Auditory Brainstem Implant

Policy Number: 7.01.83  Last Review: 3/2017
Origination: 03/2017  Next Review: 3/2018

Policy
Blue Cross and Blue Shield of Kansas City (Blue KC) will provide coverage for Auditory Brainstem Implant when it is determined to be medically necessary because the criteria shown below are met.

When Policy Topic is covered
Unilateral use of an auditory brainstem implant (using surface electrodes on the cochlear nuclei) may be considered medically necessary in patients with neurofibromatosis type 2, who are 12 years of age or older, and who are rendered deaf due to bilateral resection of neurofibromas of the auditory nerve.

When Policy Topic is not covered
An auditory brainstem implant is considered investigational for all other conditions including non-neurofibromatosis type 2 indications.

Bilateral use of an auditory brainstem implant is considered investigational.

Penetrating electrode auditory brainstem implant is considered investigational.

Considerations
There is no specific CPT code for the implantation of this device. CPT codes that might be used include codes 61863–61868 (twist drill, burr hole, craniotomy or craniectomy code range) and code 64568 (incision for implantation of cranial nerve neurostimulator electrode array and pulse generator).

In 2007, a CPT code for diagnostic analysis with programming of this device became effective:

92640: Diagnostic analysis with programming of auditory brainstem implant, per hour

Description of Procedure or Service

<table>
<thead>
<tr>
<th>Populations</th>
<th>Interventions</th>
<th>Comparators</th>
<th>Outcomes</th>
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<tr>
<td>Individuals:</td>
<td>Interventions of interest are:</td>
<td>Comparators of interest are:</td>
<td>Relevant outcomes include:</td>
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<tr>
<td>• Who are 12 years of</td>
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<td>• Functional outcomes</td>
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An auditory brainstem implant (ABI) is a device designed to restore some hearing in people with neurofibromatosis type 2 (NF2) who are rendered deaf by bilateral removal of neurofibromas involving the auditory nerve. ABIs have also been studied to restore hearing for other non-neurofibromatosis indications.

For individuals who are 12 years of age or older who are deaf due to bilateral resection of neurofibromas of the auditory nerve who receive an ABI, the evidence includes a large prospective case series. Relevant outcomes are functional outcomes, quality of life, and treatment-related morbidity. The U.S. Food and Drug Administration (FDA) approval of the Nucleus 24 device was based on a prospective case series of 90 patients, of whom 60 had the implant for at least 3 months. From this group, 95% had a significant improvement in lip reading or improvement on sound-alone tests. While use of an ABI is associated with a very modest improvement in hearing, this level of improvement is considered significant in this group of patients who have no other treatment options. Based on these results, the ABI is considered appropriate for the patient population included in the trial (ie, age ≥12 years with NF2 and deafness following tumor removal). The evidence is sufficient to determine qualitatively that the technology results in a meaningful improvement in the net health outcome.

For individuals who are deaf due to nontumor indications and do not qualify for a cochlear implant who receive an ABI, the evidence includes case series and systematic reviews of case series. Relevant outcomes are functional outcomes, quality of life, and treatment-related morbidity. In general, ABIs have not demonstrated hearing benefits over cochlear implants for many non-NF2 conditions. However, ABIs hold promise for select patients when the cochlea or cochlear nerve is absent. Many recent and ongoing studies of the ABI are being conducted in children. For children, hearing is critical for language development, and the ABI has potential to substantially improve health outcomes. The most common nontumor conditions in children are cochlear aplasia and cochlear nerve aplasia. However, there are questions about the durability of the now obsolete Nucleus 24 in active young children. Further study on the recently available Nucleus AB124 is needed to evaluate efficacy and to determine if its durability is sufficient for use in children. In addition, studies have shown inferior outcomes in children who also have other disabilities. The evidence is insufficient to determine the effects of the technology on health outcomes.
Background

The auditory brainstem implant (ABI) is intended to restore some hearing in people with neurofibromatosis type 2 who are rendered deaf by bilateral removal of the characteristic neurofibromas involving the auditory nerve. The ABI consists of an externally worn speech processor that provides auditory information by electrical signal that is transferred to a receiver/stimulator implanted in the temporal bone. The receiver stimulator is, in turn, attached to an electrode array implanted on the surface of the cochlear nerve in the brainstem, thus bypassing the inner ear and auditory nerve. The electrode stimulates multiple sites on the cochlear nucleus, which is then processed normally by the brain.

ABIs are also being studied to restore hearing for other non-neurofibromatosis causes of hearing impairment in adults and children, including absence of or trauma to the cochlea or auditory nerve. It is estimated that 1.7 per 100,000 children are affected by bilateral cochlea or cochlear nerve aplasia and 2.6 per 100,000 children are affected by bilateral cochlea or cochlear nerve hypoplasia.²

Rationale

This evidence review was originally created in July 2002 and has been updated regularly with searches of the MEDLINE database. The most recent literature review was performed through July 24, 2016. Following is a summary of the key literature to date.

Assessment of efficacy for therapeutic intervention involves a determination whether the intervention improves health outcomes compared with available alternatives. The optimal study design for this purpose is a randomized controlled trial that compares the therapeutic intervention with existing alternative treatments and includes clinically relevant measures of health outcomes. Nonrandomized comparative studies and uncontrolled studies can sometimes provide useful information on health outcomes but are prone to biases such as noncomparability of treatment groups, placebo effect, and variable natural history of the condition. In the case of the auditory brainstem implant (ABI), studies that compare outcomes before and after device implantation can provide useful information on health outcomes.

ABI for Bilateral Resection of Neurofibromas of the Auditory Nerve

U.S. Food and Drug Administration (FDA) approval of the Nucleus 24 Auditory Brainstem Implant System was based on results in a case series of 90 patients with neurofibromatosis type 2 (NF2), ages 12 years and older.²³ Of the 90 subjects evaluated, 28 complications occurred in 26 patients; 26 of these complications resolved without surgical or extensive medical intervention. Two patients had infections of the postoperative flap requiring explantation of the device. Sixty patients had a minimum experience of 3 to 6 months with the device, and thus effectiveness outcomes were also evaluated. Overall device benefit was defined as a significant enhancement of lip reading or an above-chance improvement on sound-alone tests. Based on this definition, a total of 95% (57/60) patients derived benefit from the device. Among the 90 patients receiving
the implant, 16 did not receive auditory stimulation from the device postoperatively, either due to migration of the implanted electrodes or surgical misplacement. To place the electrode array on the surface of the cochlear nucleus, the surgeon must be able to visualize specific anatomic landmarks. Because large neurofibromas compress the brainstem and distort the underlying anatomy, it can be difficult or impossible for the surgeon to correctly place the electrode array. For this reason, patients with large, long-standing tumors may not benefit from the device.

Similar results have been reported with other devices in European studies. In 2013 Mathies et al reported on 32 patients with ABIs placed for NF2. Activation of the ABI occurred in 27 patients. Three patients experienced no auditory perception. At 12-month follow-up, significant improvements were seen in the Sound Effects Recognition Test and the Monosyllable-Trochee-Polysyllable test. Open-set sentence recognition was 5% at first fitting and improved to 37% at 12 months. Performance was not significantly related to the number of active electrodes implanted. In 2012 Sanna et al reported on 25 ABIs placed in 24 patients with NF2. In this retrospective case study, patients were followed for 2 to 53 months. Sound recognition was present in 19 patients, of whom 11 had some word recognition and 8 had good speech recognition (50% speech discrimination in 4 patients, 75%-100% speech discrimination and telephone use in 4 patients). Multivariate analysis did not identify any factors that were statistically significant in predicting ABI performance outcomes. The authors also conducted a review of the literature on ABIs and found it difficult to compare outcomes because reporting methods and outcomes measured were inconsistent and imprecise.

A single small (N=10) trial from 2008 was identified on a penetrating electrode auditory brainstem implant (PABI). This prospective clinical trial enrolled patients with NF2 who received a PABI after vestibular schwannoma removal. The PABI is an extension of the ABI technology that uses surface electrodes on cochlear nuclei. The PABI uses 8 or 10 penetrating microelectrodes in conjunction with a separate array of 10 to 13 surface electrodes. The PABI met the goals of lower threshold, increased pitch range, and high selectivity, but these properties did not improve speech recognition.

**Section Summary: ABI for Bilateral Resection of Neurofibromas of the Auditory Nerve**

The largest dataset on use of the ABI in patients with NF2 is from the FDA-regulated prospective series with the Nucleus 24 implant. This study found enhancement of lip reading and improvement in sound-alone tests in this population of patients who had bilateral deafness and no sound perception prior to the ABI. Eighteen percent of patients did not receive auditory benefit after device implantation. Based on these results, FDA approved the Nucleus 24 implant for the indications in the trial (patients ≥12 years with NF2). Similar results have been shown in smaller retrospective series from Europe in patients with NF2. No benefit on speech recognition was found with penetrating electrodes compared to surface electrodes.
ABI for Nontumor Indications

Adults
Merkus et al reported on a systematic review of ABIs for non-NF2 indications in 2014. Included in the review were 144 non-NF2 ABI cases from 31 articles. Non-NF2 indications for which ABIs have been evaluated included cochlear otosclerosis, temporal bone fractures, bilateral traumatic cochlear nerve disruption, autoimmune inner ear disease, auditory neuropathy, cochlear nerve aplasia, and vestibular schwannoma in the only hearing ear. Cochlear implants have generally resulted in better hearing than ABIs when the cochlea and cochlear nerve were intact. Complete bilateral disruption of the cochlear nerve from trauma did not exist in the literature and cochlear malformation did not preclude cochlear implant. While the evidence is limited, it appears cochlear implants demonstrate greater hearing benefits than ABI in patients with non-NF2 indications.

In a 2014 literature review by Medina et al of ABI for traumatic deafness, cochlear implant performed better than ABI. However, there is limited evidence on which to draw conclusions, because only 3 articles (total N=7 patients) were identified in the review on ABI for traumatic deafness.

Children

Systematic Review
A 2015 systematic review of nontumor pediatric ABI outcomes was reported by Noij et al. The review included 21 studies with 162 children, at a mean age of 4.3 years (range, 11 months to 17 years). Nine reports were from a single group from Italy (described further below) and it could not be determined if there was patient overlap across these studies. Nearly all studies were retrospective series or cohorts; one was a case control. Most children (63.6%) had cochlear nerve aplasia. Other conditions were cochlear aplasia, cochlear nerve hypoplasia, cochlear malformations, ossified cochlea, auditory neuropathy, trauma, and cochlear hypoplasia. Twenty-five percent of the patients had previously received a cochlear implant. Forty major and minor complications were reported, the most common being cerebrospinal fluid (CSF) leak (8.5% of patients). The most common side effects associated with ABI use were discomfort of the body and/or limb, dizziness/vertigo/nystagmus, pain in the head and/or neck, and stimulation of the facial nerve or involuntary swallowing, gagging, or coughing. A variety of auditory tests were used; the most common (6 studies) was the Categories of Auditory Performance (CAP) index (range, 0-7; high score indicates better hearing). There was an improvement in CAP scores over time. After 5 years, almost 50% of patients had CAP scores greater than 4 (5 [understanding of common phrases without lip reading] to 7 [use of telephone with known speaker]). Children who also had nonauditory disabilities never attained a CAP score greater than 4. There was no significant effect of the age of implantation.

Case Series
Many of the larger series on ABI in nontumor patients are from a group that includes Colletti and Colletti. In 2013, this group reported on ABIs in 21 children,
ranging in age from 1.7 to 5 years, with deafness unrelated to neurofibromatosis, who had a poor response to cochlear implants. At surgery, the cochlear nerve was absent in each patient. Significant improvements in CAP index scores were seen after ABI (p<0.001).

In 2016, Sennaroglu et al reported follow-up of at least 1 year on 35 children who had received ABI. This followed a 2009 preliminary report of 11 prelingually deaf children ages 30 to 56 months who received an ABI. Sixty children had received an ABI from this center in Turkey. The children who had received the ABI in the previous year were excluded from the 2016 analysis. Over half (19) of the cases were due to cochlear hypoplasia. ABI models implanted were Cochlear, Med El, and Neurelec. At regular follow-up, children were evaluated with the CAP, Speech Intelligibility Rate (SIR), Functional Auditory Performance of Cochlea Implantation (FAPCI), and Manchester scores. About half the children were in the CAP category 5 and could understand common phrases without lip reading. In the subgroup with better hearing thresholds (25-40 dB), some (17.6%) were able to understand conversation without lip reading, use the telephone with known speaker (11.8%), and follow group conversation in a noisy room (5.9%). For children with higher hearing thresholds (>50 dB), none of the children exceeded CAP category 5. SIR and Manchester scores were also better with greater hearing thresholds. Auditory performance measured with the FAPCI was in the 10th percentile for all groups and was worse compared to cochlear implantation. As was also found in the Noiiji et al systematic review, children with additional nonauditory handicaps had worse outcomes (eg, intellectual disability).

Also in 2016, Puram et al reported on early experiences with pediatric ABI in a North American center conducting an ongoing FDA-regulated investigational device exemption trial (NCT01864291). Of 17 candidates evaluated, 5 (average age, 19.2 months) met the study selection criteria and received an implant (Nucleus AB124). Detailed inclusion/exclusion criteria are described in the report. The age at implantation ranged from 11 months to 2.5 years. After implantation, all patients had responses such as babbling and responses to sounds and speech. There were no major or minor complications such as CSF leak. Two devices failed after blunt trauma (falls) at 6 and 7 months postimplantation, respectively, and 1 had spontaneous device failure at 15 months postsurgery. The current protocol includes use of a helmet in children who are at risk of falling.

Mixed Populations
Other reports from the group of Colletti and Colletti include a 2005 report on ABIs in 16 children and adults who had nontumor diseases of the cochlear nerve or cochlea and 13 patients with NF2. Ages ranged from 14 months to 70 years; the nontumor group included patients with head trauma, complete cochlear ossification, auditory neuropathy, and bilateral cochlear nerve aplasia. Following implantation, the adult nontumor group scored substantially higher than the patients with NF2 in open set speech perception tests. Some children showed dramatic improvements in word and sentence recognition over a 1-year follow-up. Short-term adverse effects included dizziness or tingling sensations in the leg, arm, and throat (20/29 patients). Additional studies from this group have reported
improvement in hearing with ABIs in “nontumor” patients; including a 2006 report on 54 nontumor patients\textsuperscript{15} and a 2007 report on 22 non-neurofibromatosis patients.\textsuperscript{16}

In a 2010 retrospective review, Colletti et al reported on the complications from ABI surgery in 83 adults and 31 children, 78 of whom had nontumor cochlear or cochlear nerve disorders.\textsuperscript{17} Authors found complication rates were similar to cochlear implant surgery. Additionally, there were significantly fewer major and minor complications in nontumor patients than in NF2 patients.

**Section Summary: ABI in Nontumor Indications**

The evidence on ABI in nontumor patients includes case series and systematic reviews of case series. A 2014 systematic review suggested that ABI may have potential for improved outcomes in bilateral complete cochlear and inner ear aplasia, when imaging and electrophysiologic testing demonstrate that the cochlear nerve is absent. Recent work includes studies of children who are deaf but would not benefit from a cochlear implant. The most common conditions in these studies are cochlear aplasia and cochlear nerve aplasia. Hearing in this age group is critical for language development, and the ABI has potential to substantially improve health outcomes for this age group. However, a 2016 study from the United States found a high rate of device failure with the only device approved for use in the United States (now obsolete), and other studies have indicated that outcomes are inferior when children have additional disabilities. A number of studies in children are ongoing (see Table 1). Results from these studies are needed to identify the patient populations who would benefit most from this device. Results on the recently available Nucleus AB124 are also needed to evaluate device efficacy and durability.

Some currently unpublished trials that might influence this review are listed in Table 1.

**Table 1. Summary of Key Trials**

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<thead>
<tr>
<th>NCT No.</th>
<th>Trial Name</th>
<th>Planned Enrollment</th>
<th>Completion Date</th>
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<tr>
<td>NCT02310399</td>
<td>Auditory Brainstem Implant (ABI) in Children With No Cochleae or Nerves</td>
<td>20</td>
<td>Jul 2017</td>
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<td>NCT02102256</td>
<td>A Feasibility Study of the Placement, Use, and Safety of the Nucleus 24 Auditory Brainstem Implant in Non-Neurofibromatosis Type 2 (NF2) Pediatric Patients</td>
<td>10</td>
<td>Feb 2019</td>
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<td>NCT02630589</td>
<td>Implantation of an Auditory Brainstem Implant for the Treatment of Incapacitating Unilateral Tinnitus</td>
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<td>NCT01864291</td>
<td>Study of the Nucleus 24 Auditory Brainstem Implant in Pediatric Non-Neurofibromatosis Type 2 Subjects</td>
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<td>Nov 2022</td>
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<tr>
<td>NCT01736267</td>
<td>Study of Nucleus 24 Auditory Brainstem Implant (ABI) in Adult Non-Neurofibromatosis Type 2 Subjects</td>
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<td>Nov 2022</td>
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<tr>
<td>NCT01904448</td>
<td>An Early Feasibility Study of the Safety and Efficacy of the Nucleus 24 Auditory Brainstem Implant in Children With Cochlear or Cochlear Nerve Disorders</td>
<td>10</td>
<td>Apr 2023</td>
</tr>
</tbody>
</table>
Summary of Evidence
For individuals who are 12 years of age or older who are deaf due to bilateral resection of neurofibromas of the auditory nerve who receive an auditory brainstem implant (ABI), the evidence includes a large prospective case series. Relevant outcomes are functional outcomes, quality of life, and treatment-related morbidity. The U.S. Food and Drug Administration (FDA) approval of the Nucleus 24 device was based on a prospective case series of 90 patients, of whom 60 had the implant for at least 3 months. From this group, 95% had a significant improvement in lip reading or improvement on sound-alone tests. While use of an ABI is associated with a very modest improvement in hearing, this level of improvement is considered significant in this group of patients who have no other treatment options. Based on these results, the ABI is considered appropriate for the patient population included in the trial (ie, age ≥12 years with neurofibromatosis type 2 (NF2) and deafness following tumor removal). The evidence is sufficient to determine qualitatively that the technology results in a meaningful improvement in the net health outcome.

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Supplemental Information

Practice Guidelines and Position Statements
In January 2005, National Institute for Clinical Excellence issued Interventional Procedure Guidance 108 on ABIs. The guidance stated the following: “...evidence on safety and efficacy of auditory brain stem implants appears adequate to support the use of this procedure by surgical teams experienced in this technique.”
U.S. Preventive Services Task Force Recommendations
Not applicable.

Medicare National Coverage
There is no national coverage determination. The Medicare Benefit Policy Manual references hearing aids and auditory implants, stating that hearing aids are excluded from coverage, including air-conduction and bone-conduction devices. However, devices that produce 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 used. Along with cochlear and ABIs, the benefit manual specifically refers to osseointegrated implants as prosthetic devices.

References
15. Colletti V. Auditory outcomes in tumor vs. nontumor patients fitted with auditory brainstem implants. Adv Otorhinolaryngol. 2006;64:167-185. PMID 16891842


Billing Coding/Physician Documentation Information

92640 Diagnostic analysis with programming of auditory brainstem implant, per hour

S2235 Implantation of auditory brain stem implant

Q85.0 Neurofibromatosis, type 2

Additional Policy Key Words

N/A

Policy Implementation/Update Information

3/2017 New Policy. Considered Medically Necessary if all criteria are met, otherwise investigational.

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