

Long-Term Glasgow Benefit Inventory Outcomes in Patients Using Transcutaneous versus Percutaneous Bone-Anchored Hearing Devices

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ABSTRACT

Background: To compare patient-reported outcomes following percutaneous and transcutaneous bone-anchored hearing aid (BAHA) implantation using the Glasgow Benefit Inventory (GBI).

Methods: This retrospective study included patients who underwent BAHA implantation at a tertiary university center between 2011 and 2023, with a median follow-up of 95.50 months [IQR: 37.00-132.00] (range, 16-158 months). Patient-reported outcomes were assessed using the validated GBI, which evaluates general benefit, social benefit, physical health, and a total score. Glasgow Benefit Inventory scores were compared between percutaneous and transcutaneous BAHA users. Owing to the limited number of patients, the softband group was evaluated descriptively only. Statistical analyses were performed using the Mann-Whitney *U*-test.

Results: A total of 46 patients were included: 33 transcutaneous and 13 percutaneous BAHA users. The general benefit score was significantly higher in the percutaneous group than in the transcutaneous group (median [IQR]: 83.34 [37.50-89.58] vs. 41.67 [20.83-70.83], $P = .032$). Total GBI scores were numerically higher in the percutaneous group; however, the difference did not reach statistical significance ($P = .069$). No statistically significant differences were observed between groups in terms of social benefit ($P = .157$) or physical health ($P = .502$).

Conclusion: Both percutaneous and transcutaneous BAHA implantation provided meaningful patient-reported benefit. Percutaneous BAHA was associated with a significantly higher general benefit score, while total, social, and physical health benefits were comparable between techniques. These findings emphasize the importance of long-term follow-up and individualized device selection.

Keywords: Bone-anchored hearing aid, bone conduction hearing device, Glasgow Benefit Inventory, percutaneous, quality of life, transcutaneous.

Introduction

Bone-anchored hearing devices are primarily preferred for 2 main indications: in cases where conventional hearing aids cannot be used due to external or middle ear pathologies, or in patients with single-sided deafness.^{1,2} Bone conduction hearing devices operate on the principle that sound is detected by an external processor, converted into mechanical vibrations, and these vibrations are transmitted through the skull bones to stimulate the cochlea. In this way, sound bypasses the external and middle ear and directly stimulates the cochlea. The organ of Corti within the cochlea then converts these mechanical vibrations into neural signals, allowing hearing to occur. Unlike conventional hearing aids, the absence of a

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loudspeaker placed in the external auditory canal provides a significant advantage in terms of ease of use and improved patient compliance.^{2,3}

Bone-anchored hearing devices are classified into transcutaneous and percutaneous systems based on the presence or absence of a skin-penetrating abutment that provides the connection between the internal and external components. In percutaneous devices, the internal and external components are directly connected via an abutment that exits through the skin following a surgical incision; therefore, the external component is directly coupled to the skull. In transcutaneous devices, the internal and external components are magnetically coupled through intact skin, without the need for a skin incision or an intermediate connecting element. In addition, bone-anchored hearing devices are further categorized as active or passive systems depending on whether the vibrating component is located in the external or internal unit.⁴

In passive transcutaneous systems, sound waves detected by the external unit are converted into mechanical vibrations, and these vibrations are transmitted to the internal component through the skin. In active transcutaneous systems, the microphone and sound processor are located in the external unit; sound signals are transmitted electronically to the internal unit, and vibrations are generated directly at the level of the implanted component. By this mechanism, mechanical vibration losses that may occur through the skin are minimized. Both percutaneous and transcutaneous bone conduction hearing devices have their own specific advantages and limitations.^{1,5}

The most important disadvantage of percutaneous systems is the complications that may develop around the abutment, which is in direct contact with the skin. In the literature, problems such as skin infections, skin overgrowth, graft necrosis, and implant loss have been reported.^{6,7} In addition, the incidence of implant loss has been reported to be higher particularly in pediatric and cognitively impaired patients, which may be related to the increased susceptibility of the abutment site to trauma.⁸ Furthermore, aesthetic concerns constitute another important factor limiting the use of percutaneous systems, especially in the adolescent population.

MAIN POINTS

- *This long-term retrospective study compared patient-reported quality-of-life outcomes between percutaneous and transcutaneous bone-anchored hearing aid users.*
- *Both implantation techniques were associated with clinically meaningful improvements in general well-being on the Glasgow Benefit Inventory.*
- *Higher general benefit scores were observed in the percutaneous group compared with transcutaneous implantation, differing from several previous reports, while social and physical health outcomes were comparable; this difference may be related to longer follow-up and patient-related factors.*
- *Although overall quality-of-life scores tended to favor percutaneous implantation, the lack of statistically significant differences supports individualized device selection and the importance of long-term follow-up.*

Material and Methods

Patient-reported outcomes of patients who underwent bone-anchored hearing aid (BAHA) implantation at the tertiary university center between 2011 and 2023, with a median follow-up duration of 95.50 months [IQR: 37.00-132.00] (range, 16-158 months), were assessed using the Glasgow Benefit Inventory (GBI). The GBI is a validated post-intervention questionnaire comprising 18 items that evaluate changes in health status across 3 domains: general benefit (12 questions), social benefit (3 questions), and physical health (3 questions), in addition to a total score. All percutaneous bone-anchored hearing devices used in this study were Cochlear Baha Connect systems, and all transcutaneous devices were Cochlear Baha Attract systems (Cochlear Ltd., Sydney, Australia). No active transcutaneous bone conduction devices were included in this study. The social benefit domain assesses changes in social support and interpersonal interactions, specifically patients' perceptions of support from friends and family and their engagement with others (questions 7, 11, and 15). The physical health domain evaluates health-related outcomes, including healthcare utilization, frequency of infections, and medication use following BAHA implantation (questions 8, 12, and 13). The general benefit domain evaluates overall changes in patients' well-being, psychological status, daily functioning, and perceived benefit related to hearing and quality of life following BAHA use (remaining questions). Each question is scored on a scale from -2 to +2, where -2 represents the worst outcome, +2 the best outcome, and 0 indicates no change. Subscale and total scores are calculated by averaging question scores and multiplying by 50, yielding final scores ranging from -100 to +100, with higher scores indicating greater perceived benefit.

Ethical approval was obtained from the İstanbul University Faculty of Medicine Clinical Research Ethics Committee. (Approval No: 2024/2313; Date: December 27, 2024).

Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics version 31.0 (IBM SPSS Corp.; Armonk, NY, USA). The distribution of continuous variables was evaluated using the Shapiro-Wilk test, Q-Q plots, and assessments of skewness and kurtosis. Categorical data are expressed as frequencies and percentages (n, %). The Mann-Whitney *U*-test was applied for non-normally distributed continuous variables. A *P*-value < .05 was considered statistically significant.

Results

A total of 46 patients who underwent BAHA implantation were included in the study, comprising percutaneous (n = 13) and transcutaneous (n = 33) users. The median age of the entire cohort was 32.50 years [interquartile range (IQR): 15.75-47.75] (range, 8-76 years), and the median follow-up duration was 95.50 months [IQR: 37.00-132.00] (range, 16-158 months). Of the total cohort, 24 patients (52.2%) were female and 22 (47.8%) were male. BAHA implantation was performed on the right side in 30 patients (65.2%) and on the left side in 16 patients (34.8%). Demographic and clinical characteristics of the patients are summarized in Table 1.

Glasgow Benefit Inventory scores were compared between the percutaneous and transcutaneous BAHA groups (Table 2). A statistically significant difference was observed only for the general benefit score, which was higher in the percutaneous group than in the transcutaneous group (median [IQR]: 83.34 [37.50-89.58] vs.

Table 1. Demographic and Clinical Characteristics of Patients

	BAHA Types	
	Transcutaneous	Percutaneous
Patient count, n (%)	33	13
Age, median (IQR) (min-max)	30 [15-45] (8-76)	40 [19-61.5] (17-65)
Sex, n (%)		
Female	15 (45.5)	9 (69.2)
Male	18 (54.5)	4 (30.8)
Side		
Right	23 (69.7)	7 (53.8)
Left	10 (30.3)	6 (46.2)
Follow-up duration, months, median [IQR] (min-max)	67 [26.5-110] (16-141)	134 [132-142] (129-158)

BAHA, bone-anchored hearing aid; IQR, interquartile range. Data are presented as n (%) or median [interquartile range] (minimum–maximum), as appropriate.

41.67 [20.83-70.83], $P = .032$). For total GBI, scores were numerically higher in the percutaneous group; however, the difference did not reach statistical significance ($P = .069$). Differences in social benefit ($P = .157$) and physical health ($P = .502$) were also not statistically significant.

Due to the small number of patients in the softband BAHA group ($n = 3$), this group was not included in comparative statistical analyses and was evaluated descriptively. Median (min-max) scores in the softband group were 44.44 (16.67-47.22) for total GBI, 33.33 (0.00-33.33) for social benefit, 0.00 (0.00-50.00) for physical health, and 45.83 (16.67-70.83) for general benefit.

Discussion

Percutaneous and transcutaneous bone-anchored hearing devices each have their own advantages and disadvantages, and this topic has been the subject of numerous studies. In percutaneous bone conduction hearing systems, the direct mechanical coupling to the skull via an abutment eliminates impedance related to the skin and soft tissues, allowing sound energy to be transmitted more efficiently across all frequency bands. This feature provides a clear advantage over passive transcutaneous systems, particularly in terms of vibration transmission. In passive transcutaneous devices, because vibrations are transmitted to the implant component through the skin, transmission losses of up to approximately 20 dB—especially at high frequencies—have been reported.^{9,10}

In contrast, a major disadvantage of percutaneous systems is the skin and wound-related complications that may develop due to surgical

incisions disrupting skin integrity and the presence of a transcutaneous abutment penetrating the skin. These complications may, over time, lead to device extrusion and the need for additional revision surgeries.¹¹⁻¹³ The primary purpose of developing transcutaneous devices is to minimize the skin-related problems associated with the abutment in percutaneous systems. In transcutaneous systems, the external processor is magnetically retained by a magnet placed within the implant while preserving skin integrity, and there is no component that traverses the skin. Although the absence of a skin incision for abutment placement represents an important advantage, complications such as skin irritation, pain, and, in advanced cases, skin necrosis may occur due to the pressure force generated by the magnet.^{14,15}

In passive devices, a tight coupling to the skin is required to minimize signal attenuation; however, under these conditions, the risk of pressure-related skin complications increases.^{14,16} Active bone conduction hearing systems aim to reduce skin-related problems observed in percutaneous and passive transcutaneous devices and to eliminate signal loss associated with vibration transmission. In these systems, sound signals detected by the external processor are transmitted to the internal component in the form of electrical stimulation, in a manner similar to cochlear implant technology. By generating mechanical vibrations at the level of the implant, transmission loss related to the skin and soft tissues does not occur, and moreover, there is no need to apply high magnetic pressure on the skin for the device to function. With these characteristics, active systems are considered a more advantageous option compared with passive transcutaneous devices in terms of both audiological performance and complication risk.^{5,17}

In this study, the long-term patient-reported outcomes of patients using transcutaneous and percutaneous bone conduction hearing devices were compared using the GBI. The findings demonstrate that both implant types provide significant patient benefit in the long-term. However, the fact that the general benefit subscore was statistically significantly higher in favor of the percutaneous group represents a noteworthy finding that contradicts some expectations frequently emphasized in the literature. Apart from this, no significant difference was detected in subscales such as total benefit, social benefit, and physical health. These findings indicate that bone conduction implants provide subjective benefit after hearing rehabilitation with both systems, but that the perception of subjective satisfaction between the systems may be complex.

In the literature, comparisons between percutaneous and transcutaneous systems in terms of quality-of-life scores have reported that transcutaneous systems are more advantageous in certain subscales. For example, in a detailed systematic review including 52 studies conducted by Gutierrez et al, transcutaneous devices were found to have significantly higher GBI scores compared with percutaneous devices.¹⁵ This represents a different trend from the higher general benefit scores observed in the study and suggests that transcutaneous systems may provide superior subjective benefit in some cases. In most of the studies included in the meta-analysis, the mean follow-up duration was either not clearly specified or reported within a wide range; in many studies, follow-up periods varied between 6 and 24 months, indicating that data on long-term outcomes remain limited.¹⁵ This situation makes it difficult to evaluate adaptation over time, changes in expectations, and patterns of

Table 2. GBI Scores According to BAHA Type

GBI Subgroups	Transcutaneous (n = 33)	Percutaneous (n = 13)	P
Total	41.67 [12.50-59.72]	69.45 [29.17-81.94]	.069
General benefit	41.67 [20.83-70.83]	83.34 [37.50-89.58]	.032
Social benefit	16.67 [0-50.00]	66.67 [8.33-100]	.157
Physical health	16.67 [0-41.67]	16.67 [0-75.00]	.502

Data are presented as median [interquartile range]. GBI scores range from -100 to +100, with higher scores indicating greater perceived benefit. Between-group comparisons were performed using the Mann-Whitney U-test, and P values < .05 were considered statistically significant and are indicated in bold. BAHA, bone-anchored hearing aid; GBI, Glasgow Benefit Inventory.

device use. In contrast, in the present study, a particularly long follow-up period was observed, especially in the percutaneous group (median 134 months). During long-term follow-up, it is possible that patients' adaptation to device use increases, maintenance procedures become routine, and certain factors initially perceived as problematic are gradually tolerated over time. This may have led to skin care requirements and abutment-related issues, which are considered disadvantages of percutaneous systems in the early period, being perceived as less problematic by patients in the long-term. In transcutaneous systems, the preservation of skin integrity, which provides an advantage in the early period, may be counterbalanced over time by problems related to magnetic pressure, such as skin sensitivity, pain, erythema, skin thinning, and pressure intolerance. Particularly in patients who require increased magnet strength, it can be suggested that this chronic pressure may negatively affect patient comfort over the years and reduce the perception of subjective benefit. This suggests that although transcutaneous systems may be better tolerated in the short term, they may not always maintain the expected advantage in long-term patient-reported outcomes. Therefore, the general benefit perception and GBI general benefit scores of long-term users in the study are believed to differ from those reported in the literature.

On the other hand, in a retrospective comparison conducted by Robinette et al, no statistically significant difference in overall quality of life was found between percutaneous and transcutaneous systems; however, the percutaneous group was reported to have relatively higher complication rates.¹⁸ In addition to GBI scores, other studies evaluating quality of life have also demonstrated positive effects of bone conduction implants on patient-reported outcomes. In particular, a study examining patients using percutaneous bone conduction devices reported significant improvements in both GBI and Glasgow Hearing Aid Benefit Profile scores, and these gains were shown to be sustainable over long-term follow-up.¹⁹

The results of this study indicate that the subjective benefit obtained by patients using bone conduction implants may vary depending on the type of device. The observation of a higher perception of general benefit in some patients using percutaneous systems may be related to factors such as patient selection, level of expectation, duration of adaptation to device use, and long-term clinical follow-up. On the other hand, transcutaneous systems are thought to positively affect quality of life, particularly in certain patient groups, due to the lower incidence of soft tissue complications and reduced maintenance requirements. Nevertheless, the study demonstrated that both systems provide significant subjective benefits for their users.

The imbalance in sample size between the transcutaneous and percutaneous groups represents a limitation of this study and may affect the statistical power and generalizability of the findings. Another limitation of this study is the lack of standardized pre- and post-operative audiometric data. Owing to the retrospective design and long study period, audiological records from earlier implantations were not consistently available, preventing correlation between objective hearing outcomes and patient-reported quality-of-life measures; additionally, information regarding magnet strength was not consistently available and therefore could not be evaluated.

In conclusion, percutaneous and transcutaneous bone conduction implants are effective options for improving auditory rehabilitation

and quality of life when applied with appropriate indications. In the clinical decision-making process, patient age, comorbidities, skin characteristics, aesthetic expectations, and anticipated long-term use should be taken into consideration. It is believed that future studies with a prospective design and larger patient cohorts will more clearly elucidate the long-term effects of different implant systems on quality of life.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Ethics Committee Approval: Ethical committee approval was received from the Istanbul University Faculty of Medicine Clinical Research Ethics Committee (Approval no: 2024/2313, Date: December 27, 2024).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

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