
Medical Policy



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Title: Semi-Implantable and Fully Implantable Middle Ear Hearing Aids

Description/Background

Moderate-to-severe sensorineural hearing loss is often treated with external acoustic hearing aids, while conductive hearing loss can be treated with acoustic or bone-conduction hearing aids when surgical or medical interventions do not correct hearing loss. Semi-implantable and fully implantable middle ear hearing aids detect sound and transduce signals directly to the ossicles in the middle ear and have been used as an alternative to external acoustic hearing aids.

HEARING LOSS

Hearing loss is described as conductive, sensorineural, or mixed, and can be unilateral or bilateral. Normal hearing is the detection of sound at or below 20 decibels (dB). The American Speech Language-Hearing Association has defined the degree of hearing loss based on pure-tone average (PTA) detection thresholds as mild (20-40 dB), moderate (40-60 dB), severe (60-80 dB), and profound (≥ 80 dB).

Treatment

Sound amplification through the use of an air-conduction hearing aid can provide benefit to patients with sensorineural, conductive, or mixed hearing loss. Contralateral routing of signal is a system in which a microphone on the affected side transmits a signal to an air-conduction hearing aid on the normal or less affected side.

Patients with moderate to severe sensorineural hearing loss are typically fitted with external acoustic hearing aids. Conductive hearing loss may be treated with acoustic or bone conduction hearing aids when surgical or medical interventions are unable to correct hearing loss. However, these hearing aids may not be acceptable to patients, either due to issues related to anatomic fit, sound quality, or personal preference. In some cases, external acoustic hearing aids cannot be used due to external ear pathologies (e.g., otitis externa).

Semi- and Fully Implantable Middle Ear Hearing Aids

Semi-implantable and fully implantable middle ear hearing aids are alternatives to external acoustic hearing aids. Two semi-implantable devices have Food and Drug Administration (FDA) approval, the Vibrant Soundbridge and the Maxum System. The devices consist of 3 components: a magnetic component that is implanted onto the ossicles of the middle ear, a receiver, and a sound processor. The Soundbridge device is implanted subcutaneously behind the ear while the processor is worn externally on the scalp over the receiver unit and held in place by a magnet. The Maxum System device is placed in the user's ear canal while the processor rests over the external ear. In general, the sound processor receives and amplifies the sound vibrations and transforms the sound pressure into electrical signals received by the receiver unit. The receiver unit then transduces these electrical signals into electromagnetic energy and creates an alternating electromagnetic field with the magnetic component (floating mass transducer) implanted on the ossicles of the middle ear. This electromagnetic field results in attractive and repulsive forces on the magnetic implant, causing vibration of the bones of the middle ear similar to normal hearing.

One fully implantable middle ear hearing aid has FDA approval, the Esteem Implantable Hearing System. Similar to the semi-implantable devices, the fully implantable device consists of a sensor, a sound processor, and a driver which is connected to the ossicles. The sensor detects vibrations of the tympanic membrane and transforms the vibrations into electrical signals that are processed by the sound processor. The processor transduces these signals via piezoelectric transduction, as opposed to the electromagnetic transduction used in the semi-implantable devices. A piezoelectric transducer (the sensor) is placed at the head of the incus and converts mechanical vibrations detected from the tympanic membrane to electrical signals delivered to the stapes by another piezoelectric transducer (the driver).

Regulatory Status:

Two semi-implantable devices were approved by the Food and Drug Administration (FDA) through the premarket approval process: the Vibrant® Soundbridge™ (MED-EL Corp.) in 2000, and the Direct System™ (Soundtec) in 2001. The Soundtec system was discontinued by the manufacturer Ototronix in 2004 due to performance issues; it was re-released in 2009 under the name Maxum™ System. Approved FDA labeling for both states that the devices are "...intended for use in adults, 18 years of age or older, who have a moderate to severe sensorineural hearing loss and desire an alternative to an acoustic hearing aid." FDA product code: MPV.

In 2010, the Esteem® Implantable Hearing System (Envoy Medical, St Paul, MN), a fully implantable middle ear hearing aid, was approved by FDA through the premarket approval process. FDA-approved labeling for the Esteem hearing implant indicates it is "intended to alleviate hearing loss...in adults 18 years of age or older with stable bilateral sensorineural hearing loss." FDA product code: OAF.

Another fully-implantable middle ear hearing aid, the Carina® Fully Implantable Hearing Device is in development (Otologics, now Cochlear), but does not have FDA approval. Phase I and II trials have been conducted in the United States under investigational device exemptions.(1)

Medical Policy Statement

Semi-implantable and fully implantable middle ear hearing aids are considered experimental/investigational. The safety and effectiveness of these devices have not been established.

Inclusionary and Exclusionary Guidelines

N/A

CPT/HCPCS Level II Codes *(Note: The inclusion of a code in this list is not a guarantee of coverage. Please refer to the medical policy statement to determine the status of a given procedure)*

Established codes:

N/A

Other codes (investigational, not medically necessary, etc.):

69799 S2230 V5095

Rationale

SEMI-IMPLANTABLE MIDDLE EAR HEARING AIDS

Clinical Context and Therapy Purpose

The purpose of semi-implantable middle ear hearing aids for the treatment of hearing loss is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The following PICOs were used to select literature to inform this review.

Populations

The relevant population of interest is patients with hearing loss who are unable to use external hearing aids or who are not candidates for cochlear implants.

Interventions

The therapy being considered is the use of semi-implantable middle ear hearing aids as treatment of hearing loss.

Comparators

The following therapies and practices are currently being used to make decisions about treatment of external hearing aids. Externally worn acoustic hearing aids are widely accepted devices for patients with hearing loss. Therefore, this review of semi-implantable and fully implantable hearing aids focuses on comparisons of various audiologic outcome measures

between an externally worn hearing aid and a semi- or fully implantable hearing aid in the same patient. Studies of semi- and fully implantable middle ear hearing aids have frequently reported a patient preference for an implantable device compared with an externally worn device. However, it must be determined to what extent patient preference is based on convenience compared with improved hearing.

Outcomes

The general outcomes of interest include symptoms, functional outcomes, quality of life, and treatment related morbidity. Only minimal safety concerns are related to external hearing aids. In contrast, an implantable hearing aid requires a surgical procedure. Potential risks cited for semi-implantable middle ear hearing aids include a decrease in residual hearing in the implanted ear, infection in the ear and adjacent structures, and risks associated with general anesthesia. Major ear surgery may also result in numbness, swelling, or discomfort around the ear, the possibility of facial palsy, neck pain, and disturbance of balance and taste. Therefore, equivalency or improvement in audiologic outcomes associated with an implantable hearing aid must be balanced against the potential risks inherent in a surgical procedure. Patients with hearing loss who receive a semi-implantable middle ear hearing aid will require acute post procedure follow-up and at least 6-12 months to ascertain impact on hearing.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
- To assess longer term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence

Trials Supporting Regulatory Approval of Semi-Implantable Hearing Aids for Sensorineural Hearing Loss

The U.S. Food and Drug Administration (FDA) approvals of the Soundbridge and Soundtec (now marketed as the Maxum System) devices were based in part on clinical trials of 53 and 108 patients, respectively, who had moderate-to-severe sensorineural hearing loss and who were dissatisfied with their existing external acoustic hearing aid. Results of these trials are available in the FDA Summaries of Safety and Effectiveness.⁽²⁾ The results of the Soundbridge and Soundtec trials have also been reported in the peer-reviewed published literature.⁽³⁾ The principal outcome measures were audiologic before (with the hearing aid in use) and after the implant. The following audiologic outcomes were reported: functional gain, speech recognition, patient assessments, and safety. Each is discussed below.

Functional Gain

Functional gain is defined as the difference in sound field threshold (measured in decibels [dB]) and is an indicator of functional benefit from an amplification device. For the Soundbridge device, the improvement in functional gain was 14.1 dB, while for the Soundtec device, it was 7.9 dB. Both gains were considered modest improvements. The clinical significance of the

improvement is difficult to determine. For example, this level of improvement may be more clinically significant in patients with moderate hearing loss, for whom a 14-dB improvement in threshold might move them into the normal range for the spoken voice.

Speech Recognition

Speech recognition is assessed using the Speech Perception in Noise test and the Northwestern University–six test, which consists of a 50-item word list. For the Soundbridge device, no significant difference in word recognition was found in quiet or noisy conditions between the implant and acoustic hearing aid. For the Soundtec device, a statistically significant improvement was noted in Northwestern University–six and Speech Perception in Noise test results at 52 weeks compared with an optimally fitted hearing aid. However, only 12 patients had completed the 52-week follow-up.

Patient Assessments

Patient self-evaluation was performed in a variety of ways. The Profile of Hearing Aid Performance consists of 7 subscales that assess several dimensions of hearing aid effectiveness, such as ease of communications, reverberation, and distortion of sound. The Hearing Device Satisfaction Scale (HDSS) was developed by Symphonix, the manufacturer. This scale evaluates hearing aid and Soundbridge use and the general satisfaction level. The number of subjects who reported improvements was significant across all 7 Profile of Hearing Aid Performance subscales. The largest improvements in the Soundbridge compared with the acoustic hearing aid were reported for reverberation, reduced cues, and background noise. Based on Hearing Device Satisfaction Scale scores, 94% reported improved overall sound quality for the Soundbridge. For the Soundtec device, patient satisfaction was based on the Hough Ear Institute Profile. This profile assesses patient preference, acoustic feedback, the perception of speech quality, occlusion, and tinnitus. At 20 weeks post-implant, improvements in all of the parameters were clinically significant. For example, 89% of patients preferred the implantable hearing aid to the acoustic hearing aid, although this result is not surprising because only patients who were dissatisfied with their previous acoustic hearing participated in the trial. A total of 67% of patients reported feedback with their previous acoustic hearing aid, while only 9% reported feedback with the implanted device. The clinical significance of the improvements in functional gain and speech perception is uncertain, although there appears to be a clear patient preference for the implantable devices.(4)

Safety

Minimal safety issues were associated with either device. For the Soundbridge device, the most common complication was a fullness sensation in 18 individuals, which did not resolve in 13 individuals. Altered taste sensation was reported in 7 individuals and transient pain in 13 individuals. Two individuals reported a reduction in residual hearing. With the Soundtec device, the most common complication included device noise, ear pain, ear irritation, and processor failure. These complications resolved in almost all patients; no patient requested removal of the device. However, risks can only be adequately evaluated in broader populations over time.

Additional Studies for Semi-Implantable Middle Ear Hearing Aids for Sensorineural Hearing Loss

Systematic Reviews

Systematic reviews of semi-implantable hearing aids for sensorineural hearing loss are described below and in Tables 1 through 3.

Bruchhage et al (2017) reported on a systematic review of the Vibrant Soundbridge for the treatment of sensorineural hearing loss.(5) Reviewers included comparative and noncomparative studies with 5 or more patients published through 2012, which resulted in 24 studies reported in 22 articles, a conference proceeding, and a FDA report, with a total of 679 subjects (range, 5-125 subjects) in the articles and 1100 in the conference proceeding. In total, 14 studies had level IV and IX studies had level III evidence. Regarding adverse events, reviewers concluded: “Adverse events occurring with VSB [Vibrant Soundbridge] implantation were in general low, presenting mainly aural fullness (27%) or taste disturbances (9%).” Studies varied in the audiologic outcomes they reported, but all reported functional gains and improvements in speech perception in noise and quiet.

Ernst et al (2016) reported on a systematic review of the Vibrant Soundbridge for the treatment of mixed or conductive hearing loss.(6) Thirty-four studies were selected: 19 studies (n=294 patients) reporting on Vibrant Soundbridge outcomes; 13 studies (n=666 patients) reporting on bone conduction hearing implants; and 4 studies (n=43 patients) reporting on middle ear surgery plus hearing aid outcomes. No studies directly compared methods. The functional gains with the Vibrant Soundbridge at 3 months ranged from 12.5 to 43.4 dB hearing loss, averaging 29.6 dB. Significant improvements in speech recognition occurred, although methods of measuring speech differed across studies. Results from studies of Vibrant Soundbridge are included in Table 3.

A systematic review by Kahue et al (2014) evaluated studies of 3 FDA-approved middle ear hearing aids, the Vibrant Soundbridge, the Maxum System, and the Envoy Esteem (discussed in the following section on conductive and mixed hearing loss).(7) Studies eligible for inclusion addressed purely sensorineural hearing loss, had at least 5 implanted ears, and reported comparative data between preoperative and postoperative audiometric performance. Seventeen studies (503 ears) were included, 3 of which evaluated the Soundtec System (now Maxum System, 190 ears), 5 of which evaluated the Envoy Esteem (102 ears), and 9 of which evaluated the Vibrant Soundbridge (211 ears). The 14 studies comparing the preoperative *unaided* hearing with postoperative middle ear implant-assisted hearing demonstrated improvement in hearing thresholds (weighted mean, 25.2 dB improvement; range, 15.6-48.2 dB). However, for the 12 studies that compared the *best-aided* preoperative condition with the postoperative assisted performance, the functional gain was smaller (weighted mean, 8.1 dB improvement; range, -9.4 to 13 dB), and only 1 reported statistically significant improvements over optimally fitting hearing aids. Similarly, studies that compared the preoperative *unaided* condition and the postoperative middle ear implant-assisted hearing demonstrated improvements in speech recognition (weighted average, 44.8% improvement; range, 8.8%-64.0%), while speech recognition was similar for the middle ear implant-assisted condition and best aided preoperative condition. Ten studies reported on safety outcomes, including 5 studies that focused on partially implantable middle ear implants; in those studies, 15 (11.4%) of 132 implants malfunctioned and were explanted.

Butler et al (2013) published results of a systematic review of comparative studies evaluating partially and fully implantable middle ear hearing devices for sensorineural hearing loss.(8) Reviewers included 14 studies, none of which was a randomized controlled trial, 13 of which evaluated a semi-implantable device (most often the Vibrant Soundbridge), with 1 study evaluating the Envoy fully implantable system. Outcomes reported across studies were heterogeneous. Among the 9 studies that reported on the primary outcome (functional hearing

gain), 1 found that middle ear implants were significantly better than hearing aids, 1 found that hearing aids were significantly better than implants, and 6 studies found that middle ear implants were better than hearing aids, but without a clinically significant difference. Reviewers concluded that middle ear implants were at least as effective as hearing aids in improving hearing outcomes.

Table 1. Comparison of Studies Included in Systematic Reviews

Study	Bruchhage et al. (2017) ⁵	Ernst et al. (2016) ⁶	Kahue et al. (2014) ⁷	Butler et al. (2013) ⁸
Fisch et al. (2001)	●			
Fraysse et al. (2001)	●		●	●
Labassi and Beliaeff (2005)	●			
Mosnier et al. (2008)	●			
Luetje et al. (2010)	●		●	●
Schmuziger et al. (2006)	●			
Sterkers et al. (2003)	●			
Frenzel et al. (2009)		●		
Baumgartner et al. (2010)		●		
Boheim et al. (2012)		●		
Verhaert et al. (2013)		●		
Silverstein et al. (2005)			●	
Gerard et al. (2012)			●	
Kraus et al. (2011)			●	
Memari et al. (2011)			●	
Monini et al. (2012)			●	
Pok et al. (2010)			●	
Rameh et al. (2010)			●	
Sziklai et al. (2011)			●	
Truy et al. (2008)			●	
Todt et al. (2005)			●	●
Chen et al. (2004)			●	●
Uziel et al. (2008)			●	●
Todt et al. (2002)			●	●
Hough et al. (2001)			●	●
Snik & Cremers et al. (2000)			●	●
Roland et al. (2001)			●	●
Thill et al. (2002)				●
Verhaegen et al. (2008)				●
Jenkins et al. (2007)				●
Jenkins et al. (2004)				●
Matthews et al. (2002)				●

Table 2. Systematic Review Characteristics

Study	Dates	Trials	Participants	N (Range)	Design	Duration
Bruchhage et al (2017) ⁵	2001-2010	7	Patients with Vibrant Soundbridge for the treatment of sensorineural hearing loss	679 (5-125) in articles and 1100 in the conference proceeding	Comparative and non-comparative studies	2-24 months

			who failed all other conservative medical, surgical, pharmaceutical treatment and could not benefit from conventional hearing aids			
Ernst et al (2016) ⁵ .	2006-2014	34 (Vibrant Soundbridge, n=19; bone-conduction hearing implants, n=13; middle ear surgery plus hearing aid, n=4)	Patients with Vibrant Soundbridge for the treatment of mixed or conductive hearing loss	1003 (NR)	16 single cohort before-after studies, 2 concurrent cohort studies, and 1 non-randomized clinical trial	12-65 months
Kahue et al (2014) ⁷ .	2001-2012	19 (Maxum System, n=3; Envoy Esteem, n=5; Vibrant Soundbridge, n=9)	Patients with purely sensorineural hearing loss treated with MEI	503 (6-103)	7 prospective, 10 retrospective comparative studies	2-143 months
Butler et al (2013) ⁸ .	2001-2008	14	Patients with purely sensorineural hearing loss treated with MEI	617 (6-103)	Non-randomized, uncontrolled comparative studies	2-18 months

MEI: middle ear implant.

Table 3. Systematic Review Results

Study	Speech recognition	Functional gain	Adverse events
Bruchhage et al. (2017)⁵.			
Total N		370	3562
Effects		Range, 12.5-33 dB	Any adverse event: 39%
Range of N		NR	77-1172
Ernst et al. (2016)⁵.			
Total N	Italian disyllabic score: 94	NR	
Effects	Freiburger monosyllable score: 90 Italian disyllabic score: pooled mean difference, 71.46 (95% CI, 56.63-86.28)	29.6 dB (range, 12.5-43.4)	
<i>I</i> ² (p)	Freiburger monosyllable score: pooled mean difference, 69.03 (95% CI, 58.83-79.22) Italian disyllabic score: 0% (0.62)		
Range of N	Freiburger monosyllable score: 90% (<0.001) Italian disyllabic score: 7-16	NR (6 studies)	
	Freiburger monosyllable score: 5-19		
Kahue et al. (2014)⁷.			
Effects	Unaided: weighted average, 44.8% improvement; range, 8.8%-64.0%	Unaided: weighted mean, 25.2 dB improvement;	15/132 MEIs required

	Best-aided: weighted average, 9.2% improvement; range reported between 9.8% and +22.6%	range, 15.6 and 48.2 dB	explanation due to malfunction
Range of N	Unaided: NR (4 studies) Best-aided: NR (5 studies)	Best-aided: weighted mean, 8.1 dB improvement; range, -9.4 to 13 dB	
Butler et al. (2013)⁸.			
Effects		MEI: range, 17-31.2 dB Hearing aid: range, 14.6-20 dB	
Range of N		Unaided: NR (9 studies) Best-aided: NR (6 studies)	
		NR (6 studies)	

CI: confidence interval; MEI: middle ear implant; NR: not reported

Nonrandomized Studies

Rahne et al. (2020) performed a retrospective cohort analysis of 21 patients with sensorineural or mixed hearing loss implanted with the Vibrant Soundbridge (Tables 4 and 5).⁽⁹⁾ The mean word recognition score improved from baseline by 57.8%. Results were not reported by each type of hearing loss. There were no significant differences between coupler types (round window membrane, long process, or incus body and short process of the incus).

Seebacher et al (2020) performed a retrospective cohort study in 21 patients with sensorineural, conductive, or mixed hearing loss implanted with unilateral Vibrant Soundbridge implantation to analyze patient-reported quality of life outcomes after bilateral implantation (Tables 4 and 5).⁽¹⁰⁾ Measures used included the Speech, Spatial, and Qualities of Hearing Scale (SSQ12-B, with 12 items scored from -5 to +5 to rate benefit in listening situations) and the Glasgow Benefit Inventory (GBI, with 18 items scored on a 5-point Likert scale normalized from -100 to +100 measuring generic quality of life in otolaryngological interventions). Improvements in SSQ12-B and GBI scores were statistically significant following bilateral implantation. Results were not reported by each type of hearing loss.

Table 4. Summary of Key Observational Study Characteristics

Study	Study Type	Country	Dates	Participants	Treatment	Follow-Up
Rahne et al. (2020) ⁹	Retrospective cohort study	Germany, Poland, Spain, Italy	2014-2016	Patients with sensorineural or mixed hearing loss	Vibrant Soundbridge	12 months
Seebacher et al. (2020) ¹⁰	Retrospective cohort study	Austria	2018-2020	Patients with sensorineural, conductive, or mixed hearing loss and unilateral Vibrant Soundbridge implantation	Bilateral Vibrant Soundbridge implantation	NR

NR: not reported.

Table 5. Summary of Key Observational Study Results

Study	Speech Recognition	Self-Reported Hearing Benefit
Rahne et al. (2020)⁹	N=21	
Preoperative	Mean WRS: 14.8% (SD, 21.9)	
Postoperative	Mean WRS: 72.6% (SD, 18.6)	
Seebacher et al. (2020)¹⁰		N=21
SSQ12-B		+2.73 (p<0.001)

GBI: Glasgow Benefit Inventory; SD: standard deviation; SSQ12-B: Speech, Spatial, and Qualities of Hearing Scale; WRS: word recognition score

Case Series

Select case series are described below and in Tables 6 and 7.

One series with long-term follow up (mean, 7.5 years) focused on middle ear implants in patients who failed external hearing aids. Zwartenkot et al (2013) described outcomes for 33 patients with moderate-to-severe sensorineural hearing loss who had severe chronic otitis externa and were implanted with the Vibrant Soundbridge system or the Otologics MET system, a middle ear implant system not available in the United States.(11) Compared with baseline, at long-term follow-up, subjects had statistically significant improvements in total scores on the Abbreviated Profile of Hearing Aid Benefit Global score (63.3 at baseline vs 55.6 at follow-up, p<0.05). Eighty-five percent of subjects reported wearing the device more than 4 hours a day.

Results of a 2002 phase II trial of the SoundTec system were published,(12) but this publication lagged behind the data included in the FDA summary of safety and effectiveness.(2) An additional case series of 64 SoundTec implants was published in 2005.(13) The average functional gain varied with frequency, with the lowest functional gain in the lower speech frequencies (7 dB), and increasing functional gain at higher frequencies, ranging up to 32 dB at 2,000 Hz. The functional gain of 7 dB at lower speech frequencies was similar to that reported in the FDA summary of safety and effectiveness, while the 26 dB gain at higher frequencies was higher than reported in the FDA summary. The cause of this marked discrepancy is not apparent. In this case series, the authors also reported that a high percentage of patients heard the magnet move inside the ear, resulting in a refinement of the surgical procedure to better stabilize the magnet.

Table 6. Summary of Key Case Series Characteristics

Study	Country	Participants	Follow-Up
Zwartenkot et al. (2013) ¹¹ .	Netherlands	N=33 patients with moderate-to-severe sensorineural hearing loss who had severe chronic otitis externa	Mean, 7.5 years
Silverstein et al. (2005) ¹³ .	United States	N=64 patients with bilateral moderately severe sensorineural hearing loss	1 month

Table 7. Summary of Key Case Series Results

Study	Treatment	Speech Perception	Patient Satisfaction	Functional Gain
Zwartenkot et al. (2013) ¹¹ .	Vibrant Soundbridge system or the Otologics MET system		Significant improvements occurred between baseline and follow-up in APHAB Global score (63.3 at baseline vs 55.6 at follow-up, p<0.05) and NCIQ Total score (49.7 at baseline vs 61.1 at follow-up, p<0.01)	
Silverstein et al. (2005) ¹³ .	Soundtec implant			The average functional gain (frequencies 250–6,000 Hz) was 26 dB, ranging from 7 dB at 250 Hz to 32 dB at 2,000 Hz.

APHAB: Abbreviated Profile of Hearing Aid Benefit; NCIQ: Nijmegen Cochlear Implant Questionnaire.

Off-Label Use of Semi-Implantable Hearing Aids for Conductive or Mixed Hearing Loss

While the Vibrant Soundbridge received FDA approval for sensorineural hearing loss, several studies have evaluated it for off-label use in conductive or mixed hearing loss with coupling of the devices floating mass transducer to the middle ear's round or oval window, instead of the incus, bypassing the middle ear structures.

Ernst et al (2016) published results of a systematic review of studies reporting on the Vibrant Soundbridge for conductive or mixed hearing loss.(6) Reviewers included studies that compared the Vibrant Soundbridge with no intervention, bone conduction hearing implants (the Bonebridge implant, a fully implantable bone conduction hearing implant that uses a bone conduction floating mass transducer to transmit signals to the cochlea), and middle ear surgery plus hearing aids. Nineteen articles (n=294 individuals) comparing the Vibrant Soundbridge with no intervention were identified, including 16 cohort before-after studies, 2 concurrent cohort studies, and a nonrandomized clinical trial. No improvements in bone conduction thresholds were reported. Studies reported a variety of methods for determining air conduction thresholds, precluding pooling of results, but hearing thresholds improved substantially in all studies. For speech recognition, a meta-analysis of results for change in score on Italian disyllabic word lists and Freiburg Monosyllabic Word Test was conducted, with pooled mean improvements of 71.5% and 69%, respectively. No studies were identified that compared the Vibrant Soundbridge with the Bonebridge. Four studies (total N=43 individuals) compared the Vibrant Soundbridge with middle ear surgery plus hearing aids. Improvements in air conduction thresholds and functional gain were generally better with the Vibrant Soundbridge, but studies were mixed regarding whether the Vibrant Soundbridge was associated with greater improvements in speech recognition.

Since publication of the Ernst systematic review, Frenzel et al (2015), using a single-subject repeated-measure design, reported on outcomes with the Vibrant Soundbridge among 19 patients aged 5 to 17 years with conductive or mixed hearing loss.(14) Younger children (age range, 5-9 years) improved monosyllable word recognition score from a mean 28.9% preoperatively to 80% at the initial fitting ($p=0.005$) and 95.5% at 6-month testing ($p=0.001$). Older children (age range, 10-17 years) improved on word recognition score from a mean of 18.5% preoperatively to 80.5% at the initial fitting ($p=0.001$) and to 89% at 6 months postoperative ($p=0.001$). Improvements in speech recognition threshold and signal-to-noise ratio were also reported.

Earlier series have reported within-subject comparisons of hearing outcomes before and after hearing aid amplification and patient-reported outcomes with implantable hearing devices. One study focused on implantable hearing aid outcomes in patients who failed external hearing aids. Marino et al (2013), which was included in the Ernst et al systematic review, reported results of round window-coupled Vibrant Soundbridge implantation in 18 subjects with conductive or mixed hearing loss who could not derive benefit from conventional hearing aids due to chronic otitis externa, blind sac closure, pain with hearing aid mold use, and severe-to-profound mixed hearing loss.(15) Speech recognition in quiet settings with the Soundbridge device was similar to conventional hearing aids, while speech recognition in noisy settings was improved with the Soundbridge device. Another before and after study in 42 patients with chronic otitis media who had undergone ear surgery before receiving a Vibrant Soundbridge device found that both adults and children experienced a gain in functional hearing with the device, with no differences noted between coupling methods.(16)

In the largest case series identified, Colletti et al (2013) reported longer term outcomes for 50 patients (age range, 2 months to 74 years) with severe conductive or mixed hearing loss due to ossicular chain defects who underwent coupling of the Vibrant Soundbridge system to the round window.(16) Although subjects demonstrated improvements in speech perception and pure-tone audiometry (in adults) and auditory brainstem response thresholds (in infants), the study's implications for practice are limited due to a large number of subjects with missing data (17/50).

Gantner et al (2023) also reported retrospective long-term outcomes (mean, 4.8 years) of Vibrant Soundbridge among 51 recipients who had aural atresia or aplasia.(18) Improvements in hearing were maintained throughout follow-up, both for auditory measures and patient-reported measures.

Other series with sample sizes, ranging from 9 to 27 subjects, have reporting hearing outcomes with the Vibrant Soundbridge, using various coupling methods.(19-33) These studies generally reported improvements in hearing measures and good patient satisfaction relative to external hearing aids. Among the group, Skarzanski et al (2014), reported up to 3 years of follow-up in adults who received the Vibrant Soundbridge.(21) Over the 3 years, bone conduction hearing thresholds were stable. There were no cases of device extrusion or significant complications; 19% of patients had tinnitus, which resolved within 2 months postoperatively. Cadre et al (2023) reported follow-up of up to 6.5 years among children with congenital aural atresia who received the Vibrant Soundbridge.(33) Air conduction pure tone average thresholds, speech reception thresholds, and word recognition scores were significantly improved, but 30% of children were non-users at the last follow-up.

Section Summary: Semi-Implantable Middle Ear Hearing Aids

The evidence for the use of semi-implantable middle ear hearing aids includes the clinical trials which supported FDA approval of the Vibrant Soundbridge and the Soundtec devices, along with a large number of observational series. Most available studies have addressed the Vibrant Soundbridge device. For the use of semi-implantable middle ear hearing aids in patients with sensorineural hearing loss, the body of evidence has suggested that these devices may be associated with a modest improvement in functional gain compared with external hearing aids, with similar improvements in speech recognition scores.

Case series reporting on alternative coupling methods for the Vibrant Soundbridge for patients with conductive or mixed hearing loss have also reported improved hearing thresholds and word recognition.

Although the devices appear to have a good safety profile in the short term, given existing alternatives, studies in larger series reporting on longer term durability, safety, and efficacy are needed to permit conclusions about the devices' risks and benefits relative to external hearing aids.

FULLY IMPLANTABLE MIDDLE EAR HEARING AID FOR SENSORINEURAL HEARING LOSS

Clinical Context and Test Purpose

The purpose of fully implantable middle ear hearing aids for the treatment of hearing loss is to provide a treatment option that is an alternative to or an improvement on existing therapies.

The following PICO's were used to select literature to inform this review.

Populations

The relevant population of interest is patients with hearing loss who are unable to use external hearing aids or who are not candidates for cochlear implants.

Interventions

The therapy being considered is the use of fully implantable middle ear hearing aids as treatment of hearing loss.

Comparators

The following therapies and practices are currently being used to make decisions about treatment of external hearing aids. Externally worn acoustic hearing aids are widely accepted devices for patients with hearing loss. Therefore, this review of semi-implantable and fully implantable hearing aids focuses on comparisons of various audiologic outcome measures between an externally worn hearing aid and a semi- or fully implantable hearing aid in the same patient. Studies of semi- and fully implantable middle ear hearing aids have frequently reported a patient preference for an implantable device compared with an externally worn device. However, it must be determined to what extent patient preference is based on convenience compared with improved hearing.

Outcomes

The general outcomes of interest include symptoms, functional outcomes, quality of life, and treatment related morbidity. Only minimal safety concerns are related to external hearing aids. In contrast, an implantable hearing aid requires a surgical procedure. Potential risks cited for semi-implantable middle ear hearing aids include a decrease in residual hearing in the implanted ear, infection in the ear and adjacent structures, and risks associated with general anesthesia. Major ear surgery may also result in numbness, swelling, or discomfort around the ear, the possibility of facial palsy, neck pain, and disturbance of balance and taste. Therefore, equivalency or improvement in audiologic outcomes associated with an implantable hearing aid must be balanced against the potential risks inherent in a surgical procedure. Patients with hearing loss who receive a fully implantable middle ear hearing aid will require acute post procedure follow-up and at least 6-12 months to ascertain impact on hearing.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies.
- To assess longer term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought.
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence

Trials Supporting Regulatory Approval of a Fully Implantable Hearing Aid

The FDA approval of the Esteem Hearing System was based on a prospective, nonrandomized, multicenter trial of 60 patients with moderate-to-severe sensorineural hearing loss designed to assess the safety and efficacy.(2) Patients served as both control and test subjects as hearing was tested before (with and without hearing assistive devices) and after Esteem implantation. Results of this trial are available in the FDA summaries of safety and effectiveness. In this trial, patients experienced an improvement of 11.4 dB in mean speech reception threshold at 10 months' post-implantation compared with pre-implant aided speech reception thresholds. Overall, word recognition scores were equal to or better than pre-implant aided scores in 93% of patients. The other 7% experienced lower word recognition scores post-implant.

Ninety-six adverse device events occurred and were not considered serious. Taste disturbance was the most common, reported at 42%, followed by tinnitus in 18% and facial paralysis/paresis in 7% of patients. Severe adverse device effects were experienced by 6 of the 57 patients implanted and included 3 revisions due to fibrous adhesions that limited implant benefit, 1 incision breakdown that required explanation, and 1 wound infection and 1 case of severe pain and facial weakness, both of which resolved with medication. Overall, 70% of all adverse events resolved at 10-month follow-up. However, the serious adverse event of facial paralysis/palsy had not resolved in 2 patients by time of reporting.

Kraus et al (2011) reported on 1-year follow-up of the Esteem study.(34) Results were similar to those reported to FDA at 10-month follow-up. Mean speech reception thresholds improved 11.8 dB from a preimplant-aided score of 41.2 dB to 29.4 dB ($p \leq 0.001$). Mean word recognition scores improved by 19.8% from preimplant aided scores. The authors reported 133 adverse events, including 3 cases of facial paresis resolved with medication.

Additional Studies for a Fully-Implantable Hearing Aid for Sensorineural Hearing Loss

Systemic Reviews

Pulcherio et al (2014) reported results of a systematic review of studies of 2 fully implantable middle ear hearing devices, the FDA-approved Esteem device and the Carina device.(35) Reviewers included 22 studies with a total of 244 patients, 134 implanted with the Esteem device and 110 with the Carina device. No randomized controlled trials were identified, and most studies were small, with the largest series including 57 subjects and 12 series including fewer than 10 subjects. All studies showed improvement in sound field threshold from unaided to aided conditions the fully implantable device, but the magnitudes of the improvements varied.

A systematic review of literature by Klein et al (2012) assessing the Esteem device included 7 articles that met inclusion criteria.(36) Complications with the Esteem device most commonly included taste disturbance. Clinically significant improvements in functional gain, speech reception, and speech recognition over the unaided condition were reported. In studies comparing the Esteem implant with conventional hearing aids, findings were mixed. Improvements in functional gain were similar to those for hearing aids; however, speech recognition and quality of life were greater with the implants. This limited evidence suggested these devices may offer a relatively safe and effective treatment option, particularly for patients who are medically unable to wear conventional hearing aids. However, the included studies

were primarily quasi-experimental, pre/post comparisons of aided and unaided conditions. Furthermore, because of heterogeneity across studies, meta-analysis was not performed.

Case Series

Several representative case series provide additional data. Barbara et al (2011) reported on use of the Esteem device in 21 patients with severe bilateral sensorineural hearing loss.(37) The authors reported mean hearing threshold levels improved overall from 70 to 48 dB. In another article reporting on 6 patients implanted with the Esteem device, Barbara et al (2009) found the device improved hearing when assessed during postoperative fittings.(38) Chen et al (2004) reported on the phase I results of the Envoy Totally Implantable Hearing System in 7 patients followed at 2 and 4 months after device activation.(39) Improvements in word recognition and communication in background noise over best-fit hearing aid usage were reported by 5 patients. Patient outcomes in functional gain and speech reception thresholds were comparable to best-fit hearing aid usage.

Other small case series have also reported on hearing outcomes associated with the Esteem device, which are generally on the order of that seen with best-aided hearing.(40-43) More recently, Savas et al (2016) reported on comparisons between air and bone-conduction hearing thresholds with best- aided hearing and hearing with the Carina fully implantable middle ear implant in a study with 9 adults with bilateral mixed hearing loss.(44)

In addition, a 2014 case series, published since the Pulcherio and the Klein systematic reviews, has reported high rates of facial nerve palsies (10/34 [29.4%] subjects) after implantation of the Esteem device, which persisted to 3 months of follow up in 6 (17.6%) of 34 subjects.(45)

Section Summary: Fully Implantable Middle Ear Hearing Aids for Sensorineural Hearing Loss

The evidence on the use of fully implantable middle ear hearing aids includes the clinical trial supporting FDA approval of the Esteem device, along with small systematic reviews and observational series reporting short-term results.(2) These studies have generally found improved hearing over unaided hearing, with modest improvements over hearing with best-fit aids.

ADVERSE EVENTS FOR SEMI- AND FULLY IMPLANTABLE AIDS

Zwartenkot et al (2016) reported on a single-center retrospective cohort study summarizing the long-term complications of active middle ear implants in 94 implanted patients.(46) Subjects were implanted with a total of 128 devices, including 92 Vibrant Soundbridge devices, 32 Otologics middle ear transducer devices, and 4 Otologics fully implantable ossicular devices (the Carina device). During an average follow-up of 4.4 years (range, 1-15 years), 28 patients were considered lost to follow-up, including 7 deaths, 12 explantations, and 6 missed follow-up appointments. During the follow-up period, 36 devices were replaced or explanted, most commonly soon after implantation, with 36% replaced within 18 months of implantation. Twenty (21%) patients had a complication during follow-up, of which 17 were considered serious.

SUMMARY OF EVIDENCE

For individuals who have hearing loss who receive semi-implantable or fully implantable middle ear hearing aids, the evidence includes the single-arm interventional studies submitted to the

Food and Drug Administration, systematic reviews, and a number of observational series. Relevant outcomes include symptoms, functional outcomes, quality of life, and treatment-related morbidity. The data have suggested implantable middle ear hearing aids may provide improvement in hearing compared with conventional external acoustic hearing aids in patients with sensorineural hearing loss. However, given the safety and effectiveness of external acoustic hearing aids and the increased risks inherent in a surgical procedure, the semi- and fully-implantable device must be associated with clinically significant improvement in various hearing parameters compared with external hearing aids. While safety concerns appear to be minimal, only a limited number of patients have been included in the clinical trials with a median follow-up less than 5 years. Studies of patients with conductive or mixed hearing loss and aural atresia, when external acoustic hearing aids are not an option, have also demonstrated hearing benefit with semi-implantable middle ear hearing aids. However, these studies are few and limited to small numbers of patients. Therefore, conclusions on the safety and effectiveness of semi-implantable hearing aids are limited. Comparisons of semi-implantable devices with alternative hearing devices such as implantable bone-conduction and bone-anchored hearing aids would also be useful to determine device appropriateness for patients who are unable to use external air-conduction hearing aids. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

Supplemental Information

PRACTICE GUIDELINES AND POSITION STATEMENTS

Consensus Statement

An expert consensus statement on bone conduction devices and active middle ear implants in conductive and mixed hearing loss was published in 2022.(47) The statement provides information about patient education and technical aspects of device placement but does not provide clear recommendations regarding the patients who are most likely to benefit from implantable middle ear hearing aids over other devices.

The American Academy of Otolaryngology Head and Neck Surgery

The American Academy of Otolaryngology-Head and Neck Surgery recently updated (2016) a position statement on implantable hearing devices which stated:(48)

“The American Academy of Otolaryngology-Head and Neck Surgery, considers active middle ear implants as appropriate treatment for adults with moderate to severe hearing loss when performed by a qualified otolaryngologist-head and neck surgeon. Based on available literature demonstrating that clinically selected adults receive substantial benefit, implanting active middle ear implants is accepted medical practice in those who benefit from amplification but are unable to benefit from the amplification provided by conventional hearing aids. Use of active middle ear implants, which have been Food and Drug Administration (FDA)-approved for these indications, should adhere to the restrictions and guidelines specified by the appropriate governing agency....”

U.S. PREVENTIVE SERVICES TASK FORCE RECOMMENDATIONS

Not applicable.

Ongoing and Unpublished Clinical Trials

A search of ClinicalTrials.gov did not identify any ongoing or unpublished trials that would likely influence this review.

Government Regulations

National:

No national coverage determination has been published. The Medicare Benefit Policy Manual references hearing aids and auditory implants, stating that hearing aids are excluded from coverage.(49) However, devices producing the “perception of sound by replacing the function of the middle ear, cochlea, or auditory nerve are payable by Medicare as prosthetic devices. These devices are indicated only when hearing aids are medically inappropriate or cannot be utilized due to congenital malformations, chronic disease, severe sensorineural hearing loss or surgery.” The benefit manual does not specifically refer to semi- or fully implantable hearing aids as prosthetic devices.

Local:

There is no local coverage determination for semi-implantable or fully implantable middle ear hearing aids.

(The above Medicare information is current as of the review date for this policy. However, the coverage issues and policies maintained by the Centers for Medicare & Medicare Services [CMS, formerly HCFA] are updated and/or revised periodically. Therefore, the most current CMS information may not be contained in this document. For the most current information, the reader should contact an official Medicare source.)

Related Policies

- Auditory Brain Stem Implants
 - Cochlear Implants
 - Hearing Services
 - Implantable Bone-Conduction and Bone-Anchored Hearing Devices
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The articles reviewed in this research include those obtained in an Internet based literature search for relevant medical references through 5/22/24, the date the research was completed.

Joint BCBSM/BCN Medical Policy History

Policy Effective Date	BCBSM Signature Date	BCN Signature Date	Comments
3/19/04	3/19/04	3/19/04	Joint policy established
4/11/05	4/11/05	4/11/05	Routine maintenance
1/1/08	10/16/07	11/15/07	Routine maintenance
1/1/09	10/13/08	12/30/08	Routine maintenance
1/1/10	10/13/09	10/13/09	Routine maintenance
1/1/12	10/11/11	11/9/11	Routine maintenance
9/1/12	6/12/12	6/19/12	Added “fully implantable middle ear hearing aids” to policy; medical policy statement revised to reflect this change; description, rationale, and reference sections revised; title changed from “Semi-Implantable Hearing Aids” to “Semi-Implantable and Fully Implantable Middle Ear Hearing Aids”.
3/1/14	12/10/13	1/6/14	Routine maintenance
7/1/15	4/24/15	5/8/15	Routine maintenance
7/1/16	4/19/16	4/19/16	Routine maintenance
1/1/17	10/11/16	10/11/16	Routine maintenance
1/1/18	10/19/17	10/19/17	Routine maintenance
1/1/19	10/16/18	10/16/18	Routine maintenance
11/1/19	8/20/19		Routine maintenance
11/1/20	8/18/20		Routine maintenance
11/1/21	8/17/21		Routine maintenance
11/1/22	8/16/22		Routine maintenance
11/1/23	8/15/23		Routine maintenance (slp) Vendor managed: N/A
11/1/24	8/20/24		Routine maintenance (slp) Vendor managed: N/A

Next Review Date: 3rd Qtr, 2025

Pre-Consolidation Medical Policy History

Original Policy Date	Comments
BCN: N/A	Revised: N/A
BCBSM: N/A	Revised: N/A

BLUE CARE NETWORK BENEFIT COVERAGE

POLICY: SEMI-IMPLANTABLE AND FULLY IMPLANTABLE MIDDLE EAR HEARING AIDS

I. Coverage Determination:

Commercial HMO (includes Self-Funded groups unless otherwise specified)	Not a covered benefit.
BCNA (Medicare Advantage)	Refer to the Medicare information under the Government Regulations section of this policy.
BCN65 (Medicare Complementary)	Coinsurance covered if primary Medicare covers the service.

II. Administrative Guidelines:

- The member's contract must be active at the time the service is rendered.
- Coverage is based on each member's certificate and is not guaranteed. Please consult the individual member's certificate for details. Additional information regarding coverage or benefits may also be obtained through customer or provider inquiry services at BCN.
- The service must be authorized by the member's PCP except for Self-Referral Option (SRO) members seeking Tier 2 coverage.
- Services must be performed by a BCN-contracted provider, if available, except for Self-Referral Option (SRO) members seeking Tier 2 coverage.
- Payment is based on BCN payment rules, individual certificate and certificate riders.
- Appropriate copayments will apply. Refer to certificate and applicable riders for detailed information.
- CPT - HCPCS codes are used for descriptive purposes only and are not a guarantee of coverage.