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Review

# Hearing rehabilitation with middle ear implants: An overview

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ABSTRACT

Implant otology has been a rapidly growing field with growing needs and development Over a few decades. The introduction of middle ear implants in the last 2 decades has seen good short-term success in rehabilitation of patients with deafness ranging from mild to severe degree. Middle ear implants are alternatives to conventional hearing aids and bone anchored hearing aids; together these aids and implants provide patients with a range of available options in augmentation of hearing. This article describes the types of middle ear implants and their mechanism of action, the surgical and audio-logical criteria for implantation, their limitations and reported outcomes.



## Introduction

Conventional hearing aids (CHA) remain the first line option for patients with moderate to severe hearing loss. However, despite advances in hearing aid technology, there is a significant population in whom hearing aids are unsuitable. Common reasons contributing to patient dissatisfaction and subsequent rejection of conventional hearing aids include cosmetic issues, external ear infections, wax impaction, occlusion effect, improper fitting or programming, and feedback.[1]

Surgically implanted hearing devices provide suitable alternatives to rehabilitate hearing in individuals who are unable to tolerate conventional hearing aids. These devices include the osseointegrated implant for bone conduction commonly called Bone Anchored hearing aid (BAHA); cochlear implants (CI); and more recently Middle Ear Implants (MEI). Middle ear implant is a device surgically implanted in the middle ear and coupled with the ossicles. Perceived sound is converted to electrical energy, which is transduced mechanically to drive the ossicles and transfer sound energy to cochlea. These implants bypass the external auditory canal, which remain unoccluded and hence free of infections and wax impaction as compared to CHA. In addition these are cosmetically more acceptable to patients. Advances in implant technology and increasing surgical expertise have significantly contributed to restoring hearing and improving the quality of life in individuals with hearing loss where CHA are unsuitable.

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## Middle ear implants – surgical and audiological criteria

The more recent introduction of the MEI now allows the otologist to offer an implantable option for individuals who are unsuitable for either a Cochlear implant or BAHA.

The surgeon and the audiologist jointly do candidate selection for surgically implantable hearing devices. MEIs are indicated in patients with moderate to severe hearing loss. When it was first introduced, the targets were mainly people with sensori-neural hearing loss. There have been studies on direct coupling of the MEI transducer to the round window in patients with conductive and mixed hearing loss[2] with good hearing benefit. This has extended the audiological criteria for MEI.

### *Surgical criteria*

It is essential to try CHA on all patients seeking augmentation of hearing, before considering implantation. Patients not receiving adequate hearing benefit after having explored all options of CHA appropriate for their hearing loss; and patients having problems with use of ear moulds such as occlusion effect, feedback phenomenon, recurrent otitis externa, meatal stenosis and CSOM can be offered MEI. Candidates for MEI should be free of any middle ear disease or infection at the time of implantation.

It has been suggested that the sound quality produced by MEIs may be better than CHA, more so in the presence of background noise.[3] These implants may be also of benefit in patients who require their outer ear canal to be open for professional needs, example musicians and singers and physicians who need to use a stethoscope.[4] Linder[5] et al. have reported safe use of VSB in patients operated for petrosectomy with or without obliteration of cavity for cholesteatoma cases. Other cases like cochlear otosclerosis, external ear atresia,[6,7] exostosis, or other abnormalities of external ear can also be offered MEI for hearing rehabilitation. Recently, an international consensus[8] on their use in children has been published. Garin P[9] et al. have reported improved speech intelligibility in background noise in patients with bilateral sequential Vibrant Sound-Bridge (a semi-implantable MEI) implantation. There may certainly be a role of bilateral implantation in aiding binaural benefits with sound localisation, similar to the use of bilateral HA. However, cost implications of this will be a limiting factor.

### *Audiological criteria*

MEIs are suitable for patients with moderate to severe sensorineural hearing loss, with hearing thresholds of up to 65–70 dB. It is important to check that hearing thresholds have been stable over a two year period. Patients should have speech discrimination scores of over 50%. Patients in whom hearing thresholds fulfil criteria for a MEI yet exhibit speech discrimination scores below 50%, are then possible candidates for a CI. For these candidates it is now possible to insert cochlear implants and preserve their natural low frequency hearing. Cochlear implants surgery using a hearing preservation technique provides improved pitch perception and speech performance in noise.[10] Hence, it is necessary to refer all individuals that may be potential candidates for an implantable hearing aid to an implant centre. A thorough audiological assessment and the expertise of the implant team are vital steps towards selecting the most appropriate implant and optimal outcomes for an individual.

In patients with conductive or mixed hearing loss with 30–60 dB bone-conduction levels and 30–40 dB air bone gap, the transducer can be coupled directly to the round window (RW), using sono-inversion for hearing amplification. This method is particularly useful in patients with previous treated cholesteatoma and resultant conductive/mixed hearing loss, ossicular discontinuity, middle ear malformations and chronic inactive middle ear disease. These patients are also suitable for BAHA. However, some patients would not wish to consider a per-cutaneous device and opt for MEI if given a choice.

Indications for BAHA and MEI do significantly overlap, in that they can be offered to the group of patients who benefit audio-logically with a hearing aid, however cannot wear a CHA mould in their external auditory canal for various reasons. BAHA can also be provided as a CROS aid in patients with single-sided deafness. The clinical indications for the implantable aids are summarised in Table 1. Further detailed description of BAHA and CI is beyond the scope of this article.

## Types of middle ear implant

The MEI device is surgically implanted and increases the vibratory signal[11] to the cochlea. MEI's are available as totally implantable or semi-implantable devices. The benefits of totally implantable MEIs include the ability to hear during sleep or water activities; and are cosmetically more

**Table 1 – Indications of implantable hearing aids.**

| Device | Indications |
|---|---|
| BAHA | • Bilateral/unilateral conductive hearing loss<br>• Bone conduction thresholds better than 60 dBHL<br>• Unilateral severe/profound hearing loss[a] |
| Cochlear implant | • Profound deafness (Unaided HTL >90 dBHL at 2 and 4 kHz),<br>• Severe deafness in patients who do not receive adequate benefit from acoustic hearing aids[b] |
| Middle ear implant | • Moderate to severe sensorineural hearing loss[c]<br>• Conductive or mixed hearing loss[c] |

HTL – hearing threshold level.
a CROS aid in single sided deafness.
b Adequate benefit from acoustic hearing aids is defined as a score of 50% or greater on Bamford–Kowal–Bench (BKB) sentence testing at a sound intensity of 70 dB SPL.
c Hearing threshold up to 70 dBHL & speech discrimination scores of over 50%.