BAHA in the auditory rehabilitation of patients with chronic cholesteatomatous otitis media

Original Article

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Abstract

Introduction: The treatment of chronic cholesteatomatous otitis media (CCOM) is surgical and may require an open technique mastoidectomy. Hearing loss resulting from the disease and/or its surgical removal is traditionally corrected with tympanoplasty or conventional hearing aids, but other options are available, such as the Bone Anchored Hearing Aid (BAHA).

Objective: To evaluate the functional outcomes and impact on the quality of life of patients with CCOM rehabilitated with BAHA.

Material and Methods: All patients with CCOM who underwent auditory rehabilitation with BAHA in 2022 and 2023 at a Tertiary Hospital Center were included. Demographic data, surgical interventions performed for CCOM, pre- and post-implantation tonal and speech thresholds, type of anesthesia used, and complications associated with the procedure were collected. The impact on quality of life was assessed using the Nijmegen Cochlear Implant Questionnaire (NCIQ) validated for European Portuguese.

Results: Eight patients, seven female, with a mean age of 56 years, were rehabilitated with unilateral BAHA (a total of 8 ears) due to conductive hearing loss (1 patient) or mixed hearing loss (7 patients). All rehabilitated ears had undergone an open technique mastoidectomy for CCOM surgical treatment. All implanted BAHA devices were percutaneous.

Before implantation, the average tonal threshold of the nine patients was 87 dB, and the mean audiometric Rinne was 45 dB. The preoperative mean speech recognition threshold (SRT) was 69 dB. After implantation, the mean tonal thresholds improved to 38 dB, with an average tonal threshold improvement of 49 dB. The postoperative SRT mean was 32 dB.

Four patients presented skin alterations classified as grades 1 and 2 according to the Holgers classification, and there was one case of spontaneous pillar extrusion.

The average overall satisfaction score on the NCIQ was 79.36. The subdomains with the highest mean scores were speech production (86.25) and advanced sound perception (84.9). The self-esteem subdomain had the lowest mean score (66.48).

Conclusion: Auditory rehabilitation with BAHA

proved effective in improving hearing thresholds and quality of life in CCOM patients who underwent open technique mastoidectomy, making it a valid option for their auditory rehabilitation. Cutaneous complications with percutaneous BAHA are frequent, highlighting the importance of skin care and monitoring around the pillar area.
Keywords: Chronic cholesteatomatous otitis media, conductive hearing loss, mixed hearing loss, auditory rehabilitation, Bone Anchored Hearing Aid, otorrhea, quality of life.

Introduction

Chronic otitis media with cholesteatoma (COMC) is one of the most prevalent infectious ear diseases worldwide and is frequently associated with significant otologic complications, including conductive and mixed hearing loss.[1] Surgical intervention is the treatment of choice for COMC, with open mastoidectomy often required, particularly in more advanced cases.[1,2] However, despite appropriate surgical management, many patients continue to experience hearing impairment, highlighting the need for effective auditory rehabilitation strategies to restore auditory function and enhance the quality of life.[2]

Although several surgical techniques have been proposed to optimize functional hearing outcomes, there is currently no consensus on the most effective therapeutic strategy for these patients. Conventional air conduction hearing aids are typically the first-line treatment. However, in patients with chronic inflammation of the external auditory canal or mastoidectomy cavity, they may be contraindicated due to persistent otorrhea, discomfort, or adaptation difficulties.[1–3]

Bone conduction implants (BCIs), including the bone-anchored hearing aid (BAHA), are an effective alternative for auditory rehabilitation in patients with conductive or mixed hearing loss.[3] BAHAs are indicated for conductive or mixed hearing loss and single-sided deafness, and have no requirements regarding laterality or symmetry of the hearing loss. BAHA indication should be based on the functional status of both ears, as bone conduction involves bilateral sound transmission. The current evidence suggests that the most favorable outcomes are achieved in patients with bilateral symmetrical conductive hearing loss.[3] The BAHA system consists of two components: an external sound processor and internal implant, and is classified into transcutaneous and percutaneous. In both configurations, sound is transmitted mechanically via skull vibrations directly to the cochlea, resulting in wave propagation along the basilar membrane and subsequent stimulation of the auditory nerve. BAHA eliminates the need for inserting molds, ear tips, or any sound-conducting materials into the external auditory canal, and offers improved audiological outcomes.[1–5]

This study aimed to evaluate the functional hearing outcomes and impact on the quality of life in patients with COMC who underwent hearing rehabilitation with BAHA.

Materials and Methods

This retrospective observational study included all patients with COMC who underwent auditory rehabilitation with BAHA between January 2022 and December 2023 at a tertiary care hospital. The study assessed audiological outcomes, surgical complications, and impact on the quality of life in this population.

Inclusion and exclusion criteria

The inclusion criteria were a confirmed diagnosis of COMC in patients who had previously undergone otologic surgery, indication for auditory rehabilitation with BAHA due to conductive or mixed hearing loss, and a minimum follow-up of six months after device activation. The exclusion criteria were bilateral profound sensorineural hearing loss or implant failure due to rejection or non-adherence to clinical follow-up protocols.

Data collection

The following data were collected and analyzed: demographic characteristics (age, sex), history of otologic interventions related to chronic suppurative otitis media, type of anesthesia used during BAHA implantation,

model of the BAHA device used, intraoperative and postoperative complications, and need for surgical revision.

The Holgers classification system was used to grade skin reactions at the implant site. This system defines five grades as follows:

- Grade 0: Healthy skin.
- Grade 1: Mild erythema and irritation.
- Grade 2: Erythema and secretion.
- Grade 3: Granulation tissue.
- Grade 4: Infection leading to the extrusion of the abutment.

Audiological assessment

Auditory thresholds for pure tones and speech were measured pre- and post-implantation.

Quality of life assessment

To assess the impact of auditory rehabilitation on the quality of life, the European Portuguese validated version of the Nijmegen Cochlear Implant Questionnaire (NCIQ) was administered. This instrument measures the effect of hearing rehabilitation across multiple domains, including communication ability, self-esteem, and social interaction.

Results

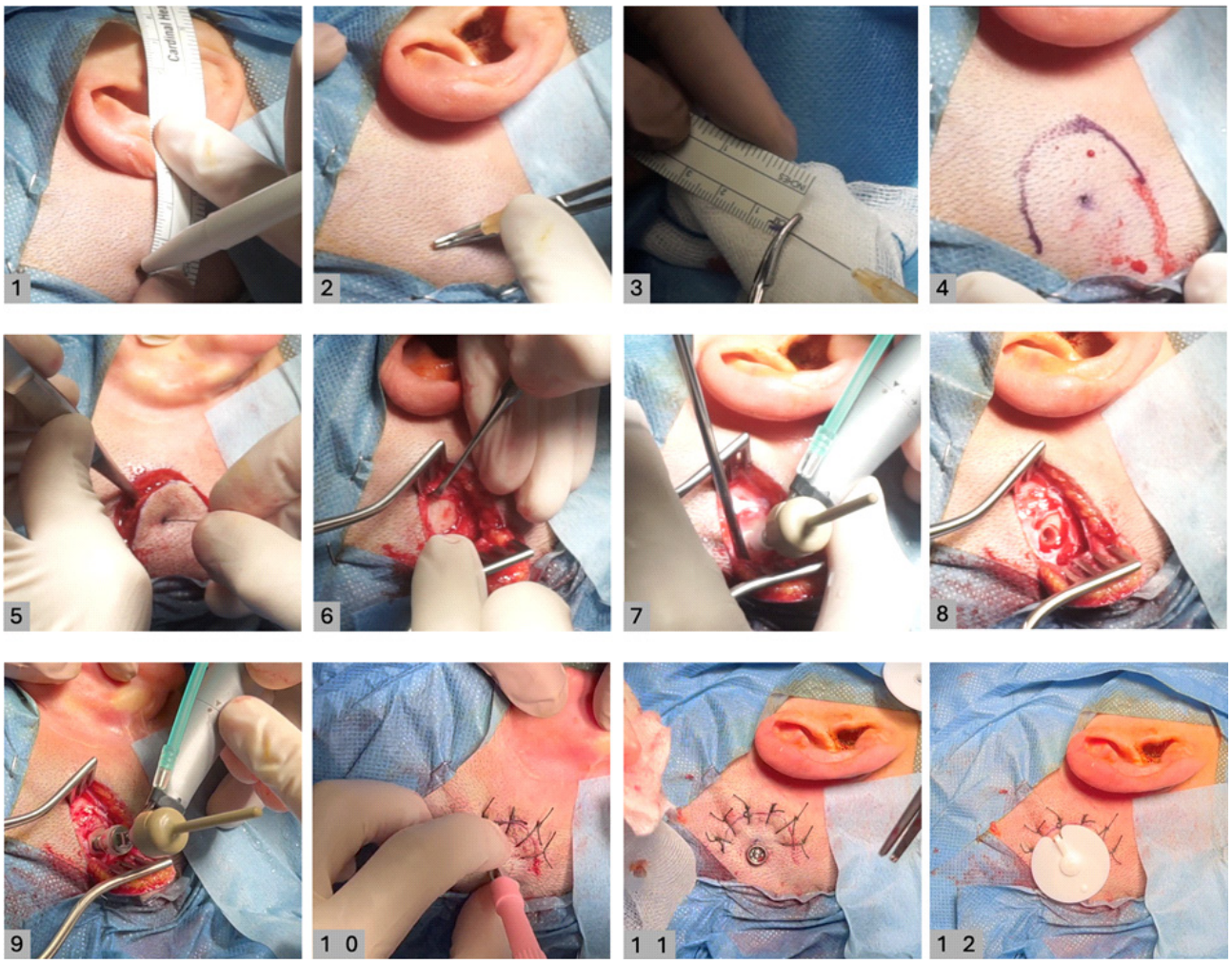
Between 2023 and 2024, eight patients with a history of COMC underwent unilateral rehabilitation with BAHA. Among them, seven were women, with an average age of 56 (22–75) years. All implanted ears had previously undergone open mastoidectomy for the surgical management of COMC. One patient required three revision surgeries due to chronic otorrhea from the mastoidectomy cavity. The remaining cases underwent a single surgical intervention. BAHA implantation was indicated for conductive hearing loss in one case and mixed hearing loss in seven cases. All patients received a percutaneous BAHA Connect device (Cochlear®), amounting to eight implants, five in the right ear and three in the left. The procedure was performed under general anesthesia in two cases and local anesthesia in six. All implants were placed using the same surgical technique. First, the implant site was marked approximately 6 cm from the tragus, along a line tangent to the upper curvature of the helix. Next, the skin and soft tissue thickness was measured using a subcutaneous needle, which is essential for determining the appropriate abutment size. Subsequently, the soft tissues were infiltrated with lidocaine and adrenaline. An arc-shaped incision was made extending to the supra-periosteal plane, 1–2 cm anterior to the abutment site, followed by dissection of tissues in this plane. A periosteal incision was then made in a cross pattern, with careful elevation of the periosteum. The implant bed was prepared using a 3 mm drill and, if necessary, a 4 mm drill. The orifice was widened to create a circumferential margin in the bone at the implant site, and the implant and abutment were placed. Next, closure of the incision was performed, followed by exposure of the abutment using the punch technique. The final step was the placement of a healing cap to support the healing process. Prior to implantation, the mean pure-tone average (PTA) in the implanted ear was 87 dB, and the mean Rinne audiometric result was 45 dB. The mean preoperative speech recognition threshold (SRT) was 69 dB. Following implantation, the PTA improved to 38 dB, with a mean gain of 49 dB. The mean postoperative SRT was 32 dB. Audiometric evaluation of the contralateral (non-implanted) ear revealed severe hearing impairment in most cases, with a mean air conduction (AC) PTA of 69 dB and bone conduction (BC) PTA of 20 dB.

Skin reactions occurred in four patients, classified as Holgers grades 1 and 2. These complications were managed with topical ointment containing corticosteroids and antibiotics, leading to complete resolution without the need for additional treatment.

The mean overall satisfaction score on the NCIQ was 79.36. The mean subdomain scores were as follows: basic sound perception, 80.31; speech production, 86.25; advanced sound perception, 84.9; self-esteem, 66.48; activity limitation, 81.91; and social interaction, 76.31.

In general, all patients reported a significant

Figure 1
1. Marking of the implant site, 6 cm from the tragus. **2** and **3**. Measurement of skin and soft tissue thickness using a subcutaneous needle. **4**. Marking of the arc-shaped incision. **5**. Arc-shaped incision extending to the supra-periosteal plane and verification of the implant site using a subcutaneous needle. **6**. Periosteal incision in a cross pattern, with elevation of the periosteum. **7**. Preparation of the implant bed using a drill and widening of the orifice to create a circumferential margin in the bone at the implant site. **(8)**. **9**. Placement of the implant and abutment. **10** and **11**. Closure of the incision and exposure of the abutment using a punch. **12**. Placement of the healing cap.



improvement in the quality of life following auditory rehabilitation with BAHA.

Discussion

The results demonstrated a significant improvement in PTA, which decreased from 87 dB preoperatively to 38 dB postoperatively, an average auditory gain of 49 dB. This improvement is particularly relevant because hearing loss associated with COMC is typically conductive or mixed, and often refractory to conventional treatments such as hearing aids.[1]

BAHA provides an effective solution by enabling direct bone conduction, bypassing the affected structures of the external and middle ear. This is particularly advantageous for patients with COMC, who frequently exhibit chronic inflammation and anatomical changes in the external auditory canal and mastoid, making traditional hearing aids an unviable option.[3,5]

All patients in this study presented with an air-bone gap in the contralateral ear, indicative of bilateral conductive or mixed hearing loss. Additionally, BC-PTAs in the

Figure 2
Mean audiometric results prior to implantation. The left image shows the mean air conduction (AC) and bone conduction-pure-tone averages (BC-PTAs) for each frequency in the implanted ear; the middle image shows the AC and BC-PTAs for each frequency in the contralateral ear; and the right image shows the average thresholds for each frequency of free-field asymptotic threshold shift (ATS) after bone-anchored hearing aid (BAHA) implantation.

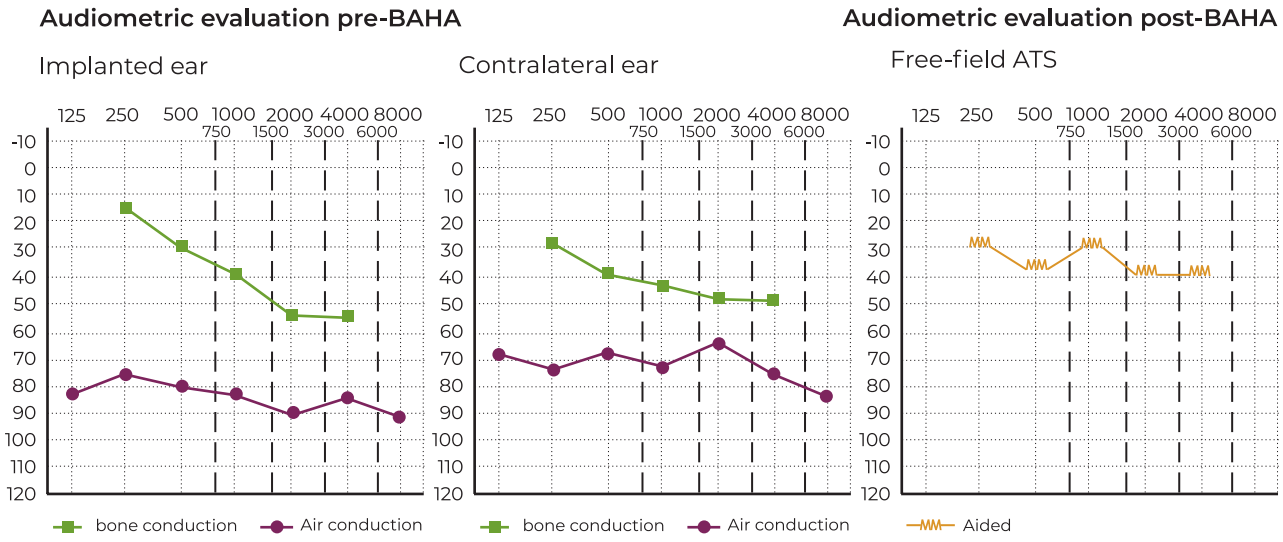
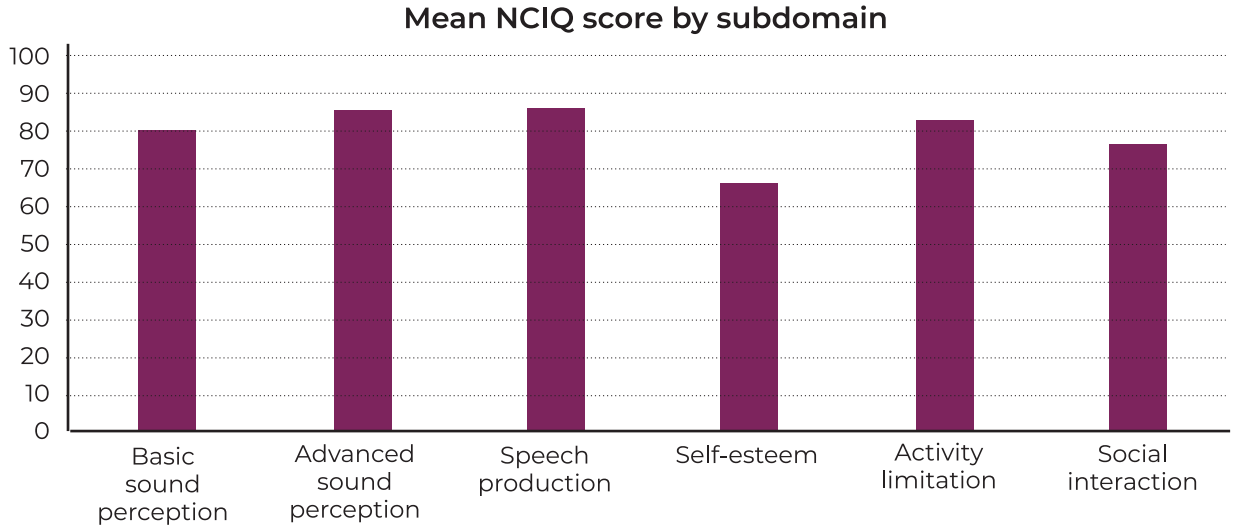


Figure 3
Mean Nijmegen Cochlear Implant Questionnaire (NCIQ) score by subdomain



implanted ears were generally worse than those in the contralateral ears, possibly due to longstanding inflammatory damage. Because BAHA transmits sound to the cochlea with better BC-PTA, preserved contralateral cochlear function can significantly enhance auditory outcomes. Therefore, thorough evaluation of the contralateral ear is essential, as its condition directly influences both the indication for implantation and efficacy of auditory rehabilitation, particularly in COMC cases where bilateral involvement is common.[1] Beyond the objective improvements in auditory thresholds, BAHA offers substantial benefits in terms of binaural hearing, especially for patients with bilateral hearing impairment. By routing sound to the contralateral cochlea with a better threshold,

the device facilitates more balanced auditory perception, improved sound localization, and enhanced speech intelligibility, particularly in noisy environments. This effect, referred to as cross-hearing or contralateral routing of signal (CROS), is particularly beneficial when bilateral air conduction is compromised. It has been shown that BAHA, by partially restoring bilateral hearing, improves the spatial perception of sound and ability to discern speech in the presence of background noise, one of the most significant challenges faced by patients with COMC. These benefits translate into a significant functional gain that directly affects daily communication and quality of life.[5,6]

In this study, all BAHA implants were percutaneous. In this system, the stimulation is transmitted directly through the abutment, generating skull vibrations without the attenuation typically caused by the skin, thus enhancing the gain at high frequencies. Frequencies above 3 kHz are particularly important for understanding speech in noisy environments.[5]

In our study, four patients developed skin complications classified as Holgers grades 1 and 2. These were successfully managed with a topical corticosteroid and antibiotic ointment, leading to complete symptom resolution. These findings underscore the importance of ongoing monitoring and preventive care at the abutment site. Although skin reactions are relatively common with BAHA implantation, they are typically manageable and do not significantly affect the auditory outcomes or quality of life of patients.

Skin complications are a known postoperative complication of BAHA implantation. Flap necrosis, though relatively rare, is the most common short-term complication. Long-term skin reactions, observed in 15–21% of implanted patients, primarily include soft tissue inflammation and infection surrounding the abutment. These often present as erythema, tenderness, granulation, and discharge, and result from infiltration by B cells, multinucleated cells, and plasma cells. Continuous follow-up is essential to mitigate the infection risk and preserve the integrity of the skin-implant interface.[10]

Several studies have demonstrated that BAHA implantation leads to consistent improvements in the quality of life, including reduced social isolation, enhanced development in children, and cognitive preservation in older adults.[6,7] A study reported NCIQ scores ranging from 49–65 post-BAHA implantation, indicating that the patients were able to function or hear normally in different situations, which was considered a favorable outcome.[11]

In the present study, all patients reported a significant improvement in the quality of life following auditory rehabilitation with BAHA, with high levels of satisfaction on the NCIQ (mean score of 79.36, ranging from 69.16–96.67), particularly in the domains of speech production and advanced sound perception.

Self-esteem was the subdomain with the lowest score, likely influenced by multiple factors. The use of a visible hearing device such as BAHA may be associated with negative aesthetic perceptions. Although BAHA effectively improves hearing, the percutaneous abutment can create discomfort or insecurity due to its visibility, potentially affecting the patient's self-image. Another factor worth considering is the psychological burden of hearing loss itself, which may negatively impact self-esteem even prior to rehabilitation. Finally, self-esteem may also be influenced by unrealistic expectations regarding auditory rehabilitation. While BAHA significantly improves the hearing thresholds and quality of life, it may not fully replicate the experience of natural hearing, which can lead to frustration or dissatisfaction in some patients.

Limitations

This study has several limitations that should be considered when interpreting the results. First, it was a retrospective study with a relatively small sample size of eight patients, which limits the generalizability of the findings to a broader population. The quality of life was

assessed using the NCIQ, a subjective tool that may not fully capture all dimensions of the patients' quality of life. Furthermore, the absence of a control group limits comparisons with other auditory rehabilitation approaches. Finally, the exclusion of failed or complicated cases may have introduced potential selection bias, possibly leading to an overestimation of the observed benefits.

Conclusion

BAHA is an effective auditory rehabilitation option for patients with COMC who have undergone open mastoidectomy, and significantly improves the hearing thresholds and quality of life. However, skin complications are commonly associated with percutaneous BAHA, highlighting the importance of diligent skin care and regular monitoring of the abutment site.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Data Confidentiality

The authors declare having followed the protocols used at their working center regarding patient data publication.

Protection of humans and animals

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and the 2013 Helsinki Declaration of The World Medical Association.

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Availability of scientific data

There are no datasets available, or publicity related to this work.

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