 was considered statistically significant. Questionnaire data (GBI and IOI-HA-TR) were analyzed descriptively and presented as mean values and percentages.

3. Results

The sum of the patients was 23. The average age of the patients was 33.5±16.9. Five patients were under the age of 18. There were 16 female (69.6%) and 7 male (30.4%) patients. The causes for the operation were chronic suppurative otitis media in 17 patients (73.9%) and congenital ear malformations including external auditory canal atresia in 6 patients (26.1%). The mean time of evaluation after surgery was 18.3±5.9 months.

Two patients (8.7 %) had osseointegration problems with their implants. Both patients preferred explantation and they continued to use the device with softband. None of the patients were operated because of skin regrowth or flap necrosis.

Otorrhea complaints of the patients were also evaluated. 15 patients (65.2 %) had less otorrhea after surgery and 8 patients (34.8 %) had no change. The results for tinnitus condition were; 14 patients (60.9 %) had never tinnitus whatsoever, 6 patients (26.1 %) had less tinnitus after surgery and 3 patients (13.0 %) had no change.

The demographic and clinical characteristics of the patients are presented in Table 1.

Patients were also asked if they would recommend the Baha to another person. 19 patients (82.6 %) answered as yes, 3 patients (13.0 %) were not sure and one patient's (4.3 %) answer was no. Also 17 patients (73.9 %) answered as yes when they were asked if they would do it again, 3 patients answered as no and 3 patients were not sure.

Table 1. Demographic and Clinical Characteristics of the Study Population

Variable	Value
Number of patients, n	23
Age (years), mean ± SD	33.5 ± 16.9
Female/Male, n	16/7
Pediatric patients (<18 years), n (%)	5 (21.7)
Adult patients (≥18 years), n (%)	18 (78.3)
Chronic suppurative otitis media, n (%)	17 (73.9)
Congenital ear malformation/external auditory canal atresia, n (%)	6 (26.1)
Follow-up duration (months), mean ± SD	18.3 ± 5.9
Osseointegration failure, n (%)	2 (8.7)

Abbreviations: SD, standard deviation.

3.1. Audiological Assessment

The mean preoperative bone-conduction thresholds were 38.5, 30.0, 28.0, and 35.4 dB at 500, 1000, 2000, and 4000 Hz, respectively. The mean preoperative air-conduction thresholds were 68.3, 70.0, 66.5, and 69.3 dB at the same frequencies, with corresponding mean air–bone gaps of 29.8, 40.0, 38.5, and 33.9 dB. Functional gain, calculated by subtracting postoperative free-field thresholds with BAHA from preoperative air-conduction thresholds of the better-hearing ear, was 31.3, 45.5, 44.5, and 44.3 dB at 500, 1000, 2000, and 4000 Hz, respectively. Preoperative and postoperative audiological results are shown in Table 2.

Postoperative free-field thresholds with BAHA were significantly better than preoperative air-conduction thresholds at all tested frequencies ($p < 0.05$).

Table 2. Preoperative and Postoperative Audiological Outcomes

Frequency (Hz)	Preop AC (dB)	Preop BC (dB)	ABG (dB)	Functional Gain (dB)	p Value
500	68.3	38.5	29.8	31.3	<0.05
1000	70.0	30.0	40.0	45.5	<0.05
2000	66.5	28.0	38.5	44.5	<0.05
4000	69.3	35.4	33.9	44.3	<0.05

AC: Air conduction; BC: Bone conduction; ABG: Air–bone gap.

3.2. Questionnaires

Glasgow Benefit Inventory for adults and children were applied to 18 adults and 5 pediatric patients. The total benefit for adults was found to be 37.6 and the subscales of general, social and physical benefit were 35.8, 39.8 and 34.2 respectively. Whereas the total benefit for children was 41.6 and the subscales of emotional, social, educational and vital

were 51.4, 30.0, 47.1 and 32.0 respectively. Glasgow Benefit Inventory (GBI) results for adult and pediatric patients are presented in Table 3.

Patients were also asked to complete the International Outcome Inventory for Hearing Aids Turkish Version (IOI-HA-TR). Total score was found to be 25.22 and the scores in subscales were 4.35 in daily use, 3.52 in benefit, 3.65 in residual activity limitations, 3.52 in satisfaction, 3.04 in residual participation restrictions, 3.35 in impact on others and 3.78 in quality of life. International Outcome Inventory for Hearing Aids – Turkish Version (IOI-HA-TR) results are presented in Table 4.

Mean GBI and IOI-HA-TR scores indicated overall patient satisfaction and functional benefit following BAHA implantation.

Table 3 Glasgow Benefit Inventory Scores Following Bone-Anchored Hearing Device Implantation

Domain	Mean Score
Adults – Total score	37.6
General subscale	35.8
Social support subscale	39.8
Physical health subscale	34.2
Pediatric – Total score	41.6
Emotional domain	51.4
Social domain	30.0
Educational domain	47.1
Vitality domain	32.0

Higher scores indicate greater perceived benefit.

Table 4 International Outcome Inventory for Hearing Aids—Turkish Version (IOI-HA-TR) Scores.

Domain	Mean Score
Daily use	4.35
Benefit	3.52
Residual activity limitation	3.65
Satisfaction	3.52
Residual participation restriction	3.04
Impact on others	3.35
Quality of life	3.78
Total score	25.22

IOI-HA-TR: International Outcome Inventory for Hearing Aids—Turkish Version.

4. Discussion

Bone anchored hearing aid is a worldwide accepted rehabilitation method for conductive and mixed type hearing loss for a long time.[4,5] Baha had FDA approval for adults in 1996 and for children in 1999 in United States of America. Indications were expanded in last years, such as single sided deafness and otosclerosis in western countries.[6,7]

The most common indication is conductive or mixed type hearing loss caused by chronic suppurative otitis media. This is followed by patients with hearing loss caused by congenital ear malformations including external auditory canal atresia.[8] Minimum age is a controversial subject but generally surgery is performed after 5 years because of temporal bone thickness and low patient cooperation. During this period patients can be rehabilitated with softband devices.[9]

Devices which are used in rehabilitation of conductive type hearing loss are expected to maintain hearing levels at patients cochlear reserve.[10] In our study, this is achieved in 500 and 4000 Hz. Also the functional gains were found to be 31.3, 45.5, 44.5, 44.3 dB at 500,1000,2000 and 4000 Hz respectively. In the study of Ricci et al[11] patients average preoperative bone hearing threshold was 30.2 dB, postoperative free field threshold was 26.2 and functional gain was 28.5 dB. Also air-bone gap closure at 0-10 dB was observed in 40

patients (%85.1). Patients can also have better hearing results than their preoperative bone thresholds.

Osseointegration failure is a major complication and a reason for revision surgeries in Baha. In our study, 2 patients (8.7%) had this problem and they used softband devices for hearing. None of our patients had revision surgery for skin overgrowth. In literature, osseointegration failure is 1.3-10% and skin problems are 5-7.5%.[12,13] Otorrhea is also a major problem for patients with chronic suppurative otitis media who use conventional hearing aids. Baha is expected to decrease otorrhea because of the lack of external ear canal component. In our study, 15 patients (65.2%) had less otorrhea after surgery. MacNamara[14] and Mylanus[15] found 84% and 97% respectively.

Lekue et al[16] reported 50% of their patients experienced no tinnitus at all after surgery. In our study this rate was only 26.1%. When patients were asked "if they would recommend to another person" and "if they would do it again", they answered "yes" 82.6% and 73.9% respectively.

Total score of Glasgow Benefit Inventory (GBI) for adults was found to be 37.6 and the subscales of general, social and physical benefit were 35.8, 39.8 and 34.2 respectively. Whereas the total benefit for children was 41.6 and the subscales of emotional, social, educational and vital were 51.4, 30.0, 47.1 and 32.0 respectively. In a study by Arunachalam et al, total score was 34.0, social subscale was 21.0 and physical was 10.0.[17] Total scores were 33.3 and 17.9 in other studies. (3,22) Total score was 40.7 for adults and the subscales of general, social and physical health were 55.2, 14.0 and 9.3 respectively in a study of Lekue et al.[16] In a study from Italy, total scores were found to be 47.5 for adults and 52.0 for pediatric patients.

Total score of International Outcome Inventory for Hearing Aids (IOI-HA) was 25.22 in our study. Patients 60.9% were found to be using the device over 8 hours in a day. Total score was 29.78 and daily use over 8 hours was 80% in Maarten's study.[18] In same study, young patients were found to have more benefit considering to older patients. Also same amount of patients answered as "quite a lot" or "very much" to the question of "how much do you benefit in places where you need the device most?". Disturbance of other people were found to be 56.5% as "bothered slightly" or "bothered not at all". In the last question of quality of life, the change in total enjoyment was 61.1% as "quite a lot better" and "very much better".

In our series, no patient had bilateral Baha system but it may be recommended to patients to improve speech discrimination and sound localization. Especially patients with symmetric hearing loss tend to benefit more. Despite of high satisfaction rates, cosmetic and social problems may cause difficulties in using Baha. In a study of Zawawi et al.[19] 11% of patients were non-users and the highest rate was in patients with unilateral deafness.

Recent evidence supports the effectiveness of bone-anchored hearing implants in improving both objective audiological outcomes and subjective patient-reported results. A prospective case series by Azevedo et al.[20] reported an average functional gain of approximately 29 dB following percutaneous BAHA implantation, with significant improvements in hearing handicap and daily life satisfaction scales at 6 months post-activation, although the correlation between functional gain and patient-reported outcomes was not strong, highlighting the multifaceted impact of these devices on auditory rehabilitation.

Large registry-based analyses and systematic reviews also indicate that bone conduction hearing implants yield meaningful gains in speech perception, auditory thresholds, and quality of life measures across diverse patient populations with conductive or mixed hearing loss, and that these benefits tend to be maintained over time.[21]

With respect to health-related quality of life specifically, contemporary research has demonstrated clinically relevant improvements in overall utility and hearing-specific

domains following bone conduction implantation in patients with chronic otitis media, further underscoring the positive impact of these devices on psychological and functional well-being.[22]

However, variability in tinnitus outcomes remains evident in the literature. While some cohorts report notable reductions in tinnitus perception after bone conduction device use, others have found more modest or inconsistent effects, which may be influenced by differences in baseline tinnitus characteristics, assessment methods, and follow-up durations. This heterogeneity highlights the need for standardized tinnitus evaluation tools in future studies.

Taken together, the existing literature corroborates our findings of audiological gain and subjective benefit following BAHA implantation, while also illustrating that patient-reported outcomes such as quality of life can vary depending on demographic factors, etiology, and the instruments used to measure subjective benefit.

This study has limitations. First, the relatively small sample size (n = 23) may limit the generalizability of the results. Second, the retrospective design is inherently subject to selection and information bias. Third, the absence of a control group prevents direct comparison with other hearing rehabilitation modalities or untreated patients. In addition, no patient in the present series underwent bilateral BAHA implantation; therefore, potential benefits of bilateral stimulation on speech perception and sound localization could not be evaluated. Future prospective studies with larger sample sizes and controlled designs are warranted to further clarify the audiological and quality-of-life outcomes of BAHA implantation.

5. Conclusions

Bone anchored hearing aids are safe and effective rehabilitation method for conductive and mixed type hearing loss. It has positive effect on quality of life issue also. Further researches are required in order to understand the long term results of these devices.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Non-Interventional Clinical Research Ethics Committee of Çukurova University Faculty of Medicine for the residency thesis entitled "Quality of Life and Hearing Outcomes in Patients Using Bone-Anchored Hearing Aids" (Decision No. 8, Meeting No. 20, approved on 6 June 2013).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy restrictions.

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