SUMMARY OF SAFETY AND EFFECTIVENESS DATA (SSED)

I. GENERAL INFORMATION

Device Generic Name: Implant, Cochlear

Device Trade Name: HiResolution™ Bionic Ear System (previously CLARION Multi-Strategy™ Cochlear Implant System, Model 1.2)

Device Product Code: MCM

Applicant's Name and Address: Advanced Bionics
28515 Westinghouse Pl.
Valencia, CA 91355

Date(s) of Panel Recommendation: None

Premarket Approval Application (PMA) Number: P960058/S167

Date of FDA Notice of Approval: July 22, 2026

The original PMA (P940022) was approved on March 22, 1996, indicated for adults with bilateral severe to profound sensorineural hearing loss. The original Pediatric PMA (P960058) was approved on June 26, 1997, for children as young as 12 months with profound, bilateral sensorineural deafness. On October 19, 2002, P940022 was combined into P960058. The current supplement was submitted to expand the indications for the HiResolution™ Bionic Ear System for single sided deafness or asymmetric hearing loss (SSD/AHL).

II. INDICATIONS FOR USE

The HiResolution™ Bionic Ear System is intended to restore a level of auditory sensation to individuals with severe-to-profound sensorineural hearing loss via electrical stimulation of the auditory nerve.

Bilateral Hearing Loss

Adults

18 years of age or older.

- Severe-to-profound, bilateral sensorineural hearing loss (≥ 70 dB HL).
- Postlingual onset of severe or profound hearing loss.
- Limited benefit from appropriately fitted hearing aids, defined as scoring 50% or less on a test of open-set sentence recognition (HINT Sentences).

Children

12 months through 17 years of age.

- Profound, bilateral sensorineural deafness (≥ 90 dB HL).
- Use of appropriately fitted hearing aids for at least 6 months in children 2 through 17 years of age, or at least 3 months in children 12 through 23 months of age. The minimum duration of hearing aid use is waived if x-rays indicate ossification of the cochlea.
- Little or no benefit from appropriately fitted hearing aids. In younger children (< 4 years of age), lack of benefit is defined as a failure to reach developmentally appropriate auditory milestones (such as spontaneous response to name in quiet or to environmental sounds) measured using the Infant-Toddler Meaningful Auditory Integration Scale or Meaningful Auditory Integration Scale or ≤ 20% correct on a simple open-set word recognition test (Multisyllabic Lexical Neighborhood Test) administered using monitored live voice (70 dB SPL). In older children (≥ 4 years of age), lack of hearing aid benefit is defined as scoring ≤12% on a difficult open-set word recognition test (Phonetically Balanced-Kindergarten Test) or ≤ 30% on an open-set sentence test (Hearing In Noise Test for Children) administered using recorded materials in the soundfield (70 dB SPL).

Unilateral Hearing Loss

The HiResolution™ Bionic Ear System is indicated for individuals with unilateral hearing loss who meet the following criteria:

Asymmetric Hearing Loss (AHL)

Individuals with AHL are defined as those with a mild to moderately severe hearing loss in the better ear, i.e., a 4PTA of 31 to 65 dB HL at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz, with a difference of at least 15 dB in the 4PTA between ears.

It is recommended that individuals with AHL have at least two (2) weeks experience wearing an appropriately fitted Contralateral Routing of Signal (CROS) system or suitable hearing device prior to cochlear implantation.

The ear to be implanted will be as follows:

Adults (18 years of age or older):

- Severe to profound sensorineural hearing loss (4PTA of 500, 1000, 2000, and 4000 Hz ≥ 80 dB HL)
- A score of ≤ 20% on a Consonant-Nucleus-Consonant (CNC) word test

Children (5 years through 17 years of age):

- Profound sensorineural hearing loss (4PTA of 500, 1000, 2000, and 4000 Hz ≥ 90 dB HL)
- Insufficient functional access to sound in the ear to be implanted must be determined by aided speech perception test scores of 5% or less on a developmentally appropriate monosyllabic word list when tested in the ear to be implanted alone.

Single-Sided Deafness (SSD)
Individuals with SSD are defined as those with normal hearing or mild sensorineural hearing loss in the better ear (4PTA of ≤ 30 dB HL at 500, 1000, 2000, and 4000 Hz).

It is recommended that individuals with SSD have at least two (2) weeks experience wearing an appropriately fitted Contralateral Routing of Signal (CROS) system or suitable hearing device prior to cochlear implantation.

The ear to be implanted will be as follows:

Adults (18 years of age or older):

- Severe to profound sensorineural hearing loss (4PTA of 500, 1000, 2000, and 4000 Hz ≥ 80 dB HL)
- A score of ≤ 20% on a Consonant-Nucleus-Consonant (CNC) word test

Children (5 years through 17 years of age):

- Profound sensorineural hearing loss (4PTA of 500, 1000, 2000, and 4000 Hz ≥ 90 dB HL)
- Insufficient functional access to sound in the ear to be implanted must be determined by aided speech perception test scores of 5% or less on a developmentally appropriate monosyllabic word list when tested in the ear to be implanted alone.

III. CONTRAINDICATIONS

The HiResolution™ Bionics Ear system is not suitable for individuals with the following conditions:

- Deafness due to lesions of the acoustic nerve or central auditory pathway;
- Active external or middle ear infections;
- Cochlear ossification that prevents electrode insertion;
- Absence of cochlear development;
- Tympanic membrane perforations associated with recurrent middle ear infections
- For individuals with AHL/SSD, duration of profound deafness > 10 years

IV. WARNINGS AND PRECAUTIONS

The warnings and precautions can be found in the HiResolution™ Bionic Ear System labeling.

V. DEVICE DESCRIPTION

No design changes to the approved devices in the HiResolution™ Bionic Ear System are required for the new indication.

The HiResolution™ Bionic Ear System is a cochlear implant (CI) designed to provide useful hearing to individuals with severe-to-profound hearing loss. It consists of the following main components:

- CIs (consisting of a receiver stimulator, an antenna coil with a magnet, and an electrode array):
  - HiRes™ Ultra series
  - HiRes™ Ultra 3D series
- Sound Processors
  - Naida CI Q series
  - Naida CI M series
- Fitting Software:
  - Target CI
- Applications
  - AB Remote
  - AB Remote Support

Figure 1: Advanced Bionics external sound processor (left) and internal electrode array (right)

A CI system consists of one internal component and an external sound process and accessories (see Figure 1). The internal components include the HiRes Ultra and HiRes Ultra 3D receiver with either the HiFocus SlimJ or the HiFocus Mid-Scala electrode array that are implanted surgically under the skin behind the ear (see Figure 1).

In the HiResolution™ Bionic Ear System, sound is captured by external microphones and is converted into a digital signal CIs can receive sound from T-Mic, headpiece and processor microphones and auxiliary audio input sources). The external processor sends power and digital information via the headpiece to the internal implant, which is implanted under the skin. The internal implant converts the digital information into electrical stimulation which is delivered to the auditory nerve through the electrode array

implanted in the cochlear. These electrical signals stimulate the auditory nerve, sending impulses to the brain where they are interpreted as sound.

Within the HiResolution™ Bionic Ear System, clinician-controlled fitting software is used to adjust stimulation parameters based on the individual user's auditory needs.

VI. ALTERNATIVE PRACTICES AND PROCEDURES

There are several other alternatives for the correction of SSD/AHL conditions. These treatments include bone conduction hearing aids, bone anchored hearing aids, implantable bone conduction hearing aids, and CROS hearing aids. Each alternative has its own advantages and disadvantages. A patient should fully discuss these alternatives with his/her physician to select the method that best meets expectations and lifestyle.

VII. MARKETING HISTORY

The HiResolution™ Bionic Ear System was first approved in the United States in March 1996 (originally as the CLARION Multi-Strategy™ Cochlear Implant System).

The indications for use in countries other than the US do not have identical age or audiometric indications. Countries with unilateral and bilateral indications include Austria, Belgium, Bulgaria, Switzerland, Czech Republic, Germany, Denmark, Algeria, Spain, Finland, France, United Kingdom, Greece, Croatia, Hungary, Ireland, Iran, Israel, Italy, Kazakhstan, South Korea, Lithuania, Luxembourg, Morocco, Netherlands, Norway, Oman, Poland, Portugal, Romania, Russia, Saudi Arabia, Slovenia, Sweden, Tunisia, Ukraine, South Africa, Canada, United Arab Emirates, Hong Kong, Indonesia, India, Myanmar, Malaysia, New Zealand, Singapore, Taiwan, Vietnam, and Australia.

The devices have not been withdrawn from any market due to a change in indications for any reason related to safety or effectiveness.

VIII. POTENTIAL ADVERSE EFFECTS OF THE DEVICE ON HEALTH

Below is a list of the potential adverse effects (e.g., complications) associated with the implantation and use of the HiResolution™ Bionic Ear System:

- Implant recipients incur the normal risks of surgery and general anesthesia.
- Major ear surgery may result in numbness, swelling or discomfort around the ear, disturbance of taste or balance, or pain including headache and/or neck pain. If these events occur, they are usually temporary and subside within a few weeks of surgery.
- Rarely, cochlear implantation may cause a leak of the inner ear fluid, which may result in meningitis.
- During the surgery, it is a rare possibility that the facial nerve could be injured resulting in a temporary or permanent weakening or full paralysis on the same side of the face as the implant.

- During the surgery, there is a rare possibility that cerebrospinal fluid leakage or perilymph fluid leakage could occur.
- As a result of the surgery, it is possible that dizziness, tinnitus, or vertigo may result. If these events occur, they are usually temporary and subside over time.
- The presence of a foreign body may cause irritation, inflammation, or skin breakdown and may require additional medical treatment or removal of the internal device.
- Skin infection in the area of the implant may require additional medical treatment or removal of the internal device.
- There is a possibility that the electrode or device may migrate requiring additional medical treatment or removal of the internal device to address any resulting injury.

IX. SUMMARY OF NONCLINICAL STUDIES

The preclinical studies (bench and animal) that were previously submitted to FDA in the original PMA (P960058) and its supplements continue to support the safety and effectiveness of the commercially available HiResolution™ Bionic Ear System.

No additional preclinical studies were required to evaluate the performance of the HiResolution™ Bionic Ear System for the treatment of patient populations under the expanded indications for SSD/AHL. The previously approved supplements which support the device system and its components are listed below in Table 1.

Table 1: Summary of recent System / Device Components and Their Respective Approval References

Device	Approval Reference
Cochlear Implants:	
HiRes™ Ultra CI HiFocus MS Electrode and HiRes™ Ultra CI HiFocus Slim J Electrode	P960058/S117 and S121
HiRes™ Ultra 3D HiFocus MS Electrode and HiRes™ Ultra 3D CI HiFocus Slim J Electrode	P960058/S129
Sound Processors:	
Naida CI Q series (Naida CI Q70, Q30 and Q90)	P960058/S102 and S114
Naida CI M series (Naida CI M30, Naida CI M90, and Sky CI M90)	P960058/S149
Fitting Software:	
Target CI	P960058/S149
Applications:	
AB Remote	P960058/S149
AB Remote Support	P960058/S159

X. SUMMARY OF PRIMARY CLINICAL STUDY

The applicant provided clinical performance data to establish a reasonable assurance of safety and effectiveness of expanding the approved indications with the HiResolution™ Bionics Ear System to include recipients with SSD/AHL in the US. Clinical data is presented from a prospectively designed, retrospective study conducted in accordance with the FDA guidance "Use of Real-World Evidence to Support Regulatory Decision-Making for Medical Devices." The applicant also performed a supporting systematic literature review for both adult and pediatric patients.

A summary of the real-world evidence is presented below.

A. Study Design

The purpose of this retrospective study (CR1022) was to gather real-world data (RWD) to demonstrate a reasonable assurance of the safety and effectiveness of cochlear implantation with the Advanced Bionics HiResolution™ Bionic Ear System in the worse ear for recipients with severe to profound sensorineural hearing loss in one ear and mild to moderately severe sensorineural hearing loss (i.e., AHL) or normal or near normal hearing in the contralateral ear (i.e., SSD).

This study used a retrospective, within-subject, repeated-measures design. A within-subject repeated-measures study design was considered appropriate as it accommodates the heterogeneity that characterizes hearing-impaired populations.

The study was designed as a multi-center study to provide a more representative sample of the target population and to support generalization of the study findings. Existing audiological outcomes and safety data obtained as a part of either routine clinical follow-up or previous research projects were extracted via a retrospective review of data sources such as billing or medical records, clinic or research databases, and commercial CI fitting software databases.

Device and procedure-related Adverse Events (AE) and Serious Adverse Events (SAE) were collected during the study as documented in medical records. Events were recorded and tracked between implantation and the last study visit.

1. Clinical Inclusion and Exclusion Criteria

   Enrollment in the Retrospective Study of Advanced Bionics Recipient Outcomes with Single-Sided Deafness and Asymmetric Hearing Loss study was limited to patients who met the following inclusion criteria:

   - Patients who received an AB CI (HiRes 90K, HiRes 90K Advantage, HiRes Ultra, HiRes Ultra 3D) in the year 2008 or later for the treatment of SSD or AHL.
   - Aged 13 years or older at time of implantation.

- Pre-op audiometric thresholds and speech perception scores:
    - Ear to be implanted:
        - Severe to profound sensorineural hearing loss (4PTA of 500, 1000, 2000, and 4000 Hz ≥ 70 dB HL)
        - Aided speech perception score (CNC) of ≤ 40%.

    - Contralateral Ear:
        - SSD: Normal or near normal hearing (NH; 4PTA of 500, 1000, 2000, and 4000 Hz ≤ 30 dB HL).
        - AHL: Up to moderately severe HL, i.e., a 4PTA >30 and ≤ 70 dB HL at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz, with a difference of at least 15 dB in PTAs between ears.
- Minimum of six months of post-activation CI use experience
- Availability of CNC word scores in quiet at baseline (pre-surgery) and 1 year ± 6 months post-CI activation.

Patients were not permitted to enroll in the Retrospective Study of Advanced Bionics Recipient Outcomes with Single-Sided Deafness and Asymmetric Hearing Loss study if they met any of the following exclusion criteria:

- Clinical presentation indicative of potential implanted device malfunction at or within ± 6 months of CI activation.
- Unavailability of speech outcomes with validated tests in the English language.

2. Follow-up Schedule

Existing audiological outcomes and safety data obtained as a part of either routine clinical follow-up or previous research projects were extracted via a retrospective review of data sources such as billing or medical records, clinic or research databases, and commercial CI fitting software databases. Data from postoperative follow-up visits conducted approximately 1, 2, 3, 4, and 5 years after the baseline measurement were retrospectively collected and analyzed. There was no prospective data collection. Hence, no additional clinic visits were required by subjects.

3. Clinical Endpoints

Safety data were gathered from the currently approved indications for individuals with bilateral sensorineural hearing loss with the same device. Since unilateral implantation is not expected to differ from bilateral implantation in rate or severity of adverse events, a safety analysis of the current literature was conducted (see Section XI).

Effectiveness testing included speech perception in quiet using monosyllabic CNC words in the implanted ear at 1 year ± 6 months post-CI activation compared to baseline best-aided scores. Supporting data included speech perception in noise (AzBio and HINT sentences), sound source localization accuracy (RMS error), and subjective ratings obtained with the Speech, Spatial and Qualities of Hearing Scale (SSQ) and Tinnitus

Handicap Inventory (THI), each compared to baseline. Unaided air conduction thresholds in the non-implanted ear and average daily CI sound processor usage were also collected. Supporting data were collected through 5 years ± 6 months post-CI activation where available.

Primary Effectiveness Endpoint

- Improvement in speech perception scores in quiet obtained with the implanted-ear-only at 1 year ± 6 months post-CI activation compared to the best-aided pre-operative scores. Scores were obtained with monosyllabic CNC words using one of the two methodologies: 1) From the front loudspeaker in the sound booth at 50 dB HL or 60 dBA with the better ear masked with speech-shaped noise at a level ranging from 50 to 75 dB HL and/or plugged and/or muffed and, 2) Using direct audio input to the CI sound processor.

  The pre-specified null and alternative hypothesis are as follows:

  H_0: For participants with SSD/AHL, change in mean word recognition scores from pre-operation to 1-year (+ 6 months) post-CI activation is less than or equal to 10 percentage points.

  $$\mu POST - \mu PRE \leq 10\%$$

  H_A: For participants with SSD/AHL, change in mean word recognition scores from pre-operation to 1-year (+ 6 months) post-CI activation is greater than 10 percentage points.

  $$\mu POST - \mu PRE > 10\%$$

  At the individual level, a change of >10% was considered clinically meaningful (Firszt et al., 2023). Although the primary endpoint comparison was between pre-operative scores and 1-year post-CI activation (± 6 months) scores, available data up to 5 years post-CI activation (± 6 months) were also extracted. The change in CNC scores from 1 year ± 6 months to 5 years ± 6 months post-CI activation was evaluated by examining the slope over that time span using a linear mixed model. Separate analyses were conducted for the AHL and SSD cohorts. A nonlinear trend was expected, with a change from baseline to 1 year ± 6 months, but relatively flat at later time points.

  Two analysis populations were used: the Intent-to-Treat (ITT) population, which included all eligible enrolled subjects with imputed values where needed and served as the primary population for the safety and effectiveness analyses. The Modified ITT (mITT) population, which included only subjects with measured (non-imputed) data and served as the primary population for supporting data analyses.

Where a baseline CNC score was not measured, an "assumed 0" score was recorded consistent with common clinical practice for profoundly impaired ears. To avoid inflating the magnitude of post-implant improvement, multiple imputation (Little and Rubin, 2002) was applied using available baseline audiological and demographic variables.

Secondary Effectiveness Endpoints

- Pre-operative (baseline) best-aided speech in noise scores with AzBio and HINT sentences at fixed SNR in the S_0N_0 and S_0N_{BE} speaker configurations were compared to those obtained at 1 year (± 6 months) post-CI activation with the everyday listening configuration. The pre-specified null and alternative hypotheses are as follows:

  H_0: For participants with SSD/AHL, change in mean of the percent correct speech perception scores from pre-operation to 1-year (± 6 months) post-CI activation are equivalent is less than or equal to 10%.

  $$\mu POST - \mu PRE \leq 10\%$$

  H_A: For participants with SSD/AHL, change in mean of the percent correct speech perception scores from pre-operation to 1-year (± 6 months) post-CI activation is greater than 10%.

  $$\mu POST - \mu PRE > 10\%$$

  At an individual level, a change of >10% was considered clinically meaningful based on the 95% confidence intervals reported by Spahr et al. (2012).

- Sound source localization accuracy at 1 year (± 6 months) post-CI activation with everyday listening configuration (both ears) was compared to pre-operative performance. Localization accuracy was measured using a multi-speaker array in the horizontal plane via one of two methodologies: A) sixteen different everyday sounds presented randomly at 60 dB SPL from one of eight speakers arranged in a 108-degree horizontal arc (Hansen et al., 2013; Sullivan et al., 2020) and, B) monosyllabic words presented randomly at 60 dB SPL from one of 15 speakers arranged in a 140-degrees horizontal arc (Firszt et al., 2018). In both methods, listeners were asked to identify the speaker from which the sound was presented.

  The pre-specified null and alternative hypotheses are as follows:

  H0: For participants with SSD/AHL , change in mean RMS error from pre-operation to 1 year (± 6 months) post-CI activation is greater than or equal to -6°.

  $$\mu POST - \mu PRE \geq -6°$$

H_A: For participants with SSD/AHL, change in mean RMS error from pre-operation to 1-year (± 6 months) post-CI activation is less -6°.

$$\mu POST - \mu PRE < -6°$$

At an individual level, a change of ≥ -6° was considered a meaningful change. Localization abilities have been widely studied and found to differ greatly across listeners based on hearing loss severity, as well as the listener's hearing technology, and hearing device configuration. The 6° margin was selected based on a medium effect size (0.5 × 12° SD; Leppink et al., 2016), consistent with published RMS error variability in bilateral CI and SSD populations (Jones et al., 2014; Dorman et al., 2016).

- Subjective ratings obtained with the SSQ at 1 year (± 6 months) post-CI activation were compared to that measured pre-operatively. The pre-specified null and alternative hypotheses are as follows:

  H_0: For participants with SSD/AHL, change in mean SSQ ratings from pre-operation to 1 year (± 6 months) post-CI activation is less than or equal to 1.

  $$\mu POST - \mu PRE \leq 1$$

  H_A: For participants with SSD/AHL, change in mean SSQ ratings from pre-operation to 1 year (± 6 months) post-CI activation is greater than 1.

  $$\mu POST - \mu PRE > 1$$

  At the individual level, a change of >1 was considered a clinically meaningful change as reported by Wick et al. (2020) and Cowan et al. (2024).

  These data were collected up to 5 years (± 6 months) post-CI activation and reported to document longer-term effectiveness. The change in outcomes from 1 year (± 6 months) to 5 years (± 6months) post-CI activation was evaluated by examining the slope over that time span using a linear mixed model.

B. Accountability of PMA Cohort

Six USA study sites enrolled a total of 91 subjects implanted with a HiResolution™ Bionic Ear System (HiRes 90K and newer), with surgeries occurring between February 2002 and September 2023. Prior to data extraction, Institutional Review Board (IRB) approval and HIPAA waivers were obtained at all participating sites. Of the 91 subjects, 19 screen failed; five of these were retained in the ITT population due to missing baseline and/or 1-year CNC scores.

Of the remaining 72 subjects, 25 were enrolled in the SSD cohort and 47 were enrolled in the AHL cohort and form the primary analysis population. Fifty-two of

the 72 subjects were noted to have "completed the study," because they either had a data point available at the 5 years ± 6 months visit interval or were still under clinical care at the time of data extraction. Twenty subjects were classified as discontinued following the 1-year visit due to lost to follow-up or CI revision surgery; their available data were included in the analysis. The label "discontinued" indicates that they had either been lost to clinical follow-up or were in the process of getting a CI revision surgery after the 1-year (± 6 months) visit. Data were available from 72, 35, 25, 15, and 16 subjects at the 1-, 2-, 3-, 4-, and 5-year ± 6 months intervals, respectively.

C. Study Population Demographics and Baseline Parameters

The ITT population consists of 77 subjects (28 SSD and 49 AHL). Of the 77 ITT subjects, 64 subjects (19 SSD and 45 AHL) were included in the mITT population, which consists of subjects from the ITT population with available measured data.

Of the 72 subjects enrolled who met eligibility criteria, 37 subjects (12 SSD and 25 AHL) were female, and 35 subjects (13 SSD and 22 AHL) were male. All subjects were over 18 years of age at the time of implantation. In the SSD cohort, age at the time of implantation ranged from 25.72 years to 76.9 years with a mean of 53.08 years. In the AHL cohort, subject age at the time of implantation ranged from 18.33 years to 85.72 years, with a mean of 61.3 years.

CNC word scores in quiet were available for all 72 enrolled subjects. Availability of supporting data (speech in noise, SSQ, THI) varied across subjects and time points, as expected in a retrospective study. Supporting data were included when available at baseline and at least one follow-up interval, with the additional requirement that speech in noise scores were obtained under the same noise type and signal-to-noise ratio (SNR) at both visits.

D. Safety and Effectiveness Results

1. Safety Results

The safety analysis was based on the 72 subjects described above, with data from 52 subjects available for the 5-year 6-month evaluation.

Adverse events were collected during the study as documented in the data sources, and these events were recorded and tracked from the time of implantation until the last study visit date. In total, 78 AEs were documented, with five of these being classified as SAEs. For the identified SAEs, four were due to hospitalization or prolongation of hospitalization, and one required intervention to prevent impairment. The remaining AEs were anticipated risks of this device and/or procedure. No unanticipated AEs or serious procedure-related AEs were reported during the study. The frequency and type of AEs did not reveal unexpected safety concerns.

2. Primary Effectiveness Results

The primary effectiveness endpoint for SSD/AHL CI recipients was the comparison of monosyllabic (CNC) word scores obtained in quiet in the implanted ear only at 1 year ± 6 months post-CI activation with baseline best-aided CNC scores.

SSD Cohort:

Outcomes were first analyzed for 19 subjects who had a best-aided CNC score available at baseline and for the combined group of 28 to include the 9 subjects with "assumed 0" scores at baseline or missing CNC scores at 1 year.

In the group with measured baseline CNC scores (N=19), mean scores at 1 year ± 6 months were greater than those at baseline by 32.32% (22.22 SD, 95% CI: 21.61 to 43.02, p=0.0002). Fifteen of 19 subjects (78.9%) demonstrated a clinically meaningful improvement of ≥10%.

In the combined analysis (n=28), imputed scores were used as baseline CNC scores for the six subjects with "assumed 0" baseline CNC scores, and imputed scores were used as CNC scores at 1 year for the three subjects missing CNC scores at 1 year. Mean CNC scores at 1 year ± 6 months were greater than those at baseline by 35.7% (26.72 SD, 95% CI: 25.34 to 46.06, p < 0.0001). Twenty-two of 28 subjects (78.6%) demonstrated a clinically meaningful improvement of ≥10%.

AHL Cohort:

Outcomes were analyzed first for 45 subjects who had a best-aided CNC score available at baseline and then for the combined group of 49 that included the four subjects with "assumed 0" scores at baseline or missing CNC scores at 1 year.

In the group with measured baseline CNC scores, mean improvement in scores at 1 year ± 6 months was 36.22% (28.62 SD, 95% CI: 27.62 to 44.82, p < 0.0001). Thirty-six of 45 subjects (80%) showed a clinically meaningful improvement of ≥ 10%.

As with the SSD cohort, imputed scores were used as baseline CNC scores for the two subjects with "assumed 0" baseline CNC scores, and imputed scores were used as CNC scores at 1 year for the two subjects with missing CNC scores at 1 year in the combined analysis for the AHL cohort. Across the 49 subjects, mean change at 1 year ± 6 months as compared to baseline was 34.05% (28.85 SD, 95% CI: 25.76 to 42.34, p < 0.0001). Thirty-eight of 49 subjects (77.6%) demonstrated a clinically meaningful improvement of ≥ 10%.

Long-Term Effectiveness:

SSD subjects (n=28): At follow-up intervals of 2 years, 3 years, 4 years, and 5 years (± 6 months), the following percentages of subjects showed a ≥10% improvement in CNC scores from baseline: 81.8% (9/11), 90.9% (10/11), 100% (5/5), and 100% (5/5),

respectively. The change from baseline was statistically significant through the 3 years ± 6 month time point. Linear mixed model analysis resulted in a slope of 0.427 (p=0.8050), indicating that the scores remained stable out to 5 years ± 6 months.

AHL subjects (N=49): At follow-up intervals of 2 years, 3 years, 4 years, and 5 years (± 6 months), the following percentages of subjects showed a ≥10% improvement in CNC scores from baseline: 87% (20/23), 76.9% (10/13), 87.5% (7/8), and 100% (8/8), respectively. The change from baseline was statistically significant at all follow-up intervals. Linear mixed model analysis resulted in a slope of 4.314 (p=0.0031), indicating an improvement in scores out to 5 years ± 6 months.

Effectiveness in Adults with Baseline CNC Scores of 6-20%

To support the adult speech criterion of ≤20% CNC words, effectiveness was assessed across three baseline CNC subgroups in the ear to be implanted: (i) ≤5%, (ii) >5 to ≤20%, and (iii) >20 to ≤40%. The pre-specified threshold for success was >50% of subjects achieving a clinically meaningful improvement of ≥10%. This threshold was met in subgroups (i) and (ii) in both cohorts, supporting the expanded candidacy criterion up to a baseline CNC score of 20%.

- **SSD**: 87% (13/15) in the ≤5% group; 100% (6/6) in the >5–≤20% group; 50% (2/4) in the >20–≤40% group.
- **AHL**: 85% (23/27) in the ≤5% group; 71% (10/14) in the >5–≤20% group; 50%(3/6) in the >20–≤40% group

Table 2: Pooled CNC In Quiet Data (Measured With Best Aided CI Ear) mITT Adult Subjects With Baseline CNC Scores From 6-20%

	Baseline	1Y +/- 6mo	2Y +/- 6mo	3Y +/- 6mo	4Y +/- 6mo	5Y +/- 6mo
SSD Cohort						
Mean ± SD (N)	9.75 ± 3.50 (4)	41.25 ± 16.28 (4)	42.50 ± 2.12 (2)	68.00 ± 0.00 (1)	26.00 ± 0.00 (1)	
Median (Min, Max)	9.50 (6.00, 14.00)	40.50 (24.00, 60.00)	42.50 (41.00, 44.00)	68.00 (68.00, 68.00)	26.00 (26.00, 26.00)	
Post-op data comparison with baseline data						
N		4	2	1	1	
N (%) achieving ≥ 10%		4 (100.0%)	2 (100.0%)	1 (100.0%)	1 (100.0%)	

Table 2: Pooled CNC In Quiet Data (Measured With Best Aided CI Ear) mITT Adult Subjects With Baseline CNC Scores From 6-20%						
	Baseline	**1Y +/- 6mo**	**2Y +/- 6mo**	**3Y +/- 6mo**	**4Y +/- 6mo**	**5Y +/- 6mo**
Mean (SD)		31.50 (12.79)	33.00 (4.24)	60.00	18.00	
(95% CI)		(11.14, 51.86)	(-5.12, 71.12)			
t-statistics		3.36	7.67			
Degrees of freedom		3	1			
One sided p-value		0.0218	0.0413			
Linear mixed model assessment of change after 1Y +/- 6mo						
Slope		-0.225				
SE		4.697				
p-value		0.9633				
AHL Cohort						
Mean ± SD (N)	13.58 ± 4.93 (12)	49.00 ± 25.66 (12)	66.40 ± 11.78 (5)	83.00 ± 10.82 (3)	63.33 ± 6.11 (3)	66.00 ± 19.08 (3)
Median (Min, Max)	15.00 (6.00, 20.00)	50.00 (8.00, 92.00)	60.00 (56.00, 82.00)	80.00 (74.00, 95.00)	62.00 (58.00, 70.00)	76.00 (44.00, 78.00)
Post-op data comparison with baseline data						
N		12	5	3	3	3
N (%) achieving ≥ 10%		10 (83.3%)	5 (100.0%)	3 (100.0%)	3 (100.0%)	3 (100.0%)
Mean (SD)		35.42 (26.47)	52.00 (12.08)	68.33 (12.74)	46.67 (4.62)	49.33 (20.23)
(95% CI)		(18.60, 52.24)	(37.00, 67.00)	(36.68, 99.98)	(35.19, 58.14)	(-0.93, 99.59)
t-statistics		3.33	7.77	7.93	13.75	3.37

Table 2: Pooled CNC In Quiet Data (Measured With Best Aided CI Ear) mITT Adult Subjects With Baseline CNC Scores From 6-20%						
	Baseline	**1Y +/- 6mo**	**2Y +/- 6mo**	**3Y +/- 6mo**	**4Y +/- 6mo**	**5Y +/- 6mo**
Degrees of freedom		11	4	2	2	2
One sided p-value		0.0034	0.0007	0.0078	0.0026	0.0390
Linear mixed model assessment of change after 1Y +/- 6mo						
Slope		4.451				
SE		2.369				
p-value		0.0725				

Note 1: Table does not include screen failures.
Note 2: Table only includes subjects with measured CNC scores at baseline.
Note 3: Table does not include subjects who do not have data at Baseline and at a minimum One Year visit.
Note 4: One-sided p-value based on the paired t-test, testing the null hypothesis: H_0: μ_{post} - μ_{pre} <= 10%, where μ_{pre} represents the mean word recognition scores in quiet at baseline, and μ_{post} represents the mean word recognition scores in quiet at 1- year post CI activation.

Among adult subjects with baseline CNC scores in the 6–20% range, clinically meaningful improvement of ≥10% was achieved in 100% of SSD subjects (6/6) and 71% of AHL subjects (10/14), exceeding the pre-specified >50% responder threshold in both cohorts. Across both groups combined, 16 of 20 subjects (80%) with baseline scores in this range demonstrated clinically meaningful benefit, supporting the expanded adult speech criterion of ≤20%. Speech perception in noise data for this subgroup were limited due to small sample sizes, particularly in the SSD cohort, and are therefore not presented in tabular form. Available AHL data showed clinically meaningful improvement (>10%) in the majority of subjects with data at most intervals through 5 years, though these results should be interpreted with caution given the limited sample sizes.

3. Secondary Effectiveness Results

Speech Perception Scores In Noise

Speech perception in noise data were limited across both cohorts and should be interpreted with caution. In the SSD cohort, six subjects had S_0N_0 data at 1 year ± 6 months; the mean change of 15.3% was clinically meaningful but did not reach statistical significance (p=0.31), likely reflecting insufficient sample size. S0NBE data were available for only four subjects, with a mean change of 4.1% at 1 year (p=0.99).

In the AHL cohort, 20 subjects had S_0N_0 data at 1 year ± 6 months; the mean change of 21.1% was clinically meaningful with 60% of subjects showing >10% improvement, though statistical significance was not reached (p=0.057). The majority of subjects with available data at 2-, 3-, 4-, and 5-year intervals continued to show >10% improvement. S_0N_{BE} data were available for only one subject, who showed a 62% and 44% improvement at 1 and 3 years, respectively.

Sound Source Localization Accuracy

Localization data were available from two sites using different methodologies (Method A: 8-speaker 108° arc; Method B: 15-speaker 140° arc) and were analyzed by methodology where within-subject comparisons were possible.
In the SSD cohort, combined data from both methods were available for 6 subjects at baseline and 1 year ± 6 months. Mean RMS error improved from 41.5° to 27.0° (mean improvement 14.5°, p=0.17); the null hypothesis could not be rejected. Half of subjects (3/6) achieved the >6° individual threshold at 1 year, with limited longer-term data available.

In the AHL cohort, combined data were available for 12 subjects at baseline and 1 year ± 6 months. Mean RMS error improved from 43.4° to 29.4° (mean improvement 14.0°, p=0.033); the null hypothesis could not be rejected as the improvement did not significantly exceed the −6° threshold. The majority of subjects with available data showed a >6° improvement at each follow-up interval: 75% (9/12) at 1 year, 86% (6/7) at 2 years, and 100% at 3 and 4 years.

Speech, Spatial And Qualities Of Hearing Scale (SSQ)

In the SSD cohort, SSQ data were available from seven subjects. Statistically significant improvements from baseline to 1 year ± 6 months were observed across all subscales and the global score (speech: +3.3, p=0.003; spatial: +4.3, p=0.005; qualities: +1.8, p=0.036; global: +3.1, p=0.004), rejecting the null hypothesis for the global score. All subjects with available data reported improved ratings on the speech and spatial subscales; 71% showed improvement on the qualities subscale. Limited 2-year data (n=3) showed sustained improvement across all subscales.

In the AHL cohort, SSQ data were available from 12 subjects. Statistically significant improvements from baseline to 1 year ± 6 months were observed across all subscales and the global score (speech: +3.1, p=0.005; spatial: +3.5, p=0.0003; qualities: +2.5, p=0.003; global: +3.0, p=0.001), rejecting the null hypothesis for the global score. At least 75% of subjects showed a clinically meaningful improvement of >1 on each subscale at 1 year, with all subjects showing continued improvement at 2- and 3-year intervals where data were available.

Tinnitus Handicap Inventory (THI)

In the SSD cohort, data were available from two subjects at baseline and 1 year ± 6

months, and the mean ratings dropped from 44 (5.66 SD) to 5 (7.07 SD). The mean change was 39 (12.73 SD) with both subjects reporting a change in degree of perceived tinnitus from moderate to slight. In the AHL cohort, data were available from only one subject at baseline and 1 year ± 6 months, where the rating dropped from 16 to 0.

4. Subgroup / Covariate Analyses

   Subgroup analyses of the primary effectiveness endpoint were performed across the following variables: duration of hearing loss, implant type, sex, age at implantation, baseline 4PTA, baseline best-aided CNC score, duration of severe-to-profound hearing loss, and timing of onset. Subgroup analyses were not performed for speech in noise due to limited available data.

   In the AHL cohort, potential lack of homogeneity was observed for duration of hearing loss (p=0.002), implant type (p=0.052), baseline 4PTA (p=0.006), and baseline best-aided CNC score (p=0.128). Subjects with longer duration of hearing loss showed greater mean improvement (55.4% vs. 26.5% for ≥ vs. < median duration). Subjects with higher baseline 4PTA showed greater improvement (47.5% vs. 24.5% for ≥ vs. < median PTA), as did those with poorer baseline CNC scores (43.2% vs. 30.1% for < vs. ≥ median CNC). Mean paired differences across implant types ranged from 28.5% to 58.3%. No evidence of heterogeneity was observed for sex, age, duration of severe-to-profound hearing loss, or timing of onset.

   In the SSD cohort, potential lack of homogeneity was observed only for baseline best-aided CNC score (p=0.098), with subjects below the median showing greater improvement (41.2% vs. 24.3%). No evidence of heterogeneity was observed for the remaining variables, suggesting consistent benefit regardless of baseline characteristics.

   Continuous covariates were assessed with linear regression and categorical covariates with an ANOVA, with change in CNC word scores from baseline to 1 year ± 6 months as the outcome variable. In the AHL cohort, duration of hearing loss was positively associated with improvement (slope=0.76, 95% CI: 0.15–1.35; p=0.015) and baseline CNC score was negatively associated with improvement (slope=−0.90, 95% CI: −1.63 to −0.18; p=0.015), consistent with the subgroup findings above. No statistically significant covariate relationships were identified in the SSD cohort. Covariate analyses were not performed for speech in noise due to limited data availability.

   Stratified Analysis for Co-Primary Endpoints

   Stratified performance analyses were conducted for CNC words in quiet; speech-in-noise data were insufficient for stratified analysis. Better, similar, and poorer performance were defined as a change of >10%, −10% to 10%, and <−10% from baseline, respectively. In the SSD cohort (N=19), 79% of subjects demonstrated better

performance, 21% similar, and none poorer. In the AHL cohort (N=45), 80% demonstrated better performance, 16% similar, and 4% poorer.

Discussion of Results

The primary effectiveness endpoint was met in both cohorts, with clinically significant improvements in CNC word scores in the implanted ear at 1 year ± 6 months post-CI activation. Mean improvement was 35.7% in the SSD cohort ($p<0.0001$) and 34.1% in the AHL cohort ($p<0.0001$), with approximately 79% and 78% of subjects, respectively, achieving the ≥10% clinically meaningful threshold. Improvement was sustained 5 years ± 6 months in both cohorts (for a subset of subjects with available data at this time point).

Secondary effectiveness endpoints demonstrated that speech perception in noise scores showed clinically significant mean improvements in both cohorts at 1 year, though statistical significance was not reached (potentially due to insufficient sample size). Localization accuracy improved in the majority of subjects in both cohorts at 1 year. SSQ global scores improved in both cohorts at 1 year, with improvements sustained through available longer-term follow-up. Audiometric thresholds in the non-implanted ear remained stable within test-retest reliability limits through 3–4 years post-activation.

Subgroup analyses identified that subjects with poorer baseline CNC scores and, in the AHL cohort, longer duration of hearing loss and higher baseline 4PTA, tended to show greater improvement, which is consistent with outcomes in bilateral CI literature. Importantly, clinically significant improvement was demonstrated in subjects with baseline CNC scores up to 20% in the ear to be implanted, supporting the expanded adult audiometric speech criterion.

5. Pediatric Extrapolation

In this premarket application, existing clinical data was leveraged to support the reasonable assurance of safety and effectiveness of the HiResolution™ Bionics Ear System in children 5 years and older with SSD or AHL.

Advanced Bionics used the Pediatric Extrapolation Decision Tree provided in the FDA guidance Leveraging Existing Clinical Data for Extrapolation to Pediatric Uses of Medical Devices to determine whether a full or partial extrapolation of the existing data from studies with adult participants would be appropriate for this submission.

Pediatric Extrapolation Decision Tree

Question A: Does the treated disease or condition occur in a pediatric (sub)population(s)?

Yes. Unilateral profound sensorineural hearing loss occurs in the pediatric population as well as in adults. In the US, the overall prevalence of unilateral hearing loss (UHL) in adults has been reported to be 7.2% (95% confidence interval 6.1%-8.6%), with

1.5% (0.1%-2.1%) with moderate-or-worse UHL (Golub et al, 2018). More recently, Kay-Rivest et al (2022) estimated the prevalence of SSD in adults in the US to be 0.14% (95% CI=0.08-.024).

In infants, the incidence of UHL is reported to be 1/1000 live births in the US (Lieu et al, 2018). In the 2022 annual data report of the Early Hearing Detection and Intervention (EHDI), the US Centers for Disease Control and Prevention (US CDC, 2024) reported that 6,272 infants born between January 1, 2022 and December 31, 2022 were diagnosed with hearing loss. Of these, 593 infants had a mild to severe unilateral sensorineural hearing loss and 289 infants had a unilateral profound sensorineural hearing loss. Further, 113 infants were reported to have a mild to severe UHL and 25 had a profound UHL of unknown type. Estimates of prevalence of AHL are typically more difficult to estimate as these individuals are often combined with those with bilateral symmetric hearing loss.

By ages 6 to 9 years, the prevalence of UHL is reported to be higher at approximately 3% to 6.3% (Lieu et al, 2018; Ross et al, 2010; Shargorodsky et al, 2010). Boyd (2015) estimated that of the children with HL, the proportion of those with severe to profound UHL may be around 30-50%.

Thus, the treated condition occurs in the pediatric population.

Question B: Is there an endpoint present in the existing data source that measures device effects relevant to the intended pediatric (sub)population(s)?

Yes. Monosyllabic word recognition tasks (CNC) were used to measure efficacy in the AB adult retrospective SSD/AHL study. Similar speech perception measures are typically used with children, depending on their age. While individual variability exists, children are generally capable of completing monosyllabic word recognition tasks, exhibiting results similar to adult datasets by the age of 4-5 years (Uhler et al., 2017). For children under 5 years of age there is significant uncertainty when obtaining ear-specific hearing information, particularly related to speech perception. Therefore, data extrapolation is not currently considered suitable for children under 5 years of age. Supporting data in the AB adult retrospective study included comparisons of pre- and post-CI surgery subjective ratings obtained with a validated questionnaire (SSQ), speech perception in noise scores, and sound source localization accuracy. All these measures are relevant to the intended pediatric population as children spend 80% of their time in speech-in-noise situations (Crukley, Scollie & Parsa, 2011). In addition, average daily device use was evaluated through sound processor datalogs. The literature also shows multiple studies where children with CIs were evaluated with the same measures as in the AB adult retrospective study. For example, Benchetrit et al (2021) performed meta-analyses on 119 children with SSD. They found CIs to provide clinically meaningful improvements in most children for speech perception in quiet and in noise, and sound localization and significantly improved subjective hearing outcomes measured by the SSQ.

Arndt et al (2024) utilized measures of speech perception in quiet and in noise, localization and SSQ to retrospectively evaluate outcomes in 36 children with SSD. Cadieux et al (2013) evaluated five adolescents with AHL with tests of speech recognition in quiet (CNCs) and in noise and localization. Examples of average daily device use duration measured with sound processor datalogs in SSD children include Arndt et al (2024), Deep et al (2021a) and Polonenko et al (2017). Therefore, the endpoints used in the existing adult data (CNC, speech perception in noise, sound localization, SSQ and device use logs) are relevant to the intended pediatric population. The relevance of these endpoints is further detailed in a literature review in section 3 below.

Question C: Expected similarity of response to intervention

Question C-1: Is the device implanted or in contact with the body, and if so, does either the location or duration of the implantation differ between the adult and intended pediatric (sub)population(s) in such a way that either the safety or effectiveness of the device could be impacted in a clinically meaningful way?

No. The HiResolution™ Bionic Ear System is comprised of external components (sound processor, cable, head/earpiece) and internal components (cochlear stimulator and electrode). The system is identical for adults and children. The location and the duration of implantation of the internal components is not different between children and adults. The HiResolution™ Bionic Ear System is already approved for pediatric subpopulations of ages 12 months and older with bilateral profound sensorineural hearing loss. To date, over 11,000 pediatric CI recipients have been implanted with AB devices in the US with a well-established benefit/risk profile. The intended location and the duration of implantation of the internal components for children with SSD or AHL is the same as what is already in on-label use with adults as well as children ages 12 months and older with bilateral profound hearing loss. This supplement seeks approval for an expanded indication but does not change the surgical procedure for the device.

Question C-2: Are there differences in the device characteristics between pediatric and adult use that could impact either device safety or effectiveness in the pediatric (sub)population(s) in a clinically meaningful way?

No. As stated above, the HiResolution™ Bionic Ear system used by both adults and children is the same and is currently in on-label use for individuals 12 months and older. The mechanism of action of the internal components of the implant is similar in both populations. The nature of reported adverse events is no different than that observed in CI recipients implanted under currently approved indications.

There may be differences in how clinicians program noise management settings in younger children. However, this clinical scenario is no different than that for children who meet current approved AB indications. Program settings are intended to be adjusted by healthcare professionals to suit individual CI recipients. These differences in device characteristics are considered minor and are not expected to impact safety or effectiveness.

Question C-3: Are there characteristics unique to the intended pediatric (sub)population(s) that could impact either device safety or effectiveness in the pediatric (sub)population(s) in a clinically meaningful way?

No. The benefit-risk profile for this population, already established in children with bilateral profound hearing loss, is not expected to change for children and adolescents with SSD and AHL where only the ear with profound sensorineural hearing loss is to be implanted. Existing literature shows that a majority of children and adults show improved outcomes post implantation, especially those with acquired UHL. For children who present with AHL or SSD, only the affected ear is implanted. Since the non-implanted ear remains intact, evaluation of auditory benefit can be determined in this pediatric population. By age 5 years language should be developed, so this age group can be evaluated and treated similarly to adults.

Question C-4: Are there differences in disease characteristics between adult and pediatric (sub)population(s) that could impact either device safety or effectiveness in the pediatric (sub)population(s) in a clinically meaningful way?

No. There are no differences in the fundamental characteristics of profound sensorineural hearing loss between adult and pediatric populations that would impact device safety or effectiveness. Adult and pediatric patients with severe and/or profound sensorineural hearing loss are treated with the same CI systems and full electrode insertions are feasible in both populations with typical cochlear anatomies.

Question C-5: Are there any other differences between adult and pediatric (sub)population(s) that could impact either device safety or effectiveness in the pediatric (sub)population(s) in a clinically meaningful way?

No. There are no additional differences between the two populations that could impact either device safety or effectiveness in children in a clinically meaningful way. The safety profile of cochlear implantation has been well-established and confirmed in pediatric populations aged 12 months and older with bilateral, profound, sensorineural hearing loss. Effectiveness in the adult AHL/SSD population has been established in the Advanced Bionics retrospective study demonstrating statistically significant improvement in quiet both groups (SSD: mean change= 35.2%, 24.28 SD, $p<0.0001$; AHL: mean change= 34.35%, 29.43

SD, p<0.0001). A clinically meaningful improvement of >10% from baseline was observed in 80% of the subjects in the SSD cohort and 76.6% of the subjects in the AHL cohort. The improvement persisted long term (out to 5 years ± 6 months, the maximum study duration.) In both the AHL and SSD cohort, SSQ ratings (global as well as for the speech and spatial subscales) improved significantly from baseline at 1 year ± 6 months post-CI activation, thereby suggesting improved hearing outcomes in everyday situations. Average daily device use was stable out to 5 years ± 6 months post-CI activation, with annual daily averages ranging between 7.82 to 9.2 hours/day in the SSD cohort and 8.47 to 9.77 hours/day in the AHL cohort. Adverse events were collected during the study as documented in the data sources, and these events were recorded and tracked from the time of implantation until the last study visit date. In total, 78 AEs were documented, with five of these being classified as SAEs. Of the events noted as SAEs, four were classified as such due to hospitalization or prolongation of hospitalization, and one required intervention to prevent impairment. The frequency and type of adverse events did not reveal unexpected safety concerns.

Overall Conclusions

Analysis of retrospective data from 72 subjects (25 SSD and 47 AHL) who received a CI in the worse ear demonstrated that the majority of subjects experienced clinically significant benefit following implantation.

The primary effectiveness endpoint was met in both cohorts, with mean CNC word scores in the implanted ear improving by 35.7% in the SSD cohort and 34.1% in the AHL cohort at 1 year ± 6 months post-activation (both p<0.0001). Approximately 79% of SSD subjects and 78% of AHL subjects achieved the pre-specified clinically meaningful threshold of ≥10% improvement. Clinically significant improvement was demonstrated in adult subjects with baseline CNC scores up to 20% in the ear to be implanted, supporting the expanded adult audiometric speech criterion. Speech perception in noise and sound localization trended toward improvement in both cohorts, though statistical significance was not reached, likely reflecting the limited sample sizes available for these measures. SSQ global scores improved significantly in both cohorts at 1 year, with improvements sustained through available longer-term follow-up.

In conclusion, the outcomes of this real-world retrospective analysis provide valid clinical evidence that cochlear implantation with the HiResolution™ Bionic Ear System in individuals with SSD or AHL is a safe and effective treatment option, with large, consistent, and durable benefit across speech perception, spatial hearing, and quality of life. Full extrapolation of these adult data to pediatric patients aged 5 years and older is supported by the consistency of the device, surgical procedure, and disease characteristics across populations. No prospective clinical data in the pediatric population were provided in this submission. Data extrapolation is not considered suitable for children under 5

years of age, given the significant uncertainty in obtaining reliable ear-specific hearing information in this age group, consistent with the age indication for the bone anchored hearing aid (BAHA) for the same patient population.

Clinical Study Data Limitations

The primary clinical evidence supporting this approval is derived from a prospectively designed retrospective analysis of RWD collected from 72 subjects across six US sites. The relevance and reliability of the RWD were evaluated in accordance with FDA RWE guidance and were determined to be of sufficient quality to support the proposed indication expansion. However, several limitations are noted. The sample size is relatively small, particularly at longer-term follow-up intervals where available data are limited. The study enrolled primarily adults, and pediatric extrapolation was leveraged to support the pediatric indication. Data were collected retrospectively, and statistical results are based on post-hoc analyses that may be subject to unidentified bias.

E. Financial Disclosure

The Financial Disclosure by Clinical Investigators regulation (21 CFR 54) requires applicants who submit a marketing application to include certain information concerning the compensation to, and financial interests and arrangement of, any clinical investigator conducting clinical studies covered by the regulation. The pivotal clinical study included six investigators. None of the clinical investigators had disclosable financial interests/arrangements as defined in sections 54.2(a), (b), (c), and (f). The information provided does not raise any questions about the reliability of the data.

XI. SUMMARY OF SUPPLEMENTAL CLINICAL INFORMATION

A literature review was performed on UHL, performed on 29th Jul 2024. The goal of this review was to assess speech perception in quiet and in noise as well as sound localization outcomes of subjects with SSD or AHL implanted with a CI.

A. Literature Search Strategy

The search terms and inclusion and exclusion criteria are listed in Table 3 and 4 below, respectively.

Table 3: Combinations of Search Terms Used

General Search Terms	Search Strings
Cochlear implant Single-sided deafness (SSD) Asymmetric hearing loss (AHL) Comparator devices Subject devices	PubMed ((("cochlear implants"[MeSH Terms] OR "cochlear implantation"[MeSH Terms]) AND ("single-sided deafness"[All Fields] OR "single-sided deafness"[All Fields] OR "unilateral deafness"[All Fields] OR "unilaterally deaf"[All Fields] OR

General Search Terms	Search Strings
	"asymmetric deafness"[All Fields]) AND "deaf"[All Fields] AND ("single-sided hearing loss"[All Fields] OR "single-sided hearing loss"[All Fields] OR "unilateral hearing loss"[All Fields] OR "asymmetric hearing loss"[All Fields]) AND ("nucleus"[All Fields] OR "Kanso"[All Fields]) AND ("cochlea"[MeSH Terms] OR "cochlea"[All Fields] OR "cochlear"[All Fields])) OR ("Med-el"[All Fields] OR "MEDEL"[All Fields] OR "Medical electronics"[All Fields]) OR "Oticon"[All Fields] OR "Advanced Bionics"[All Fields]) AND "cochlea*"[All Fields] AND 2020/01/01:2025/12/31[Date - Publication] Results: 1,092
	Embase (((('cochlea prosthesis'/exp OR 'cochlear implantation'/exp OR 'cochlear implant' OR 'cochlear implantation') AND 'unilateral' OR 'cochlea prosthesis'/exp OR 'cochlear implantation'/exp OR 'sound processor') AND ('hearing impairment'/exp OR 'perception deafness'/exp OR 'unilateral hearing loss'/exp OR 'single-sided deafness' OR 'single sided deafness'/exp OR ('ssd' AND 'deaf') OR 'single-sided hearing loss' OR 'single sided hearing loss' OR 'unilaterally deaf' OR 'asymmetric hearing loss'/exp OR ('ahl' AND 'hearing') OR 'asymmetric deafness' OR 'asymmetrically deaf') AND ('nucleus'/dv OR nucleus OR ci2* OR ci4* OR ci5* OR ci6*) AND (cochlear/df OR cochlear) OR (('med el'/df OR 'med el' OR medel/df OR medel) AND 'cochlea') OR (('oticon medical'/df OR 'oticon medical') AND 'cochlea') OR ('advanced bionics'/df AND 'cochlea')) AND [01-01-2020]/sd NOT [31-12-2025]/sd Results: 1,209

Table 4: Inclusion and Exclusion Criteria for Retrieved Literature

Inclusion Criteria
• Publications describing or focusing on the use of Cochlear Implant Systems • Publications describing non-clinical outcomes (e.g. tinnitus) • Meta-analysis and/or systematic review describing CI outcomes in SSD and AHL • Efficacy outcomes: single-study outcomes or randomized controlled trials as relevant in ≥10 patients • Safety outcomes: studies reporting adverse events or safety data, regardless of sample size or study design e.g., case reports • Reference published in peer-reviewed journal or book; • Reference referring to a study/studies performed on human subjects
Exclusion Criteria
• Duplicates • Repetitive/overlapping datasets • Single case reports (unless safety outcomes are reported) • Narrative reviews or systematic reviews with narrative synthesis • Publications where efficacy data is visually presented (e.g., graph only) and do not report on safety data • Publications where outcomes cannot be differentiated between subjects using AB devices and subjects using comparator devices • Non-human studies (e.g., in vitro, in vivo, animal, cadaver, phantom studies, simulations) • Non-peer reviewed (e.g., letters to editor, opinions, editorials etc.) • Conference abstracts, presentations or posters

The following flow chart describes how the literature was initially identified, screened, reviewed, and the final determination of the relevant literature.

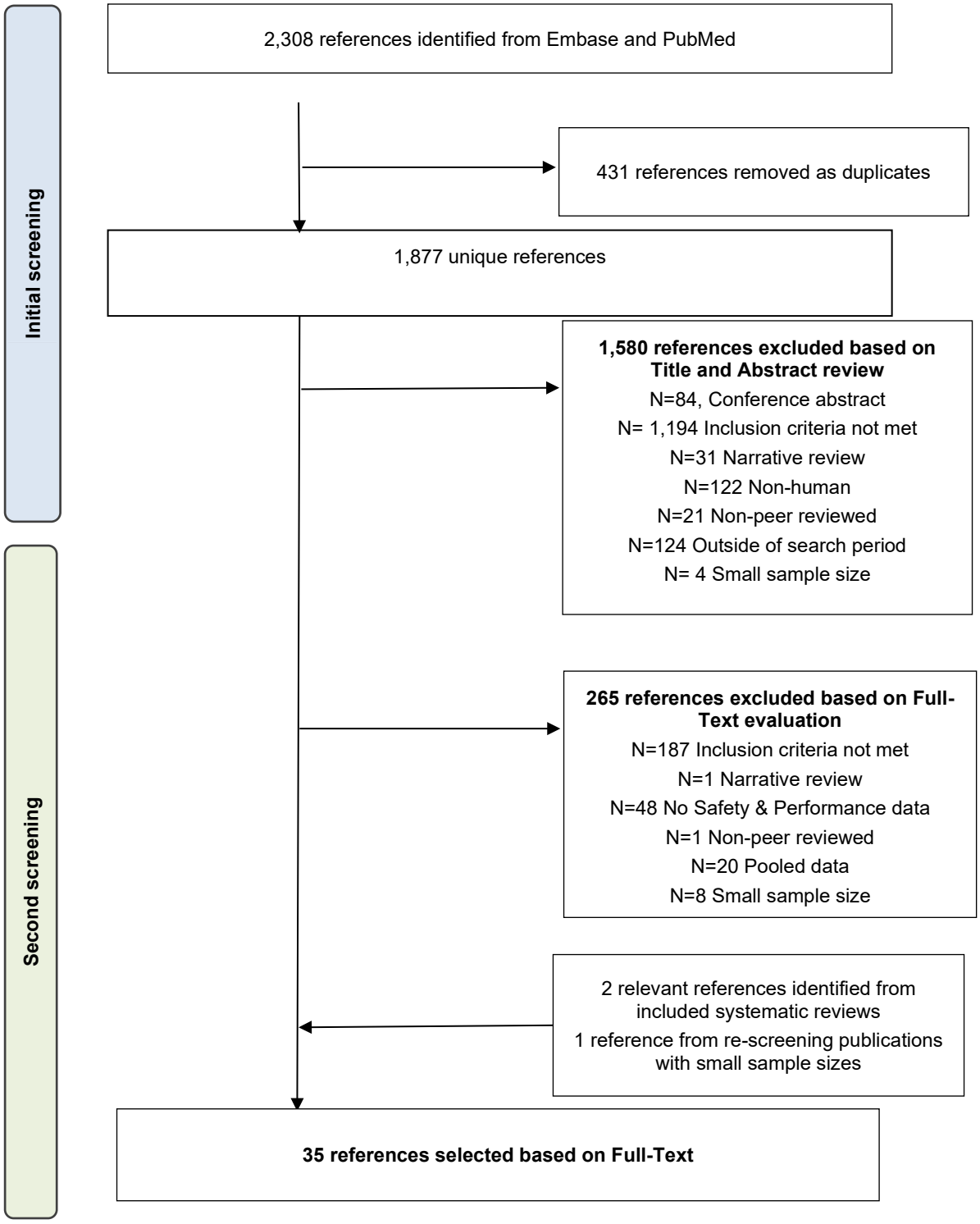

Figure 2: Flowchart for how the literature review was constructed

Of the 35 identified references, 4 were systematic reviews. The references used within these reviews were screened for relevance, but the systematic reviews themselves are not included.

1. Outcomes in Adults

The systematic literature review yielded 22 peer reviewed articles reporting on the effectiveness of CI in adult SSD and AHL patients and three peer reviewed articles reporting on the effectiveness of CI in a mix of adult and pediatric SSD and AHL patients. Across the 25 studies identified as relevant to the review question, data from a total of 1020 adults with SSD or AHL were reviewed. A summary of the literature is provided in Table 5 below.

Table 5: Adult Literature Review Results

Study	Key Results
Achena, A., et al. (2022).	After cochlear implant surgery, concerning the preimplantation daily listening condition, a significantly improved speech perception score in silence and noise was found in all four groups ($p < 0.05$ for all).
Asfour, L., et. al (2025)	A total of 122 adults were evaluated. Mean age was 56.3 (±13.0) years, and 59.8% were male. Mean SSD duration was 10.8 (±15.8) years. The most common etiology was sudden sensorineural hearing loss. The top primary motivations were improving overall hearing (23.0%), restoring hearing to the deaf ear (22.1%), and improving hearing in noise (21.3%). Most patients (45.1%) opted for a hearing aid, CROS or BiCROS system; 38.5% chose CI; and 14.8% declined treatment. Only 57.4% of those who selected CI had the implant, primarily due to surgery avoidance (31.5%) and insurance limitations (10.5%). Motivation did not predict treatment choice or CI receipt. Among CI recipients (n = 27), those motivated by hearing restoration demonstrated poorer speech outcomes and datalogging.
Astefanei, et. al. (2025).	In adult CI users, localization error significantly decreased from 81.9◦ ± 15.8◦ to 43.7◦ ± 13.5◦ ($p < 0.001$). In children, regardless of the implant type (CI or BCI), localization error improved from 74.3◦ to 44.8◦ , indicating a consistent spatial benefit. In adult BCI users, localization error decreased from 74.6◦ to 69.2◦ , but the improvement did not reach statistical significance. Tinnitus severity, measured on a 10-point VAS scale, decreased significantly in CI users (mean reduction: 2.8 ± 2.0, $p < 0.001$), while changes in BCI users were small and of limited clinical relevance. SSQ12B/C scores improved in all adult groups, with the largest gains observed in spatial hearing for CI users (2.1 ± 1.2) and in speech understanding for BCI users (1.6 ± 0.9); children reported high benefits across all domains. Head shadow yielded the most consistent benefit across all groups (up to 4.9 dB in adult CI users, 3.8 dB in adult BCI users, and 4.6 dB in children). Although binaural effects were smaller in BCI users, positive gains were observed, especially in pediatric cases. Correlation analysis showed that daily device use positively predicted SSQ12 improvement ($r = 0.57$) and tinnitus relief ($r = 0.42$), while longer deafness duration was associated with poorer localization outcomes ($r = –0.48$).
Dillon, M. T., et al (2020)	A prospective clinical trial evaluated the effectiveness of cochlear implantation in adults with AHL. Twenty subjects with mild-to-moderate hearing loss in the better ear and moderate-to-profound hearing loss in the poorer ear underwent cochlear implantation of the poorer hearing ear. Subjects were evaluated preoperatively and at 1, 3, 6, 9, and 12 months post-activation. Preoperative

Study	Key Results
	performance was evaluated unaided, with traditional HAs or with a BAHA. Post-activation performance was evaluated with the cochlear implant (CI) alone or in combination with a contralateral HA (bimodal). Test measures included subjective benefit, word recognition, and spatial hearing (i.e., localization and masked sentence recognition). Significant subjective benefit was reported as early as the 1-month interval, indicating better performance with the CI compared with the preferred preoperative condition. Aided word recognition with the CI alone was significantly improved at the 1-month interval compared with preoperative performance with an HA and continued to improve through the 12-month interval. Subjects demonstrated early, significant improvements in the bimodal condition on the spatial hearing tasks compared with baseline preoperative performance tested unaided. The magnitude of the benefit was reduced for subjects with AHL when compared with published data on CI users with normal hearing in the contralateral ear; this finding may reflect significant differences in age at implantation and hearing sensitivity across cohorts
Diong, H. T., et al (2024).	To report a case of cochlear implantation with a misplaced electrode array in the vestibule and the causes for the delay in identification. A 23-year-old male with left single-sided deafness underwent cochlear implantation. The intraoperative assessment did not reveal any major red flags of electrode array misplacement. He did not display any vestibular symptoms postoperatively but showed poor speech performance, even though the aided tone audiometry revealed good sound detection thresholds. High-resolution computed tomography (HRCT) showed that the entire perimodiolar electrode array was situated within the vestibule, and a revision surgery was conducted. Retrospective analysis of the neural response telemetry (NRT) revealed subtle differences in responses between the misplaced and correctly placed electrode arrays. Unlike previously reported cases, the patient did not display vestibular symptoms despite the misplacement of the electrode in the vestibule due to existing weakness in otolithic function. Further investigation is warranted when a motivated patient with normal inner ear anatomy does not show benefit with the cochlear implant post-operatively. One patient had a Misplacement of electrode array in the vestibule and a Reimplantation
Firszt, J. B., et al. (2023).	Forty adults with AHL from four, metropolitan CI centers participated. Hearing criteria for the ear to be implanted included: 1) pure tone average (PTA, .5, 1, 2 kHz) of > 70 dB HL, 2) aided, monosyllabic word score of ≤ 30%, 3) duration of severe-to-profound hearing loss of ≥ 6 months, and 4) onset of hearing loss ≥ 6 years of age. Hearing criteria for the better ear (BE) included: 1) PTA (.5, 1, 2, 4 kHz) of 40–70 dB HL, 2) currently using a HA, 3) aided, word score of > 40%, and 4) stable hearing for the previous 1-year period. Speech perception and localization measures, in quiet and in noise, were administered pre-implant and at 3m, 6m, 9m, and 12m post-implant. Pre-implant testing was performed in three listening conditions, PE HA, BE HA and bilateral HAs. Post-implant testing was performed in three conditions, CI, BE HA and bimodal. Outcome factors included age at implantation and length of deafness in the PE. A

Study	Key Results
	hierarchical nonlinear analysis predicted significant improvement in the PE by 3m post-implant vs. pre-implant for audibility and speech perception with a plateau in performance at approximately 6m. The model predicted significant improvement in post-implant, bimodal outcomes vs. pre-implant outcomes (bilateral HAs) for all speech perception measures by 3m. Both age and length of deafness were predicted to moderate some CI and bimodal outcomes. In contrast to speech perception, localization in quiet and noise was not predicted to improve by 6m when comparing bilateral HAs (pre-implant) to bimodal (post-implant) outcomes. However, when participants' pre-implant everyday listening condition (BE HA or bilateral HAs) was compared to bimodal performance, the model predicted significant improvement by 3m for localization in quiet and noise. Lastly, BE HA results were stable over time; a generalized linear model analysis revealed bimodal performance was significantly better than performance with a BE HA at all post-implant intervals for most speech perception measures and localization.
Han, J. S., et al. (2025).	This retrospective study enrolled adult AHL/SSD patients with significant tinnitus who underwent CI or BCI placement between 2017 and 2023. Clinical characteristics, preoperative and postoperative audiologic test results, and tinnitus questionnaires (THI, VAS) were collected and analyzed. Of 33 AHL/SSD patients with significant tinnitus (THI ≥18), 16 received CI and 17 BCI. In the CI group, all four VAS scores (loudness, awareness, annoyance, and effect on life) and THI scores significantly improved. In the BCI group, annoyance and effect on life categories of VAS and THI scores significantly improved, while VAS loudness and awareness remained similar. Linear mixed model analysis showed that the decrease in VAS loudness, awareness, and annoyance scores was significantly greater in the CI group compared to the BCI group. The CI group showed a significantly higher tinnitus cure rate (62.5.0%) compared with the BCI group (11.8%) at 6-months postoperative.
Häußler, S. M., et al.	In total, 21 patients (8 male and 13 female) were included, and the Charité Test Battery was applied for all patients. Data on HRQoL were collected with the Nijmegen Cochlear Implant Questionnaire and the Medical Outcome Study Short Form 36 (SF-36) Survey. Tinnitus distress was assessed with the Tinnitus Questionnaire (TQ). Data with regard to psychological comorbidities were collected using four validated questionnaires. Speech perception was assessed with the Freiburg Monosyllable Test (FMS), the Oldenburg Sentence Test (OLSA), and the Oldenburg Inventory (OI). HRQoL improved in the subdomain social interactions. Tinnitus distress dropped significantly 6 months postoperatively. SSD patients preoperatively showed elevated levels of stress, depressive symptoms, and anxiety. Postoperatively, these psychological symptoms improved with regard to stress, tension, and demands. The audiometry tools revealed a significant improvement in directional hearing (OI), speech perception in silence, and in the speech intelligibility threshold (OLSA).
Holden, L. K., et al.	The study aimed to improve outcomes in Nucleus cochlear implant (CI) recipients with SSD by reducing interaural frequency and loudness mismatches

Study	Key Results
(2025).	through device programming. In Experiment 1a, a modified frequency allocation table (FAT) was created to better match the tonotopicity of the contralateral ear and reduce interaural frequency mismatch. Twenty experienced SSD-CI users completed localization and speech recognition tests with their everyday FAT. Tests were repeated after 6 weeks' use of the modified FAT. Participants compared both FATs for 2 weeks before being tested again with each. For 10 newly implanted SSD-CI recipients (Experiment 1b), Group A was programmed with the manufacturer's default FAT and Group B with the modified FAT at activation. Speech recognition and localization were completed, after 6 weeks' use of each FAT. Participants then compared both FATs before testing with each. In Experiment 2, 15 experienced SSD-CI users were evaluated with their everyday program and a modified loudness program, which was created to obtain audibility of ~20 dB HL from 0.25 to 6 kHz and balanced loudness between ears. Three test sessions occurred, resembling Experiment 1a. Experienced participants in Experiments 1a and 2 showed significant improvement in one speech-in-noise task with a modified program compared to the everyday program. Newly implanted recipients showed no significant difference in results between FATs. Results indicate that modified programs, created to reduce interaural mismatches, may improve outcomes. The first month after activation might be too early to compare FATs as SSD-CI recipients are adjusting to electric hearing
Kurz, A., et al (2025).	Twelve SSD CI users with postlingual hearing loss. OTOPLAN (Version 3. (MED-EL) was used to determine intracochlear electrode contact positions using post-operative high-resolution flat panel volume computed tomography. From these positions, the corresponding center frequencies and bandwidths were derived for each channel. These were implemented in the clinical fitting software MAESTRO to yield an ABF map individualized to each user. Significantly higher speech perception in noise scores were observed with the ABF map compared to the CBF map (mean SRT50: -6.49 vs. -4.8 dB SNR for the S_0N_{CI} configuration and −3.85 vs. -2.75 dB SNR for the S_0N_0 configuration). Summation and squelch effects were significantly increased with the ABF map (0.86 vs. 0.21 dB SNR for summation and 0.85 vs. -0.09 dB SNR for squelch). No improvement in speech perception in quiet or spatial release from masking were observed with the ABF map. A similar level of self-perceived sound quality was reported for each map. Upon the end of the study, all users opted to keep the ABF map. This preference was independent of the angular insertion depth of the electrode array.
Lentz, B, et al (2025)	Twelve SSD CI patients underwent a 4-week training program. Twice a week, subjects completed training sessions of approximately 30 minutes, each involving 50 stimuli presented by 7 loudspeakers arranged from −90 to +90 degrees in the horizontal plane. Spatial hearing was evaluated before and after training using the root mean square error (RMSE), the mean absolute error (MAE), and the bias of source location angles, and by the Speech, Spatial and Quality of Hearing Scale (SSQ) questionnaire. Localization abilities assessed

Study	Key Results
	by MAE and by RMSE were better with CI than without ($p < 0.001$), but further significantly improved after spatial auditory training (both $p < 0.05$), especially for signals presented from the frontal direction. Furthermore, subjective spatial hearing abilities measured by the SSQ also improved after training ($p < 0.01$). Subjects with a larger pretraining bias showed a greater reduction in bias after training.
Lindquist, N. R., et al (2023)	This is a retrospective case series for adults with SSD who underwent CI between January 2013 and May 2021 at our institution. CNC and AzBio speech recognition scores, THI, SSQ12, datalogging, and the Cochlear Implant Quality of Life (CIQOL)-10 Global measure were utilized. Sixty-six adults underwent CI for SSD (median 51.3 years, range 20.0 to 74.3 years), and 57 (86.4%) remained device users at last follow-up. Compared to pre-operative performance, device users demonstrated significant improvement in speech recognition scores and achieved peak performance at six months post-activation for CNC (8.0% increased to 45.6%, $p<0.0001$) and AzBio in quiet (12.2% increased to 59.5%, $p<0.0001$). THI was decreased at 6 months post-implantation (58.1 to 14.6, $p<0.0001$), with 77% of patients reporting improved or resolved tinnitus. Patients demonstrated improved SSQ12 scores as well as the disease-specific CIQOL-10 Global questionnaire. Duration of deafness (DoD) was not associated with significant differences in speech recognition performance. Average daily wear time was positively associated with CNC and AzBio scores as well as post-operative CIQOL-10 scores.
Marx, M, et al (2021)	This prospective multicenter study was conducted in 7 tertiary university hospitals and included an observational cohort study of SSD/AHL adult patients treated using CROS HAs or BAHA systems or who declined all treatments, and a randomized controlled trial in subjects treated by cochlear implantation, after failure of CROS and BAHA systems trials. In total, 155 subjects with SSD or AHL, with or without associated tinnitus, were enrolled. After 2 consecutive trials with CROS hearing aids and BAHA systems on headband, all subjects chose any of the 4 treatment options (abstention, CROS, BAHA systems, or cochlear implant [CI]). The subjects who opted for a CI were randomized between 2 arms (CI vs. initial observation). Six months after the treatment choice, quality of life was assessed using both generic (EuroQoL-5D, EQ-5D) and auditory-specific quality-of-life indices (Nijmegen Cochlear implant Questionnaire [NCIQ] and Visual Analogue Scale [VAS] for tinnitus severity). Performances for speech-in-noise recognition and localization were measured as secondary outcomes. CROS was chosen by 75 subjects, while 51 opted for cochlear implantation, 18 for BAHA systems, and 11 for abstention. Six months after treatment, both EQ-5D VAS and auditory-specific quality-of-life indices were significantly better in the “CI” arm versus “observation” arm. The mean effect of the CI was particularly significant in subjects with associated severe tinnitus (mean improvement of 20.7 points ± 19.7 on EQ-5D VAS, 20.4 ± 12.4 on NCIQ, and 51.4 ± 35.4 on tinnitus). No significant effect of the CI was found on binaural hearing results. Before/ after comparisons showed that the CROS and BAHA systems also improved significantly NCIQ

Study	Key Results
	scores (for CROS: +7.7, 95% confidence interval [95% CI] = [4.5; 10.8]; for the BAHS: +14.3, 95% CI = [7.9; 20.7]).
Misztal, C, et al (2022)	Adult English-speaking patients with unilateral CIs implanted between 2014 and 2018 were stratified into NonAHL and AHL groups based on preoperative AzBio scores in quiet from the nonimplanted ear (0–50% vs. 51– 100%, respectively). Interventions: CI surgery in the poorer performing ear. Of 512 patients, 33 non-AHL and 27 AHL patients were included. Average ages were 65.6 and 63.6 years, respectively. As expected, preoperative AzBio scores in quiet from the nonimplanted ear were higher in the AHL group (95% confidence interval [95%CI]: 66.4–76.4%) than the non-AHL group at baseline (95%CI: 12.3–23.6%). In both cohorts, AzBio scores in quiet from the implanted ear improved from baseline, with 24-month scores (95%CI: 73.8 - 84.9%) being higher than preoperative scores (95%CI: 13.2–23.1%). There were also significant differences in AzBio scores in quiet between cohorts overall (p ¼ 0.0120) on mixed model analysis, with the AHL group performing 6.4% better than the non-AHL group; however, differences were not significant when scores were stratified by time. In addition, there were no significant differences in CNC in quiet and AzBio scores in noise at þ5 dB SNR between cohorts (p ¼ 0.1786 and p ¼ 0.6215, respectively).
Mosnier, I., et al (2025)	Sixty-four patients were included in this retrospective study. AHL candidates included patients with an aided speech perception score (SPS)<50% at 60 dB in the ear to be implanted. The better ear had to have a non-fluctuating HL, and an aided SPS≥60% for disyllabic words in quiet, with an interaural SPS gap≥40%. Ninety-seven percent of patients still used their CI all day at 1-year and 93% at 5-years post-implantation. Only four patients discontinued use. The mean duration of daily use at 5-years assessed using data-logging was 12±3.2 h. Aided SPS for the implanted ear improved at 1-year post-implantation, for both mono- and disyllabic words in quiet and sentences in noise (p<0.0001), and remained stable at 5-years. Unaided and aided SPS of the acoustic ear decreased over time. However, SPS in bimodal conditions improved at 1-year for both mono- (p<0.0001) and disyllabic words (p<0.005) and sentences in noise (p<0.0005) and the scores remained stable at 5-years.
Patro, A, et al (2022)	188 adults (mean age 70 years) undergoing CI for AHL from 2015–2020. Candidacy included pure-tone average (PTA) ≥70 dB HL and AzBio in quiet ≤60% in the implanted ear and AzBio in quiet >40% in the contralateral ear. Mean preoperative PTA and AzBio in the implanted and contralateral ears were 85.2 and 68.1 dB HL and 24.7% and 69.2%, respectively. Mean CNC in the implanted ear increased from 18.3% preoperatively to 44.4% (p<0.0001) at 6 months and 49.3% (p<0.0001) at 12 months. Mean AzBio in the implanted ear improved from 24.7% preoperatively to 60.3% (p<0.0001) at 6 months and 64.3% (p<0.0001) at 12 months. Patients demonstrated significant improvement in all SSQ domains at 6 and 12 months. When comparing patients with preoperative contralateral AzBio above 60% versus 41–60%, no significant differences existed in postoperative CNC scores (6-month: 47% vs. 41%, p=0.276; 12-month: 51% vs. 47%, p=0.543). There were no significant

Study	Key Results
	differences in 6-month (p=0.936) or 12-month (p=0.792) CNC scores between patients with AHL (contralateral ear AzBio >40%) and 169 unilateral CI patients meeting traditional Medicare criteria (contralateral ear AzBio ≤ 40%).
Poels, L., et al (2021)	Electrical stimulation with cochlear implants is able to significantly suppress the tinnitus sensations in 25–72% of implanted patients. Up to this point, no clear predictors for the effectiveness of tinnitus suppression with cochlear implants have been found and this substantially limits the possibility of the application of cochlear implants for this purpose. The objective of the study was to investigate if a trial electrical round window stimulation (RWS) could be used as a diagnostic tool for identifying candidates in whom electrical stimulation would be successful as treatment for tinnitus. Thirty-four patients with unilateral severe tinnitus and ipsilateral moderate to severe sensorineural hearing loss underwent a trial RWS under local anesthesia. Thirteen patients received a CI. All patients qualified for cochlear implantation on the basis of the trial RWS showed tinnitus suppression with the implant switched on. Complete or almost complete tinnitus suppression was obtained in 77% and partial in 23%. The mean tinnitus loudness reduction was 68% (VAS score reduction from 7.7 to 2.5). False negative results are estimated not to exceed 10–15%. We conclude that significant tinnitus suppression achieved during trial RWS under local anesthesia is a simple procedure allowing the efficient identification of candidates in whom electrical stimulation with a cochlear implant would be successful as treatment for intractable tinnitus.
Poncet-Wallet, C., et al (2020)	Twenty-six patients with SSD and incapacitating tinnitus (THI >58) underwent cochlear implantation. Interventions: First, CIs delivered only masking white noise stimulation for 1 month and then standard CI stimulation. The first month of white noise stimulation triggered a significant improvement in THI scores (72 ±9 to 55 ±20, $p < 0.05$). No change was observed for the other measures. After 1 year of standard CI stimulation, 23 patients (92%) reported a significant improvement in tinnitus. This improvement started 1 to 2 months after CI and exceeded 40% improvement for 14 patients (54%). Average speech-in-noise perception after 1 year significantly improved for the 23 patients who completed these measures.
Rahne, T., et al (2016)	We retrospectively analyze a case series of 4 children and 17 adults with SSD, treated with cochlear implantation. The outcome of adult patients was compared with a control group of 27 patients with bilateral profound hearing loss using a cochlear implant. During 12 months, the mean speech recognition score increased from 30 to 41% for monosyllabic words in adults, and from 58 to 89% for multisyllabic numbers. The cochlear implant (CI) improved hearing in noise in all SSD patients, as was demonstrated by a significant improvement of the speech reception threshold in different speech and noise configurations. Sound localization-correlated angle detection error improved with CI use at every time point. The maximum word recognition score for monosyllabic words in quiet correlated with the logarithm of the duration of deafness; improvement of the speech reception threshold and RMS angle detection error by the CI did not.

Study	Key Results
Speck, I., et al (2021)	Speech recognition in background noise and sound localization were assessed preoperatively and after at least six years of CI experience. Validated questionnaires determined the subjective benefit of CI use and the subjective evaluation of tinnitus. Over 80% of the included AHL and SSD CI recipients used their CI between 6 and 10 h daily; four subjects with SSD were non-users. Speech recognition in background noise and sound localization improved signifcantly compared with the unaided preoperative situation. Additionally, CI improved subjective speech intelligibility and spatial hearing impression while reducing tinnitus burden.
Spiegel, J.L., et al (2025)	Retrospective analysis of preoperative CT scans was performed at a tertiary center. For each patient their individual CC with the selected electrode array was calculated of the complete CDL. Patients were categorized into SSD (n=30), bimodal (n=72), and bilateral CI patients (n=29). Speech perception within the first 12 months post-implantation was compared between patient groups with shorter and longer CC. For subgroup analysis the cutoff between a shorter or longer CC was identified by the median. Cutoff between a shorter or longer CC was identified at 65% of the complete CDL for SSD and bimodal patients, and at 70% for bilateral patients. In SSD-patients longer CC was associated with better performance at activation ($CC_{shorter}$ 20.0±28.9% vs. CC_{longer} 31.5±24.7%; p=0.04) and no benefit was found with deeper insertion at 12 months. No significant benefit was found for deeper insertion in bimodal and bilateral patients.
Tóth, T.F., et al (2023)	In 12 postlingual single-sided deaf patients, subjective interaural pitch-matching was carried out to determine new central frequencies for the reallocation of the frequency bands of their speech processor (CP910, CP950 or CP1000, Cochlear, Australia). The patients were asked to compare the pitch of the tones presented to their normal hearing ear to the pitch of individual channels of their cochlear implant (CI522 or CI622, Cochlear, Australia). A third-degree polynomial curve was ft to the acquired matching frequencies to create the new frequency allocation table. Audiological measurements (free-field aided thresholds, speech reception thresholds, and monosyllabic word recognition score) in noise, together with a Speech, Spatial and Qualities of Hearing Scale (SSQ12) questionnaire (short version of the original SSQ) results were evaluated prior to the pitch-matching procedure, and again, 2 weeks later. The free-field aided thresholds of the patients showed no greater shift than±5 dB following the procedure; however, their monosyllabic word recognition score in noise improved significantly (mean − 9.58%, SD 4.98%, matched pairs t test comparison: p<0.001). The results of the SSQ12 questionnaire also showed significant improvement in speech intelligibility, sound localization, and sound quality (mean 0.96 points, SD 0.45 points, matched pairs t test comparison: p<0.001).
Wazen, J.J., et al (2024)	Prospective within-subjects repeated-measures. Setting: Two tertiary cochlear implant centers. Fourteen adults with severe-to-profound sensorineural hearing loss in the worse hearing ear and up to moderate SNHL in the better hearing ear. Intervention: Cochlear implantation in the worse hearing ear. Mean length

Study	Key Results
	of hearing loss in the worse hearing ear was 3.5 years. The mean CNC change scores from baseline were 54.8, 55.9, and 58.9 percentage points at 3-, 6-, and 12-months ($p < 0.001$). AzBio sentence test in noise demonstrated improved scores in all spatial configurations, although statistically significant in S0N0 (speech front, noise front) only. Lateralization testing showed significant improvement of 22.9, 24.5, and 24.0 percentage points at 3-, 6-, and 12 months post-activation ($p = 0.002$). All patient-related outcome measures revealed significant improvement.
Wesarg, T., et al (2020)	Eleven adult, SSD participants aided with CI from MED-EL. recognition in noise was assessed in two noRoger™ conditions, one Roger™ X condition, and two Roger™ MyLink conditions. For the Roger™ X and no-Roger™ conditions, speech recognition was tested at 60.3 dB(A) with the Oldenburg Sentence Test in classroom noise at levels of 55, 65, and 75 dB(A). For the two Roger™ MyLink conditions, speech recognition at 60.3 dB(A) was measured at a noise level of 75 dB(A). Roger™ X was assessed with an accessory mixing ratio of 1:1 (summation of unattenuated microphone and audio accessory input). For Roger™ MyLink, two accessory mixing ratios were investigated, MT (1:1, summation of unattenuated microphone and telecoil input) and T with maximum attenuation of microphone input. Speech recognition at higher noise levels (65 and 75 dB(A)) improved significantly with Roger™ in both unilateral use conditions (NH ± CIRog and NHRog ± CI) as well as bilateral use condition (NHRog ± CIRog). Both the bilateral application of Roger™ and the unilateral Roger™ application on the NH ear outperformed the Roger™ application on CI alone. There was no statistically significant effect of type of CI Roger™ receiver (Roger™ X or Roger™ MyLink) and the accessory mixing ratio (MT or T) on speech recognition.

Across the reviewed adult literature, cochlear implantation in individuals with SSD and AHL is consistently associated with clinically significant improvements in speech perception, sound localization, tinnitus handicap, and quality of life. The overall results demonstrated improved post-implant performance relative to pre-implant or unaided conditions, across a range of test materials, noise configurations, and patient populations. Reported baseline CNC word scores in adults across device manufacturers ranged from 7–18.3% (Firszt et al., 2023; Lindquist et al., 2023; Mosnier et al., 2025; Patro et al., 2022), consistent with the expanded adult speech criterion supported in this submission.

A meta-analysis of monosyllabic word recognition was conducted using comparator-device studies with within-participant pre- and post-operative data (Brown et al., 2022; Han et al., 2025; Häußler et al., 2020; n=48 SSD, n=9 AHL). Pooled results from both common-effect and random-effect models demonstrated a large, statistically significant improvement substantially exceeding the 10-percentage point clinical significance threshold.

Speech perception in noise improvements were most often observed in spatial when sound was directed at the implant ear. Localization improvements were consistently observed in SSD populations, while outcomes in AHL were more variable. Cochlear

implantation was also consistently associated with meaningful reductions in tinnitus severity across multiple validated measures (THI, VAS, TRQ, STSS), with benefits emerging within the first few months of activation. Comparative studies indicate greater and more robust tinnitus suppression with CI than with bone conduction or rerouting devices. Patient-reported outcomes across a variety of instruments showed improvement in functional hearing and quality of life, though direct comparisons across studies are limited by heterogeneity test materials and assessment timing.

2. Outcomes in Pediatrics with SSD/AHL

The systematic literature review yielded six peer reviewed articles reporting on the effectiveness of CI in pediatric SSD and AHL patients and peer reviewed articles reporting on the effectiveness of CI in a mix of adult and pediatric SSD and AHL patients.

Across the nine studies identified as relevant to the review question, data from a total of 167 pediatric subjects with SSD or AHL were reviewed. A summary of the literature is provided in Table 6 below.

Table 6: Pediatric Literature Review Results

Study	Key Results
Arndt, S., et al. (2024)	Thirty-six children with SSD treated with CI participated in the study: 20 had congenital, seven perilingual (defined: >0 to 4 years), and nine had postlingual deafness (defined as >4 years of age). Their outcome with CI were measured on both subjective and objective scales. After a mean follow-up time of 4.75 years, 32 of the 36 children used their CI on a regular basis. The remaining four children were nonusers. These children had congenital SSD and were older than three years at the time of CI surgery. Overall, for congenital/perilingual and postlingual SSD, speech intelligibility in noise and the Speech, Spatial and Qualities of Hearing Scale (SSQ) speech subscore were significantly improved, as were their subjective and objective localization ability and hearing-related quality of life. Children with postlingual SSD benefited from the CI with regard to speech intelligibility, SSQ speech/spatial/total score, and localization error, and children with congenital SSD showed better results with a short duration of deafness of less than 3 years compared with those with a longer deafness period.
Brown, K. D., et al. (2022)	Twenty children with at least moderate to profound sensory hearing loss and poor speech perception (word score <30%) in one ear and normal hearing in the contralateral ear participated in a Food and Drug Administration-approved clinical trial. Subjects were evaluated for speech perception in quiet, speech perception in noise, sound localization, and subjective benefits after implantation. CNC word score perception in quiet significantly improved (1% to 50%, P < .0001) by 12 months after activation. Speech perception in noise by BKB-SIN significantly improved in all three noise configurations; there was a 3.6 dB advantage in head shadow (P < .0001), a 1.6 dB advantage in summation (P = .003), and a 2.5 dB advantage in squelch (P = .0001). Localization improved by 26 at 9 months (P < .0001). Speech, Spatial, and

Study	Key Results
	Qualities (SSQ) demonstrated significant improvements in speech (5.2 to 7.4, P = .0012), qualities of hearing (5.9 to 7.5, P = .0056), and spatial hearing (2.7 to 6.6, P < .0001). SSQ subscales associated with binaural hearing were significantly improved, as was listening effort (P = .0082). Subjects demonstrated a non-significant improvement in fatigue.
*Deep, N. L., et al. (2021)	A retrospective case review from a tertiary referral center involving 14 pediatric patients (<18 years) with SSD who underwent unilateral CI. Speech perception testing in quiet and noise in the CI-only and bimodal conditions with at least 1 year of device use and device usage from data logs represent the main outcome measures.The mean age at CI was 5.0 years (median 4.4, range 1.0-11.8 years). The mean duration of deafness was 3.0 years (median 2.4, range 0.6-7.0 years). Mean follow-up was 3.4 years. Speech perception testing with a minimum of 1 year post-CI was available in eight patients. The mean word recognition scores (WRS) in the CI-only condition was 56%; a significant improvement from baseline. Testing in background noise with spatially separated speech and noise revealed that patients scored as well or better with the CI-on versus CI-off in all conditions and in no cases was interference from the CI noted. Data logs were reviewed for device usage which revealed an average use of 6.5 hr/d.
O'Rourke, S.P., et al (2025)	Pediatric CI recipients with functional acoustic hearing in the implanted ear (i.e., ≤ 80 dB HL) and a contralateral pure-tone average (0.5, 1, 2, and 4 kHz) ≤ 25 dB HL. Speech recognition was assessed with the consonant–nucleus–consonant (CNC) test for the affected ear preoperatively and at 6 and 12 months postactivation. Masked speech recognition was assessed with the Bamford–Kowal–Bench speech-in-noise test in the bilateral condition for three spatial configurations: target from the front and masker colocated with the target or presented 90° toward the implanted or contralateral ear. Children experienced a significant improvement in CNC scores with EAS as compared to preoperative abilities with a hearing aid ($F(2,7) = 10.0$, $p = 0.009$). Preliminary masked sentence recognition data suggest a benefit in performance when the target was spatially separated from the masker, and a benefit with EAS as compared to an unaided listening condition.
Perkins, E. L., et al (2020)	Forty-nine children with severe-to-profound hearing loss in the ear to be implanted (pure-tone average), and no worse than moderate hearing loss in the nonimplant ear. Intervention: Subjects underwent cochlear implantation from 2007 and 2017 in the ear with severe-to-profound hearing loss. Consonant Nucleus Consonant or Phonetically Balanced Kindergarten word scores pre- and postoperatively were compared in both the implanted ear and binaural setting. Comparisons were made between Phonetically Balanced Kindergarten scores pre- and postoperatively or Consonant Nucleus Consonant scores pre- and postoperatively. The average pure-tone average for the implant ear was 92 ± 13 dB HL and 55 ± 12 dB HL in the nonimplant ear. Word scores for the implant ear increased an average of 58 (± 27) % following cochlear implantation at 12 months and 62 ± 20) % at 24 months. Binaural best-aided word scores increased an average of 36 (± 29) % at 12 months and 49 (± 24) %

Study	Key Results
	at 24 months.
Rauch, A. K., et al (2021)	11 children with congenital SSD were implanted with a cochlear implant (CI). Auditory performance was measured through the results of speech discrimination, subjective assessment by the Categories of auditory performance (CAP) score, the Speech, Spatial and Qualities scale questionnaire (SSQ) and the German version of the IOI-HA. Long-term follow-up [median: 3 years and 5 months (3;5 years)] revealed that nine children use their CI (>8 h/ day) and two became nonusers. In children aged below 3;2 years at surgery, there was a substantial long-term increase in speech discrimination and subjective benefit. Children over 4;4 years of age at CI surgery improved partially in audiological/ subjective measurements. Among children above 5 years, the SSQ score did not improve despite further slight improvement in speech discrimination long-term.
Thomas, JP, et al (2017)	Twenty one children with congenital SSD who were implanted aged 10 months to 11;3 years. Speech recognition in noise via the German Oldenburg Sentence Test for Children (OlKiSa), lateralization ability, and subjective evaluation of hearing results using self- and third-party assessment questionnaires.Significant improvements of all three aspects of true binaural hearing were found. The most striking improvement was the combined head shadow effect by 2.11 dB (squelch effect: 0.95 dB, summation effect 0.98 dB). An improvement of lateralization ability was also demonstrated. Parents had a high overall level of satisfaction with their children's cochlear implantation. Subjective benefit was verified in all three subscales of the Speech, Spatial, and Qualities of Hearing Questionnaire. No significant difference was found between subjects implanted before the age of 6 with those implanted later. Three of the five subjects with a follow-up of greater than 3 years were limited users or nonusers.
Astefanei, et. al. (2025).	In this longitudinal observational study, 37 patients (adults and children) received a CI or a BCI according to clinical indications. Outcomes included localization and spatial speech-in-noise assessment, tinnitus ratings, and SSQ12 scores. Statistical analyses used parametric and non-parametric tests ($p < 0.05$). In adult CI users, localization error significantly decreased from $81.9^\circ \pm 15.8^\circ$ to $43.7^\circ \pm 13.5^\circ$ ($p < 0.001$). In children, regardless of the implant type (CI or BCI), localization error improved from 74.3° to 44.8° , indicating a consistent spatial benefit. In adult BCI users, localization error decreased from 74.6° to 69.2° , but the improvement did not reach statistical significance. Tinnitus severity, measured on a 10-point VAS scale, decreased significantly in CI users (mean reduction: 2.8 ± 2.0, $p < 0.001$), while changes in BCI users were small and of limited clinical relevance. SSQ12B/C scores improved in all adult groups, with the largest gains observed in spatial hearing for CI users (2.1 ± 1.2) and in speech understanding for BCI users (1.6 ± 0.9); children reported high benefits across all domains. Head shadow yielded the most consistent benefit across all groups (up to 4.9 dB in adult CI users, 3.8 dB in adult BCI users, and 4.6 dB in children). Although binaural effects were smaller in BCI users, positive gains were observed, especially in pediatric cases. Correlation analysis showed that daily device use positively predicted SSQ12 improvement

Study	Key Results
	(r = 0.57) and tinnitus relief (r = 0.42), while longer deafness duration was associated with poorer localization outcomes (r = –0.48).
Rahne, T., et al (2016)	We retrospectively analyze a case series of 4 children and 17 adults with SSD, treated with cochlear implantation. The outcome of adult patients was compared with a control group of 27 patients with bilateral profound hearing loss using a cochlear implant. During 12 months, the mean speech recognition score increased from 30 to 41% for monosyllabic words in adults, and from 58 to 89% for multisyllabic numbers. The cochlear implant (CI) improved hearing in noise in all SSD patients, as was demonstrated by a significant improvement of the speech reception threshold in different speech and noise configurations. Sound localization-correlated angle detection error improved with CI use at every time point. The maximum word recognition score for monosyllabic words in quiet correlated with the logarithm of the duration of deafness; improvement of the speech reception threshold and RMS angle detection error by the CI did not.
Tóth, T.F., et al (2023)	In 12 postlingual single-sided deaf patients, subjective interaural pitch-matching was carried out to determine new central frequencies for the reallocation of the frequency bands of their speech processor (CP910, CP950 or CP1000, Cochlear, Australia). The patients were asked to compare the pitch of the tones presented to their normal hearing ear to the pitch of individual channels of their cochlear implant (CI522 or CI622, Cochlear, Australia). A third-degree polynomial curve was ft to the acquired matching frequencies to create the new frequency allocation table. Audiological measurements (free-field aided thresholds, speech reception thresholds, and monosyllabic word recognition score) in noise, together with a Speech, Spatial and Qualities of Hearing Scale (SSQ12) questionnaire (short version of the original SSQ) results were evaluated prior to the pitch-matching procedure, and again, 2 weeks later. The free-field aided thresholds of the patients showed no greater shift than ±5 dB following the procedure; however, their monosyllabic word recognition score in noise improved significantly (mean − 9.58%, SD 4.98%, matched pairs t test comparison: $p<0.001$). The results of the SSQ12 questionnaire also showed significant improvement in speech intelligibility, sound localization, and sound quality (mean 0.96 points, SD 0.45 points, matched pairs t test comparison: $p<0.001$).

The reviewed evidence indicates that children with SSD or AHL derive auditory benefit from cochlear implantation with improvements observed in speech perception, binaural hearing and functional listening outcomes.

3. Safety

Across the literature, CIs are consistently reported as safe, with serious long and short-term complications being generally uncommon. Unless the study is a detailed case report, the specific patient history that may have contributed to a complication generally remains unclear. Most publications did not distinguish between complications in adults and children, and safety outcomes were typically reported only

as percentages of a combined cohort. Likewise, device manufacturers were often not reported, or all major CI manufacturers were included in a pooled AE rate. In publications that evaluate upgraded sound processors, or signal-processing strategies, recipients who have undergone revision CI surgery are typically excluded from the study population.

The global complication rate has been reported as approximately 5% major and 14.9% minor (Chen et al., 2018; Ciorba et al., 2021; Dalgic et al., 2021). Direct comparison across studies is limited by heterogeneity in reporting methods, follow-up duration, pooling of adult and pediatric data, and inconsistent manufacturer reporting. Complications associated with cochlear implantation are generally classified as major (requiring surgical revision or hospitalization) or minor (manageable with conservative treatment).

Adverse events reported across the larger studies included in this review were consistent with those observed in the bilateral CI literature. Firszt et al. (2023; n=40) reported 7 device- or procedure-related AEs including dizziness, taste disturbance, and pain at the receiver/stimulator site. Mosnier et al. (2025; n=64) reported infection, hemorrhage, and electrode extrusion each in 1 patient. Arndt et al. (2024; n=36 pediatric) reported 1 patient with increased tinnitus with CI on. No serious unanticipated device-related adverse events were reported across the reviewed literature.

Major complications which require surgical revision or hospitalization, include:

- Electrode or implant failure, electrode array migration
- Mastoiditis
- Permanent facial paralysis
- Cerebrospinal fluid (CSF) leakage
- Magnet or receiver-stimulator protrusion
- Flap necrosis
- Otitis media
- Persistent perilymph leakage
- Permanent facial nerve paresis

Minor complications are those only requiring conservative management or minimal surgery, such as:

- Imbalance/Vertigo
- Temporary facial nerve palsy dysgeusia
- Bronchospasm
- Bleeding in the implant bed
- Defect in the external ear canal because of diamond burr

Overall, the reviewed evidence indicates that serious complications occurring infrequently for cochlear implantation and rates for SSD/AHL are consistent with

those reported for the approved bilateral indication. No new indication-specific safety concerns were identified for individuals with SSD or AHL.

4. Limitation of Literature Data

The adult literature is subject to several inherent limitations. Individual-level data are limited across most studies, with results typically reported as group means or percentages. Heterogeneity in study endpoints, spatial test configurations, and comparator conditions limits direct comparison across studies, as does variability in baseline audiometric criteria, with some studies including subjects who would not meet the proposed indication. The majority of studies are retrospective in design with inconsistent follow-up durations, and safety data were not systematically reported. Despite these limitations, the adult literature provides consistent supporting evidence for the effectiveness of cochlear implantation in individuals with SSD/AHL.

The pediatric literature is similarly limited by small study cohorts with limited individual-level data, heterogeneous populations with respect to etiology, age at implantation, and duration of hearing loss, and predominantly retrospective study designs with variable and often incomplete follow-up data. Safety data were not systematically reported; however, adverse event rates are not expected to differ from those observed in cochlear implantation for the approved bilateral pediatric indication. Despite these limitations, the pediatric literature provides supporting evidence for the effectiveness of cochlear implantation in children with SSD/AHL aged 5 years and older.

Limitations of safety in the CI literature include heterogeneity in the classification of major and minor complications across studies, inconsistent reporting of device manufacturer and patient age range, and frequent pooling of adult and pediatric data. These limitations preclude precise comparison of complication rates across studies but do not alter the overall conclusion that cochlear implantation is a procedure with an acceptably low complication rate.

Conclusions from Literature Review

Across the adult SSD/AHL literature, cochlear implantation is consistently associated with clinically significant improvements in speech perception, sound localization, tinnitus burden, and quality of life. The pediatric literature, while more limited, is overall consistent with adult findings. Complication rates reported across the literature are consistent with those observed for cochlear implantation in the approved bilateral indication. For both adults and children with SSD/AHL, the surgical procedure and device are identical to those used in the approved bilateral indication; safety outcomes are therefore not expected to differ.

Taken together, and in accordance with the FDA guidance "Use of Real-World Evidence to Support Regulatory Decision-Making for Medical Devices," this literature serves as supporting real-world evidence for the safety and effectiveness of the HiResolution™ Bionic Ear System in adults and children aged 5 years and older with SSD or AHL, when considered alongside the primary clinical data presented in Section X.

XII. PANEL MEETING RECOMMENDATION AND FDA'S POST-PANEL ACTION

In accordance with the provisions of section 515(c)(3) of the act as amended by the Safe Medical Devices Act of 1990, this PMA Supplement was not referred to the Ear, Nose, and Throat Devices Panel, FDA advisory committee, for review and recommendation because the information in the PMA Supplement substantially duplicates information previously reviewed by this panel.

XIII. CONCLUSIONS DRAWN FROM PRECLINICAL AND CLINICAL STUDIES

A. Effectiveness Conclusions

The results of this retrospective study demonstrate long-term objective and subjective audiologic benefits following cochlear implantation in the worse ear for recipients with severe to profound sensorineural hearing loss in one ear and normal hearing (i.e., SSD) up to moderately severe sensorineural hearing loss in the other ear (i.e., AHL).

The primary effectiveness endpoint was met in both cohorts, with statistically significant and clinically significant improvements in CNC word scores in the implanted ear at 1 year ± 6 months (SSD: mean change = 35.7%, $p<0.0001$; AHL: mean change = 34.1%, $p<0.0001$). Approximately 79% of SSD and 78% of AHL subjects achieved the ≥10% clinically significant threshold. Improvement was sustained through 5 years ± 6 months in both cohorts (in a subgroup with available data at that time point), consistent with the broader literature reporting mean CNC improvements of 31–48% across studies in adults with SSD or AHL (Deep et al., 2021; Lindquist et al., 2023; Sladen et al., 2018; Firszt et al., 2023; Patro et al., 2022).Within the supporting datasets, substantial evidence of device use and subjective benefit in everyday life was found. The former was demonstrated by the average daily device usage (hours/day) observed out to 5 years ± 6 months. In the SSD cohort, the annual averages ranged between 7.82 to 9.2 hours/day, consistent with the values reported in the literature. Similarly, the mean annual device usage in the AHL ranged from 8.47 to 9.77 hours/day, and the median ranged from 8.59 to 11.38 hours/day. Based on the usage definition provided by Deep et al. (2021), these annual averages correspond to regular use (>7 hours/day).

Clinically significant improvement was demonstrated in subjects with baseline CNC scores up to 20% in the ear to be implanted, with >50% of subjects in both cohorts achieving the ≥10% threshold at this candidacy level, supporting the expanded adult audiometric speech criterion. These findings are consistent with published evidence that adults with pre-operative worse-ear CNC scores >5% experience meaningful benefit from cochlear implantation (Firszt et al., 2023; Bernstein et al., 2024; Sydlowski et al., 2022).

SSQ global scores improved significantly in both cohorts at 1 year ± 6 months, with sustained improvement observed at longer follow-up intervals. Average daily device usage ranged from 7.8–9.2 hours/day in the SSD cohort and 8.5–9.8 hours/day in the AHL cohort through 5 years, consistent with regular use as defined by Deep et al.

(2021), confirming that objective gains translated to meaningful real-world benefit.

Speech perception in noise and localization showed clinically significant trends in both cohorts, though statistical significance was not reached for these supporting endpoints, reflecting the limited sample sizes available in a RWD. The majority of subjects in both cohorts achieved the >6° MCID threshold for localization improvement at 1 year ± 6 months. Audiometric thresholds in the non-implanted ear remained stable within test-retest reliability limits through 3–4 years post-activation, confirming no adverse impact on contralateral residual hearing.

B. Safety Conclusions

The risks of the device are based on the published literature and clinical data from the retrospective study. The probable risks are low in aggregate severity, well characterized, and managed through design controls, clinical practice, and patient selection, consistent with the established safety profile of cochlear implantation in the approved bilateral indication. No new or unexpected safety concerns were identified for individuals with SSD/AHL. The benefit provided by the HiResolution™ Bionic Ear System to individuals with SSD/AHL outweighs the overall residual risk.

C. Benefit-Risk Determination

The clinical benefit of the HiResolution™ Bionic Ear System for the proposed SSD/AHL indication are based on data collected in the retrospective real-world study and published literature as described above. The primary effectiveness endpoint was met in both the SSD and AHL cohorts, with statistically and clinically significant improvements in CNC word scores in the implanted ear at 1-year post-activation. Approximately 79% of SSD and 78% of AHL subjects achieved the ≥10% clinically significant criterion, with improvement sustained through 5 years in subjects whose data were available. Speech perception in noise showed clinically significant mean improvements in both cohorts, though statistical significance was not reached, likely reflecting a limited sample size for that test. The majority of subjects in both cohorts achieved the >6° MCID threshold for localization improvement. SSQ global scores improved in subjects whose data were available, and approximately 90% of patients with preoperative tinnitus in subjects whose data were available experienced suppression or improvement (Levy et al., 2020). Overall, these data demonstrate that cochlear implantation in adults with SSD/AHL is expected to provide clinical benefit in the intended use population.

This supplement expands the adult audiometric speech criterion from the currently approved ≤5% to ≤20% in CNC words in the ear to be implanted, while retaining the ≤5% criterion for pediatric patients. In the retrospective study, clinically significant improvement of ≥10% was achieved in 16/20 subjects for adults with baseline CNC scores in the 6–20% range. These findings are consistent with published evidence demonstrating that adults with pre-operative worse-ear CNC scores >5% experience meaningful benefit from cochlear implantation (Firszt et al., 2023; Bernstein et al., 2024; Sydlowski et al., 2022) and supports the expanded adult speech criterion. The pediatric criterion remains unchanged at ≤5% CNC words, consistent with currently approved

devices and available clinical data.

The safety analysis was consistent with those observed for cochlear implantation in the approved bilateral indication. The primary clinical risks unique to SSD/AHL include device non-use, variable outcomes with prolonged deafness or congenital onset, and binaural integration with electrical stimulation. The primary limitation of the evidence base is that the clinical data are retrospective, non-randomized, and enrolled adults only, limiting direct generalizability to pediatric populations. These limitations are mitigated pediatric extrapolation and shifting prospective data requirements to the postmarket.

In conclusion, the benefits of the HiResolution™ Bionic Ear System outweigh the risks for individuals with SSD or AHL who meet the proposed indications.

Additional considerations for the expanded indication for cochlear implantation in adults and children with SSD/AHL included:

1. Patient Perspectives

Patient perspectives considered during the review included:

Supporting patient perspective data, such self-reported outcomes with the Speech, Spatial and Qualities of Hearing scale (SSQ) and Tinnitus Handicap Inventory, were extracted when available, between baseline and 5 years ± 6 months.

SSQ global scores improved significantly in both cohorts from baseline to 1 year ± 6 months, with sustained improvement in the AHL cohort through 2 years across the global, speech, and spatial subscales. In the SSD cohort, improvements in speech and spatial awareness were observed at 1 year, though subscale significance was not maintained at 2 years, likely reflecting the small number of subjects with available data at that interval.

THI data available from only two SSD subjects and one AHL subject at 1 year ± 6 months. In the SSD cohort, mean THI scores dropped from 44 to 5, with both subjects reporting a reduction in perceived tinnitus from moderate to slight. The single AHL subject showed a reduction from 16 to 0. While these data are insufficient to draw conclusions at the group level, they are directionally consistent with the broader literature demonstrating meaningful tinnitus suppression following cochlear implantation in SSD and AHL populations.

D. Overall Conclusions

The data in this application support the reasonable assurance of safety and effectiveness of the HiResolution™ Bionic Ear System when used in accordance with the proposed SSD/AHL indications for use, including the expanded adult audiometric speech criterion of ≤20% CNC words. The totality of evidence from the retrospective and supporting literature demonstrates significant clinical benefits with a safety profile consistent with the well-established risk profile of cochlear implantation in the

approved bilateral indication. No new risks have been identified in the unilaterally hearing-impaired CI population. The probable benefits outweigh the probable risks for adults and pediatric patients aged 5 years and older who meet the proposed indications.

XIV. CDRH DECISION

CDRH issued an approval order on July 22, 2026. The final clinical conditions of approval cited in the approval order are described below.

The Advanced Bionics New Enrollment Asymmetric Hearing Loss/Single-Sided Deafness (AHL/SSD) Study is a new enrollment post-approval study intended to assess the long-term safety and effectiveness of the HiResolution™ Bionic Ear System in treating children and adults with AHL/SSD.

The Advanced Bionics New Enrollment Asymmetric Hearing Loss/Single-Sided Deafness (AHL/SSD) Study is a new enrollment post-approval study intended to assess the long-term safety and effectiveness of the HiResolution™ Bionic Ear System in treating children and adults with AHL/SSD. The study will be conducted as a prospective, non-controlled, non-randomized, multicenter study and will include 64 subjects at up to 12 sites. Among the 64 subjects, 44 subjects will be 18 years of age or older. Twelve subjects will be between 5 and 12 years of age and 8 subjects will be between 12 and 18 years old. The primary safety endpoint is the number and proportion of subjects experiencing device-related adverse events throughout the duration of the post-approval study. The effectiveness endpoints include the within-subject differences for Consonant-Nucleus-Consonant (CNC) word recognition in quiet from the unilateral, pre-operative, best-aided condition to the unilateral, 12-month, post-activation condition, and Bamford-Kowal-Bench Speech in Noise (BKB-SIN) sentences from the bilateral, pre-operative, best-aided condition to the bilateral, 12-month, post-activation condition for speech and noise presented in S0NNH (signal from front, noise to normal ear), S0N0 (signal and noise from front), and S0NCI (signal from front, noise to the CI ear) configurations. The stability of perceived hearing benefits over time will be assessed in adults by employing the Speech, Spatial, and Qualities (SSQ) questionnaire. For pediatric subjects, the SSQ-child and SSQ-parent will be administered. Subjects will be followed at 3 months, 6 months, 12 months, 24 months, and 36 months post-activation visits.

The applicant's manufacturing facility was inspected and found to be in compliance with the device Quality System (QS) regulation (21 CFR 820), which was in effect at the time of the inspection. As of February 2, 2026, the revised part 820, referred to as the Quality Management System Regulation (QMSR), is effective.

XV. APPROVAL SPECIFICATIONS

Directions for use: See device labeling.

Hazards to Health from Use of the Device: See Indications,

Contraindications, Warnings, Precautions, and Adverse Events in the device labeling.

Post-approval Requirements and Restrictions: See approval order.

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