DE NOVO CLASSIFICATION REQUEST FOR
BONEBRIDGE™

REGULATORY INFORMATION

FDA identifies this generic type of device as:

> **Active implantable bone conduction hearing system**. An active implantable bone conduction hearing system is a prescription device consisting of an implanted transducer, implanted electronics components, and an audio processor. The active implantable bone conduction hearing system is intended to compensate for conductive or mixed hearing losses by conveying amplified acoustic signals to the cochlea via mechanical vibrations on the skull bone.
>
> **NEW REGULATION NUMBER:** 21 CFR 874.3340
>
> **CLASSIFICATION:** II
>
> **PRODUCT CODE:** PFO

BACKGROUND

> **DEVICE NAME:** BONEBRIDGE™ SYSTEM (BONEBRIDGE™)
>
> **SUBMISSION NUMBER:** DEN170009
>
> **DATE OF DE NOVO:** February 16, 2017
>
> **CONTACT:** MED-EL Elektromedinische Geraete GmbH
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> Innsbruck, A-6020
> Austria

INDICATIONS FOR USE

The BONEBRIDGE bone conduction hearing implant system is intended for the following patients and indications:

- Patients 12 years of age or older.
- Patients who have a conductive or mixed hearing loss and still can benefit from sound amplification. The pure tone average (PTA) bone conduction (BC) threshold (measured at 0.5, 1, 2, and 3 kHz) should be better than or equal to 45 dB HL.
- Bilateral fitting of the BONEBRIDGE is intended for patients having a symmetrically conductive or mixed hearing loss. The difference between the left and right sides' BC thresholds should be less than 10 dB on average measured at 0.5, 1, 2, and 3 kHz, or less than 15 dB at individual frequencies.

- Patients who have profound sensorineural hearing loss in one ear and normal hearing in the opposite ear (i.e., single-sided deafness or "SSD"). The pure tone average air conduction hearing thresholds of the hearing ear should be better than or equal to 20 dB HL (measured at 0.5, 1, 2, and 3 kHz).

- The BONEBRIDGE for SSD is also indicated for any patient who is indicated for an air-conduction contralateral routing of signals (AC CROS) hearing aid, but who for some reason cannot or will not use an AC CROS.

- Prior to receiving the device, it is recommended that an individual have experience with appropriately fit air conduction or bone conduction hearing aids.

LIMITATIONS

Prescription Use only: Federal (USA) law restricts this device to sale by or on the order of a physician. Limitations on device use are included in the Instructions for Use as Contraindications, Warnings, and Precautions.

Contraindications

- Chronic or non-revisable vestibular or balance disorders

- Abnormally progressive hearing loss

- Evidence of conditions that would prevent good speech recognition potential as determined by good clinical judgment.

- Skin or scalp conditions that may preclude attachment of the audio processor or that may interfere with the use of the audio processor.

- Skull size or abnormality that would preclude appropriate placement of the BONEBRIDGE implant as determined by CT scan.

Warnings

- Potential risks may be, but are not limited to, local skin numbness or pain, infection, transient tinnitus, vertigo or headache, dural erosion/compression, CSF leak, bleeding/hematoma from injury to sigmoid sinus, subdural hematoma, infection, and facial nerve injury.

- It is recommended that BCI recipients receive age appropriate vaccinations including a vaccination against pneumococcal meningitis prior to implantation.

- Electromagnetic fields produced by other electrical equipment such as cell phones, metal detectors microwaves, RFID systems and commercial theft detection systems (also known as electronic article surveillance [EAS]) may interfere with the device. In the event that the patient perceives unexpected noise or interference in the presence of these devices, move away from the source to mitigate the potential interference. Remove the processor and if you have further concerns, contact your hearing healthcare professional.

PLEASE REFER TO THE LABELING FOR A MORE COMPLETE LIST OF WARNINGS, PRECAUTIONS AND CONTRAINDICATIONS.

DEVICE DESCRIPTION

The BONEBRIDGE consists of a Bone Conduction Implant that is surgically implanted in the mastoid bone and an external Audio Processor that is held in place on the patient's scalp by magnetic attraction between the implant and the Audio Processor (Figure 1).

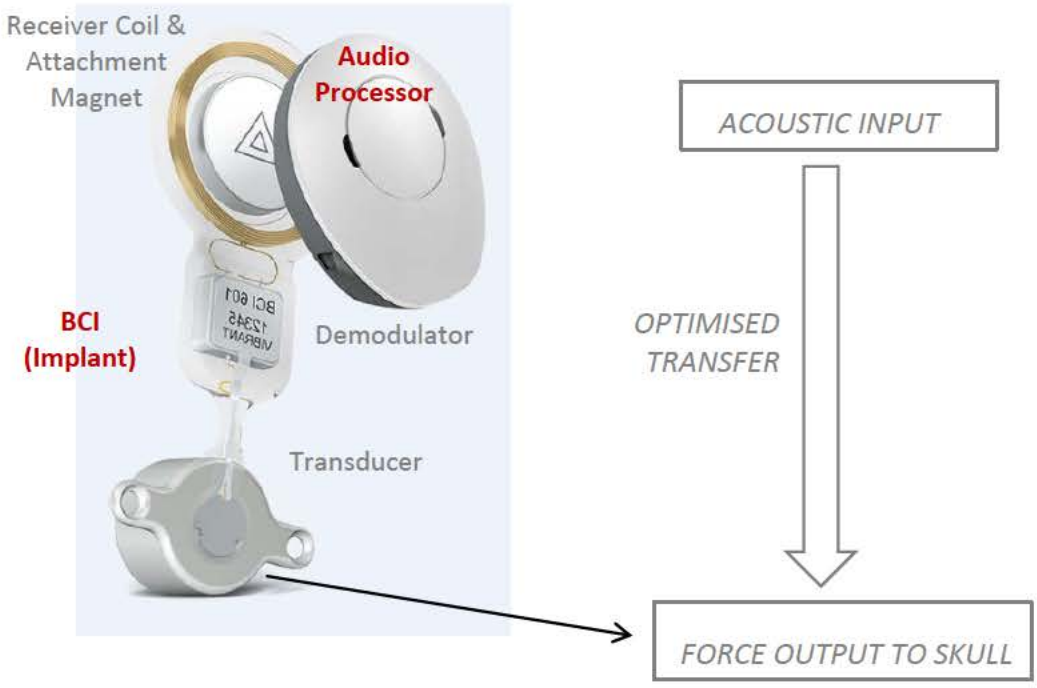

Figure 1: Diagram of the BONEBRIDGE

Bone Conduction Implant

The Bone Conduction Implant ("BCI"), also referred to as BCI 601 in this document, is an implantable hearing prosthesis that is surgically implanted on the skull in order to directly vibrate the mastoid bone, which in turn stimulates the inner ear. The BCI consists of the Receiver Coil, Attachment Magnet, Demodulator, Transition Link, Floating Mass Transducer (BC-FMT) and anchor holes for the Cortical Screws (Figure 1 & Figure 2). The implanted Receiver Coil picks up the signal from the Audio Processor transcutaneously and the signal is then demodulated and sent to the BC-FMT. The BC-FMT is implanted in the mastoid region of the skull and vibrates in a controlled manner in response to the signal. These vibrations are then transmitted via the skull bones to the inner ear, bypassing the damaged parts of the outer and/or middle ear to stimulate the inner ear hair cells; thus, allowing patients to clearly hear sounds and speech around them. The BCI is provided sterile as part of the BCI 601 Implant Kit.

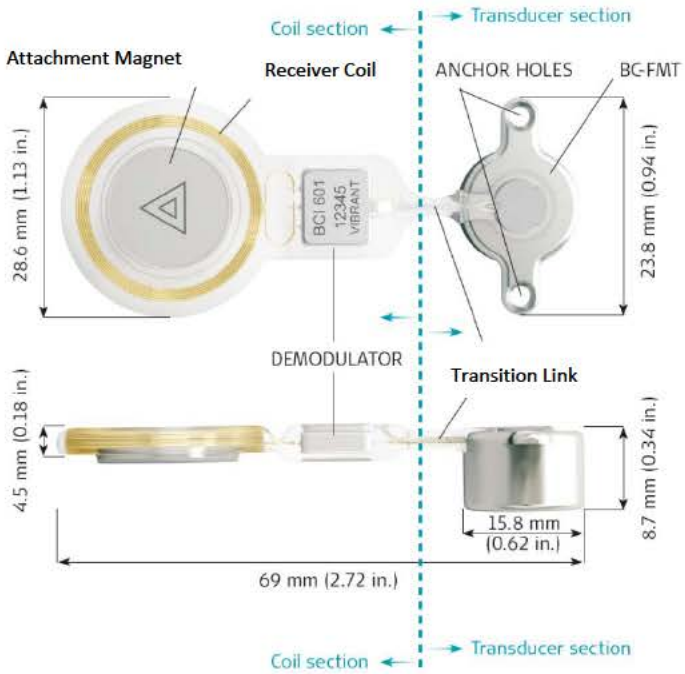

Figure 2 Bone Conduction Implant

Attachment Magnet

The Attachment Magnet of the BCI is located in the center of the Receiver Coil. The Attachment Magnet of the BCI attracts the Attachment Magnet of the Audio Processor to hold the Audio Processor in place on the user's head. The magnet has a triangular symbol on the side that should be facing the surgeon at the time of implantation.

Receiver Coil

The Receiver Coil is inductively matched to the telemetry coil of the external Audio Processor. It picks up the audio signal and conducts the signal to the Demodulator via a lead.

Demodulator

The Demodulator's electronic circuitry extracts the audio signal from the signal picked up by the Receiver Coil and converts it to a signal that elicits vibration in the Floating Mass Transducer. In this process, the Demodulator provides a surge protection for the Floating Mass Transducer from potential external interference sources by limiting the maximum amount of current transmitted to the Floating Mass Transducer. This protection ensures that the maximum Floating Mass Transducer force output will not be exceeded under reasonably foreseeable circumstances, such as strong magnetic field exposure.

Floating Mass Transducer

The Bone Conduction Floating Mass Transducer (BC-FMT) is an electromagnetic transducer. The BC-FMT titanium housing has two extensions, or "wings" with anchor holes to fix the BC-FMT to the skull behind the ear, using the Cortical Screws. When a signal from the Demodulator reaches the BC-FMT, the magnets inside the BC-FMT vibrate accordingly and these vibrations are transferred to the mastoid bone via the osseointegrated Cortical Screws.

Transition Link

The Transition Link connects the Demodulator to the BC-FMT and can be bent, if necessary, to fit the implant bed. The transition can be bent to a ±90° angle about the horizontal plane and to a ±30° angle in the vertical plane, as needed.

BCI 601 Implant Kit

The BCI 601 implant and the surgical tools are provided to the customer in the BCI 601 Implant Kit (Figure 3). The BCI 601 Implant Kit is provided sterile (Ethylene Oxide) and each of its components is intended for single-use.

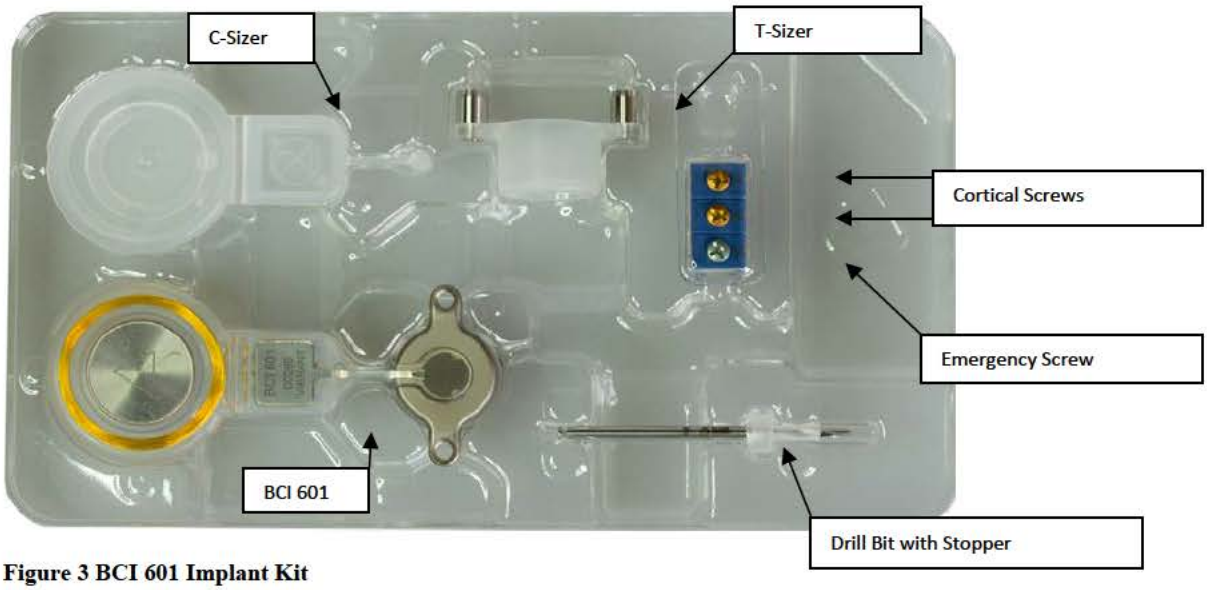

Figure 3 BCI 601 Implant Kit

Audio Processor

The Audio Processor available for use with the BONEBRIDGE is the SAMBA BB. The Audio Processor is attached to the head and BCI with a magnet and is powered by a standard hearing aid battery (Zinc-Air 675 or equivalent).

The SAMBA BB features a standard base in anthracite and 16 cover color and design variants. In addition, the SAMBA features a remote control (Figure 4).

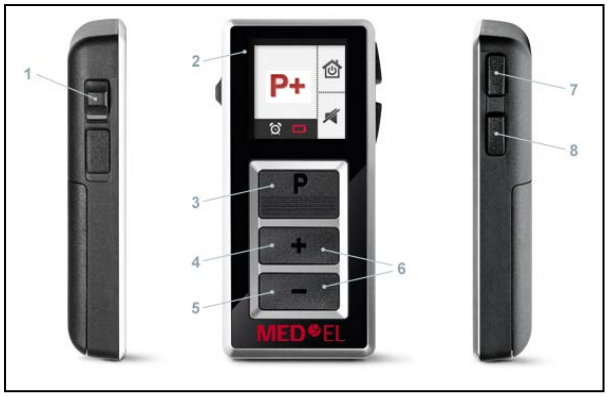

Figure 4 SAMBA Audio Processor (above) & Remote Control (below)

The Audio Processors contain dual microphones that pick up sound and speech from the environment and convert them into a signal that can be transmitted across the skin to the BCI. The signal transmitted by the Audio Processor is transferred to the Receiver Coil and relayed to the BC-FMT. The controlled vibrations of the BC-FMT are then interpreted as sound. The Audio Processor does not contain software and can be fitted to meet the patient's needs using separate software.

The SAMBA BB features a left and right variant as well as 5 magnet strength options to accommodate for variations in the thickness of the skin flap overlying the implant.

Surgical Tools & Accessories
The BCI is implanted using the following surgical accessories provided by MED-EL:

- Coil-Sizer – A template representing the Receiver Coil and the Demodulator section ("C-Sizer") used to aid the surgeon in (1) determining the optimal BCI placement on the head before incising the skin; (2) determining the exact location of the seat before drilling; and (3) verifying the size of the seat before placing the BCI;

- Transducer-Sizer – A template representing the Floating Mass Transducer section ("T-Sizer") used to (1) outline the exact size of the seat before drilling; (2) verify the size of the seat before placing the BCI; (3) provide guidance for the drill to ensure the correct distance between the two anchor holes; and (4) correct the orientation and depth of the anchor holes. Additionally, the C-Sizer and the T-Sizer can be connected to represent the complete BCI by inserting the bulge of the C-Sizer into the slot of the T-Sizer;

- Two Cortical Screws used fix the BC-FMT to the skull;

- One Emergency Screw which can be used in the case that fixation with one of the Cortical Screws is not successful; and

- Drill Bit with Stopper used for drilling the fixation points of the BCI.

<u>BCI Lifts & BCI Sizer Kit</u>
There are also two *optional* accessories to the BONEBRIDGE system:

- The BCI Lifts: If the necessary drill depth for the BCI 601 cannot be achieved for anatomical reasons, the BCI Lifts can be used. The use of the BCI Lifts together with the BCI 601 reduces the necessary drill depth for the Bone Conduction – Floating Mass Transducer (BC-FMT) in the skull bone.

- The BCI Sizer Kit: The BCI Sizer Kit can be used by surgeons during surgery to more easily measure insertion depth for the BONEBRIDGE.

Software
Specific software and hardware are needed to fit (also referred to as program) the BONEBRIDGE audio processor. It should be noted, however, that neither the BCI 601 nor the audio processors contain software.

MED-EL provides the following accessories with the BONEBRIDGE system:

- SYMFIT 7.0 software – A software database that allows programming of the Audio Processor with an off-the-shelf software.

- Programming Cable – A cable to connect the audio processor with the interface box.

SUMMARY OF NONCLINICAL/BENCH STUDIES

The non-clinical/bench studies conducted on the BONEBRIDGE System are summarized in the sections below.

BIOCOMPATIBILITY /MATERIALS

MED-EL has evaluated and tested the biocompatibility of the BONEBRIDGE System in accordance with ISO 10993-1:2009, Biological Evaluation of Medical Devices – Part 1: Evaluation and testing within a risk management process and the FDA Guidance Document, docket number FDA-2013-D-0350, Use of International Standard ISO 10993-1, "Biological evaluation of medical devices – Part 1: Evaluation and testing within a risk management process".

SAMBA BB Audio Processor Biocompatibility

Figure 5 SAMBA BB

The SAMBA BB is classified as an intact-skin contacting device for permanent use. Accordingly, the biological effects cytotoxicity, sensitization and irritation / intracutaneous reactivity testing were addressed for those components, which are in actual patient contact (the outer cover, the base, the battery cover, and the hairclip hanger).

BCI 601 Biocompatibility

The BCI 601 is implanted in and above the mastoid bone and as such, is a device in permanent tissue/bone contact. The BCI is fixed to the skull using standard implantable titanium alloy screws (Cortical Screws). Testing, as presented in Table 1, was performed in accordance with FDA's Good Laboratory Practices (GLP) regulation, 21 CFR Part 58. The results of the evaluation were supported by an experimentally performed material characterization study including determination of particulate matter. All tests were passed and confirm that the BONEBRIDGE BCI 601 is biocompatible.

Table 1 BONEBRIDGE BCI 601 Biocompatibility Evaluation

Test Description	Standard	Assessment	Result
Cytotoxicity – MEM elution	ISO 10993-5:2009	Tested	Passed
Intracutaneous reactivity / Irritation	ISO 10993-10:2010	Tested	Passed
Systemic Toxicity – ISO Acute Systemic Injection Test	ISO 10993-11:2006	Tested	Passed
Implantation	ISO 10993-6:2007	Tested	Passed
Sensitization	ISO 10993-10:2010	Tested	Passed
Genotoxicity	ISO 10993-3:2003	Tested	Passed

Test Description	Standard	Assessment	Result
Subchronic Toxicity	ISO 10993-11:2006 ISO 10993-6:2007	Tested	Passed
Carcinogenicity and Chronic Toxicity	ISO 10993-11:2006	Justification per test report	Passed
Pyrogenicity	ISO 10993-11:2006	Tested	Passed
Exhaustive Extraction	ISO 10993-18:2005	Tested	Passed
Extract Analysis – GC/MS fingerprint and Inductive Coupled Plasma Spectroscopy (ICP)	ISO 10993-18:2005	Tested	Passed
Particulate Matter (BCI and Screws)	EN45502-1:1997	Tested	Passed

BCI Lifts Biocompatibility
BCI Lifts have the same intended use and bone/tissue contact as the BCI 601. The same tests were passed and confirm that the BCI Lifts are biocompatible.

Surgical Tools Biocompatibility
The Surgical Tools are provided together with the BCI 601 implant in the BCI 601 Implant Kit. The Surgical Tools include the C-Sizer, T-Sizer, and Drill Bit with Stopper, which are all intended for transient use during the surgical operation only and have limited tissue/bone contact (≤24 hours).
The evaluation for the BONEBRIDGE Surgical Tools demonstrated biocompatibility for this intended use.

SHELF LIFE/STERILITY

Sterilization
The SAMBA BB is a non-sterile component and does not require sterilization. The other components of the BONEBRIDGE system are sterilized as follows.

As mentioned above, the BCI 601 and surgical tools and accessories are provided in the BCI 601 Implant Kit which is delivered terminally ethylene-oxide (EO) sterilized. Likewise, the BCI Lifts and BCI Sizer Kit are delivered terminally ethylene-oxide (EO) sterilized. Sterilization validation was demonstrated to be in compliance with AAMI/ANSI/ISO 11135: 2014.

Sterilization of the BCI 601 Implant Kit
A sterilization validation, based on conservative determination of the lethal rate of the sterilization process (overkill approach), was conducted on the BCI Implant Kit in accordance with AAMI/ANSI/ISO 11135-1:2007, Annex B.

BCI Lifts and BCI Sizer Kit:
Objective evidence (adoption analysis per AAMI TIR28:2009 Annex A) was provided demonstrating that the BCI Lifts and BCI Sizer Kit can be adopted in the existing sterilization validation of the BCI 601 Implant Kit.

Shelf Life & Packaging
The SAMBA BB is a non-sterile component and does not have a restricted shelf life.

BCI 601 Implant Kit:
As mentioned above, the BCI Implant Kit is provided sterile. The packaging of the device was designed and validated to ensure the sterility and integrity of the individually packaged

and sealed devices during sterilization, distribution and storage over the labeled shelf life according to ISO 11607-1:2006. Packaging materials were selected for compatibility with EO sterilization methods.

BCI Lifts and BCI Sizer Kit:
The sterile barrier system (SBS) of the BCI Lifts and BCI Sizer Kit is in compliance with the requirements of ISO 11607-1:2006.
The packaging validation included evaluation and testing of packaging, sealing and storage stability and performance during distribution.

ELECTRICAL SAFETY AND ELECTROMAGNETIC COMPATIBILITY

The BONEBRIDGE is a bone conduction hearing prosthesis system, which consists of the passive Bone Conduction Implant ("BCI") and an external Audio Processor ("AP"). Although the operation of the BCI relies on a source of magnetic flux from the AP, the BCI is designed to deliver only mechanical vibration to the human skull. Under standard operation, there is no intended electrical stimulation or other electrical output to the human body. To ensure that the device is safe for its intended use, Electromagnetic Compatibility (EMC) and electrical safety testing was performed.

EMC Testing
EMC testing was performed for the BONEBRIDGE System with both the SAMBA BB audio processor in accordance with the following standards:

- IEC 60601-1-2:2001 + A1:2004
- IEC 60601-1-2:2007
- EN 301 489-1 V1.9.2 (2011)
- EN 301 489-3 V1.6.1 (2013)
- EN 301 489-31 V1.1.1 (2005)

All acceptance criteria were met.

Additionally, wireless device compatibility testing was performed per ANSI C63.19: 2011. The BONEBRIDGE met the applicable acceptance criteria and operated as intended, with no loss of function. Finally, supplementary RFID testing was performed. All samples passed testing and no anomalies were detected. It was determined that no additional immunity testing was required to demonstrate the safety of the BONEBRIDGE System for its intended use environment. The only reported issues related to EMC are those cases where users may experience interference called parasitic demodulation which they perceive as a buzzing sound. In such instances, the product labeling advises users to move away from the source of the interference.

Electrical Safety Testing
The SAMBA BB was tested in accordance with IEC 60601-1 Medical Electrical Equipment – Part 1: General Requirements for Safety – Collateral standard: Electromagnetic compatibility – Requirements and tests.

BCI 601 Electrical Safety Testing
Leakage current and voltage difference tests were performed on the BCI 601 to ensure the safety of the implantable component of the BONEBRIDGE system. All acceptance criteria

were met. Additionally, voltage difference testing was conducted to ensure the safety of the only non-hermetically enclosed portion of the implant. The acceptance criterion was met.

SAMBA Electrical Safety Testing
Electrical safety testing for the SAMBA BB audio processor was performed in accordance with IEC 60601-1:2012 (4th edition) and IEC 60601-1-11: 2010 (1st Edition). All tests were passed and it is concluded that the SAMBA is safe for use.

MAGNETIC RESONANCE (MR) COMPATIBILITY

The BONEBRIDGE System is MR Unsafe.

SOFTWARE

The MED-EL SYMFIT software provides a parameter database, which allows fitting (also referred to as programming) of the BONEBRIDGE audio processors with standard third party fitting software.

Level of Concern
The Level of Concern for the SYMFIT software is considered to be "Minor" based on the FDA Guidance Document, "Guidance for the Content of Premarket Submissions for Software Contained in Medical Devices." Specifically, with regard to the operation of the BONEBRIDGE system, the SYMFIT software is stand-alone computer software that does not affect the safety of the BONEBRIDGE system. SYMFIT is not used to provide mitigations for any potential injury to the patient. Moreover, a failure in the SYMFIT software could only result in inability to program the audio processor. Due to the Minor Level of Concern, descriptions of the following items were addressed:

- Software Description/Summary of Functional Requirements from SRS
- Device Hazard Analysis
- Traceability Analysis
- Verification and Validation Documentation
- Revision Level History

PERFORMANCE TESTING – BENCH

SAMBA BB Audio Processor Testing
The SAMBA BB audio processor has been verified to perform as intended according to its audiological specifications as part of the BONEBRIDGE system. BONEBRIDGE System testing with the SAMBA BB included verification of audiological performance with regard to force output, transmission distance, power supply, and noise floor.

Table 2 System Performance Testing

<table>
<tr><th>Test</th><th>Design Requirement</th><th>Result</th></tr>
<tr><td>Force Output</td><td>In a completely assembled BONEBRIDGE system, acoustic input was provided to the Audio Processor as system input and the fore output of the implant was measured as system output. The force level produced by the system was greater than the following Maximum Power Output (MPO) at each corresponding frequency
<table>
<tr><th>Frequency [Hz]</th><th>MPO [dB μ N]</th></tr>
<tr><td>500</td><td>90</td></tr>
<tr><td>1000</td><td>102</td></tr>
<tr><td>2000</td><td>96</td></tr>
<tr><td>4000</td><td>90</td></tr>
</table></td><td>Passed</td></tr>
<tr><td>Transmission Scheme</td><td>The force output at 4mm coupling distance from Audio Processor to implant and at 7mm coupling distance was measured. The difference between force output level at coupling distances of 7 mm and 4 mm is ≤4 dB</td><td>Passed</td></tr>
<tr><td>Battery Lifetime</td><td>Lifetime of a standard 675-type battery should be >16 hours</td><td>Passed</td></tr>
<tr><td>Noise Floor</td><td>In a completely assembled BONEBRIDGE system, with no acoustic input, the residual noise that is generated by the electronic circuitry in the AP and BCI should be <10 dB HL at 500, 1000, 2000, and 4000 Hz.</td><td>Passed</td></tr>
</table>

In addition, individual product testing was performed on the SAMBA BB audio processor as follows:

Table 3 SAMBA BB AP Testing Overview

Test	Test Objective	Test Result
System Audiological Performance	Verify that the AP performs to the audiological specifications (e.g., Maximum Gain, Maximum Power Output, Frequency response, Harmonic Distortion and Input-referred Noise)	Passed
Dual Microphone Validation	Validate functionality of dual microphones	Passed
Physical Characteristics	Verify physical characteristics to the specifications	Passed
AP Adapter Compatibility	Verify that the AP meets frequency response range in frequencies between 500 Hz and 3000 Hz	Passed
Vibration Testing	Verify that AP meets its specifications	Passed
Shock Testing	Verify that AP meets its specifications	Passed
Drop Testing	Verify that AP meets its specifications	Passed
Operating Temperature and Humidity Exposure	Verify functionality following exposure to operating temperature and anticipated humidity exposure	Passed
Storage Temperature	Verify that AP meets its storage conditions specifications	Passed
Substance Resistance	Verify resistance of housing to external substances (e.g., skin moisturizer, cleaning solutions)	Passed
Solar Radiation	Verify that AP housing is resistant to solar radiation	Passed
Moisture Ingress	Verify that the AP is resistant to ingress of water when it is sprayed with water	Passed

Test	Test Objective	Test Result
Atmospheric Pressure	Establish resistance to atmospheric pressure changes	Passed
Light Exposure	Ensure that the electronics within the AP housing are robust against solar radiation.	Passed
Shipping	Establish suitability of product packaging for shipment	Passed
Accessory Compatibility	Establish compatibility with HiPro, ConnexxLink, and RCU	Passed
Wireless Compatibility	To establish electromagnetic compatibility per ANSI/IEEE C63.19	Passed
EMC/ESD	Establish electromagnetic compatibility of the BONEBRIDGE System	Passed
ERM	ETSI EN 300 330-1, ETSI EN 300 330-2	Passed
Biocompatibility	Evaluation of the biological safety of the SAMBA BB	Passed
Usability	Establish that intended users can carry out necessary tasks	Passed

BCI 601 & Surgical Tools Testing

Performance bench verification and validation testing has been conducted for the BCI 601 and the Surgical Tools that are used to implant the BCI. Table 6 provides an overview of this bench testing.

Table 4 BCI Testing Overview

Test Category	Test	Test Objective	Test Result
Performance	BCI Implant Performance	Verify that the BCI performs as intended with regard to signal quality (transducer distortion) and output level limitation (implant safety feature)	Passed
	Reliability	Verify that the BCI will have a <5 % failure rate after 10 years of continuous use	Passed
	Screw Torque/ Force Stability	Identify the maximum torque and force that the cortical screws can withstand	Passed
	Bending	Verify that the BCI will be functional after being bent into implantation shape	Passed
Physical Characteristics	Implant Physical Characteristics	Verify the Floating Mass Transducer dimensions, design symmetry, coil / attachment dimensions, and implant surface coating	Passed
	Simulated Surgical Implantation	Validate adequacy of implant dimensions for safe implantation and fixation to the bone and validate surgical usability	Passed
Compatibility with External Pressure, Variations in Pressure and Acceleration	Vibration	Verify that the BCI is resistant to vibrations that can occur during intended use	Passed
	Shock	Verify that the implant can sustain mechanical forces that may occur during implantation surgery	Passed
	Dynamic Impact	Verify that the BCI can withstand dynamic impact	Passed

Test Category	Test	Test Objective	Test Result
	Skull Fracture	BCI implantation shall not adversely affect the risk of skull fracture	Failed[1]
	2.5J Impact	To demonstrate that the BCI 601 implant can withstand impacts of 2.5J.	Passed
	Atmospheric Pressure	Verify that the BCI is resistant against atmospheric pressure change	Passed
	Pressurizing	Verify that the BCI can sustain pressure from recreational activities like swimming or diving	Passed
	Chronic Implant Movement	Verify that the BCI can withstand chronic movements anticipated in its implanted state	Passed
Compatibility with Medical Treatment or Examination Environment	Diagnostic Ultrasound	Verify compatibility	Passed
	Surgical Diathermy	Verify compatibility	Passed
	X-ray and CT	Verify compatibility	Passed
	Radiation Therapy and PET	Verify compatibility	Passed
Temperature Resistance	Operating Temperature	Verify that the BCI operates in a temperature range from 18°C to 43°C	Passed
	Storage Temperature	Verify that storage temperature for the BCI is in a temperature range from -20°C to 60°C	Passed

Performance

BCI performance verification testing was conducted to ensure that the BCI performs to its acoustic output specifications and that it is reliable over long term use. Acoustic performance verification testing was conducted to ensure that the BCI performs to its acoustic output specifications with regard to signal quality (transducer distortion) and output level limitation (implant safety feature). Reliability testing was performed as follows:

Table 5 Reliability Testing

Failure Mode (FM)	Sample Conditioning	FM Test Post-Conditioning	Result
1. Fatigue fracture of transducer parts	Subgroup A	Functional testing	Failure mode did not occur
2. Fatigue fracture of wire guard	Subgroup A	Visual inspection	Failure mode did not occur
3. Adhesive joint failure (transducer carrier-transducer)	Subgroup A	Functional testing	Failure mode did not occur
4. Loss of hermeticity due to corrosion (demodulator package)	Subgroup B	-Visual inspection -Leak test -RGA	Failure mode did not occur
5. Loss of hermeticity due to corrosion (transducer package)	Subgroup B	-Visual inspection -Leak test -RGA	Failure mode did not occur

[1] No skull fractures were present in the samples tested. Therefore, the test objective was reached. However, implant hermeticity was a stated acceptance criterion of the test. One implant demonstrated a fine leak following subjection to an impact of 3.5J.

Failure Mode (FM)	Sample Conditioning	FM Test Post-Conditioning	Result
6. Fracture of cortical screws due to fatigue and stress corrosion	Subgroup B	Visual inspection	Failure mode did not occur
7. Vibration induced failure of weld seams of hermetic transducer encapsulation	Subgroup B	Visual inspection	Failure mode did not occur

No implant failures were observed during conditioning. Following conditioning, all BCIs samples passed functional testing and visual inspection for evidence of fatigue. Furthermore, subgroup B samples were also subjected and passed leak testing followed by residual gas analysis testing.

- Screw Torque/Force Stability

Testing was conducted to establish the maximum torque and force that the fixation screws can withstand.

- Bending

BCI bending testing was performed to ensure that the functionality of the BCI will not be affected upon geometric fitting to the patient's skull for implantation.

Physical Characteristics
MED-EL has performed Implant Physical Characteristics and Simulated Surgical Implantation testing to verify that the implant physical characteristics are according to its specifications and to validate that the specifications are adequate for safe implantation. Additionally, Simulated Surgical Implantation testing validated that the surgical tools facilitate safe and reproducible surgery.

- Implant Physical Characteristics

Physical characterization testing was conducted on three BCI units to verify the BC-FMT dimensions, design symmetry, coil/attachment dimensions, and implant surface coating. All BCI 601 units met the physical characteristics requirement set up in the BCI design specification.

- Simulated Surgical Implantation

Simulated surgical implantation testing was conducted in order to validate that the designs of the BCI and the Surgical Tools allow implantation and fixation to the bone without undue damage to nearby body structures. In the simulated implantation testing, the BCI was implanted with the supplied surgical tools into temporal bone or half-head cadaver specimen.

Compatibility with External Pressure, Variations in Pressure and Acceleration
MED-EL has assessed compatibility of the BCI with expected external pressure, pressure variations, and acceleration. Specifically, vibration, shock, dynamic impact, atmospheric pressure, water pressure, chronic implant movement, skull fracture and impact testing at 2.5J

was performed. In each test, the BCI units were tested to the device requirements, conditioned appropriately, and tested again to the device requirements to assess whether the BCI could withstand the conditioning.

Compatibility with Medical Treatment or Examination Environment
MED-EL has assessed compatibility of the BCI with standard diagnostic or medical treatment modalities including diagnostic ultrasound, surgical diathermy, X-ray and Computed Tomography (CT), and radiation therapy and Positron Emission Tomography (PET). To evaluate the compatibility, in each test, BCI units were tested to the device requirements, conditioned per the modality, and tested again to the device requirements.

- Diagnostic Ultrasound

Diagnostic ultrasound compatibility testing was conducted per EN 45502-1:1997: one group was exposed to 500 W/m^2 ±5 % using spatial peak, temporal average mode in frequency of 2-5 MHz with a duty cycle of 50 % ±10 %. The other group was exposed to temporal average intensity of ≥1500 mW/cm^2 in frequency of 2-5 MHz with a duty cycle of 20 %. Before and after conditioning, implants were assessed per the manufacturing test requirements. All units met the acceptance criteria.

- Surgical Diathermy

Surgical diathermy compatibility testing was conducted as per EN 45502-2-1:2004. Each BCI unit was separately placed in a metal box filled with saline and exposed to electrical energy (10 pulses, pulse duration of 1 second and pulse relaxation of 5 seconds, at 500 kHz, 20 Vpp) that is typically provided by bipolar electrocauters. Following the exposure via this test, the BCIs were tested for functionality. Device requirements were met before and after conditioning with diathermy. All samples met the specified requirements and no functional degradation was observed following conditioning.

- X-ray and CT

X-ray and CT compatibility testing was conducted to assess whether exposure to X-ray and CT would have an influence on implant performance. Since the maximum beam energy of an X-ray (60-80keV) is substantially less than that of a CT scan (≤140keV), MED-EL has tested the BCI to the maximum dose of energy delivered in a CT scan to verify the compatibility of the BCI to X-ray and CT. In the testing, BCI 601 implants were placed in an acrylic glass phantom that was exposed to a maximum dose CT using state of the art CT scan. The functionality of the BCI was tested before and after exposure to the CT. The testing demonstrated that implants met the manufacturing requirements before and after the CT scan; the acceptance criteria were met.

- Radiation Therapy and PET

Radiation therapy and PET imaging compatibility testing was conducted to assess whether exposure to ionizing (gamma) radiation, which is utilized by both procedures, impacts the functionality of the BCI. Since radiation therapy is typically applied in doses of up to 60 Gy and employs higher doses of radiation than PET scan, a worst-case radiation therapy dose of 100 Gy was used for testing. During testing, a single 100 Gy dose was applied in a single irradiation cycle, which is a more severe condition than that of standard clinical use (high

irradiation doses are applied over several weeks). Before and after gamma radiation conditioning, the BCIs were tested to ensure that the device met its requirements and no performance degradation occurred due to radiation exposure. All BCI units met the device requirements both before and after conditioning.

Temperature Resistance
Testing was performed to verify the BCI operating and storage temperature ranges. The samples were tested to support operational temperature of 18-43˚C. Functionality of the BCIs was verified after the samples were conditioned at 18˚C ±3˚C for 4 hours and at 43˚C±3˚C. All units were reported to be fully functional. To verify the storage temperature, BCI samples were verified to operate after conditioning between -20°C and 60°C. Following conditioning, all samples were tested for functionality and were found to operate as intended.

BCI Lifts & Sizer Kit Testing

Performance
Two tests were performed to confirm that the BCI Lifts fulfill their performance requirements. The first test is the BCI Lifts performance test. This test addresses: performance, distortion, frequency response, and linearity. All test samples fulfilled the acceptance criteria. The second test addressed the final performance requirement, torque/force stability. As the stability of the test items far exceeded the acceptance criteria, it was concluded that the combination of the BCI 601 implant, BCI Lifts and the cortex screws fulfills this performance requirement. No performance characteristics were identified for the BCI Sizer Kit. The ability of surgeons to effectively use the equipment has been addressed through usability testing.

Mechanical Safety
In addition, the BCI Lifts were tested to demonstrate that they are able to withstand the forces expected to be exerted on the devices during daily use. The test results demonstrated the mechanical stability and safety of the BCI Lifts. The BCI Sizer Kit is used intraoperatively to aid surgeons in placing the BCI 601. The BCI Sizer Kit components are intended for single use in the operating theatre and are not subject to a large degree of mechanical stress during normal use. Shipping and storage testing has been performed to demonstrate that the BCI Sizer Kit and its packaging can withstand the stresses associated with transport.

Usability
Usability tests were performed to demonstrate that the designs of the BCI Lifts are appropriate for their intended use.

- Surgeons implanted a BCI 601 using the BCI Lifts (one of each Lift variant) and BCI Sizer Kit

SUMMARY OF CLINICAL INFORMATION

Overall study design

A prospective, single arm, open-label, pre-market study (BB001) was conducted among 12 adult and 12 pediatric patients with mild-to-moderate degree of mixed (MHL) or conductive hearing loss (CHL) up to 3 months post implantation. 10 adults and 8 children in the BB001 study along with additional 35 adults were recruited into a post-market follow-up study (BB002) to investigate the long-term safety and effectiveness of BONEBRIDGE. A

prospective, single arm, open-label, post-market study (BB 003) was conducted among 13 adult patients with Single Sided Deafness (SSD) (unilateral severe to profound sensorineural hearing loss) up to 12 months post implantation. Subjects were unilaterally implanted with the BONEBRIDGE implant system and served as their own controls (i.e., preoperative unaided = no treatment, comparted to postoperative aided with the BONEBRIDGE implant system).

Demographics

The table below provides information on subject demographics for BB001, including gender, age at implantation, average of previous ear surgeries, implant site, and etiology.

Parameter/category or statistic	Total (N = 24)	Adult (N = 12)	Pediatric (N = 12)
Gender			
Male %	29.17 % (N = 7)	25 % (N = 3)	33.3 % (N = 4)
Female %	70.83 % (N = 17)	75 % (N = 9)	66.7 % (N = 8)
Age (years) mean (min-max)	28 (5 - 69)	44 (19 - 69)	11 (5 - 17)
Implant side			
Left %	29.2 % (N = 7)	25 % (N = 3)	33.3 % (N = 4)
Right %	70.8 % (N = 17)	75 % (N = 9)	66.7 % (N = 8)
Previous ear surgeries			
Average surgeries per subject	1.3	2.1	One pediatric subject was previously operated with five previous ear surgeries.
Previously operated subjects	50 % (N = 12)	91.7 % (N = 11)	

Parameter/category or statistic	Total (N=24)		Adult (N = 12)		Pediatric (N=12)	
Disease etiology	%	N	%	N	%	N
Cholesteatoma	16.67	4	33.33	4	0.00	0
Atresia auris	41.67	10	25.00	3	58.33	7
COM	12.50	3	16.67	2	8.33	1
Chron. mastoiditis	4.17	1	8.33	1	0.00	0
Otosclerosis	4.17	1	8.33	1	0.00	0

Microtia	8.33	2	0.00	0	16.67	2
Ear canal stenosis	4.17	1	0.00	0	8.33	1
Anotia	4.17	1	0.00	0	8.33	1
Glomus tumor	4.17	1	8.33	1	0.00	0

The table below provides information on subject demographics for BB002, including gender, age at implantation, and implant side.

Parameter/category or statistic	Total (N = 53)	Adult (N = 45)	Pediatric (N = 8)
Gender			
Male %	58.5 % (N = 22)	37.7 % (N = 17)	62.5 % (N = 5)
Female %	41.5 % (N = 31)	62.3 % (N = 28)	37.5 % (N = 3)
Age (years) mean (min-max)	41 (5 - 76) (N = 53)	47 (18 - 76) (N = 45)	11 (5 - 17) (N = 8)
Implant side			
Left %	41.5 % (N = 22)	42.2 % (N = 19)	37.5 % (N = 3)
Right %	58.5 % (N = 31)	57.8 % (N = 26)	62.5 % (N = 5)
Previous ear surgeries			
Average surgeries per subject	3.66	3.61	Only one pediatric subject was previously operated with five previous ear surgeries.
Previously operated subjects	60.38 % (N=32)	68.89 % (N=31)	

Parameter/category or statistic	Total (N = 53)		Adult (N = 45)		Pediatric (N =8)	
Disease etiology	%	N	%	N	%	N
Chronic otitis media	30.19	16	28.30	15	1.89	1
Atresia	22.64	12	16.98	9	5.66	3
Cholesteatoma	20.75	11	20.75	11	0	0
Ear dysplasia	7.55	4	5.66	3	1.89	1
Malformation	1.89	1	0	0	1.89	1

Ear dysplasia / Franceschetti syndrome	1.89	1	1.89	1	0	0
Chronic mastoiditis	1.89	1	1.89	1	0	0
Stenosis	1.89	1	1.89	1	0	0
Anomalius bar	1.89	1	1.89	1	0	0
Congenital syndromic malformation	1.89	1	0	0	1.89	1
Otosclerosis	1.89	1	1.89	1	0	0
Glomus tumor	1.89	1	1.89	1	0	0
Osteogenesis imperfecta otosclerosis	1.89	1	1.89	1	0	0
Microtia	1.89	1	0	0	1.89	1

The table below provides information on subject demographics for BB003, including gender, age at implantation, and implant side.

Parameter/Category or Statistic	Total (N=13)
gender	
Male %	53.85 % (N=7)
Female %	46.15 % (N=6)
Age (years) mean (min-max)	39 (18-59) (N=13)
Implant Side	
Left %	46.15 % (N=6)
Right %	53.85 % (N=7)

Study endpoints

Safety endpoints:

1. The primary safety endpoint is evaluated by tabulations of Adverse Events (AEs) and Serious Adverse Events (SAEs) through 12-month follow-up period.
2. The secondary safety endpoint was the change in bone conduction thresholds at audiometric frequencies (500-4000 Hz) from pre-operative baseline to post-operative unaided condition after completion of the 12-month study. Success criterion was no more than mean 10 dB change in individual subject PTA across 500-4000Hz and on individual frequency.

Effectiveness endpoints:

1. The primary effectiveness endpoint was the improvement in word/sentence recognition from the preoperative unaided condition to the 12-month postoperative aided condition. An improvement of 15% was the success criteria for the primary endpoint.
2. The secondary effectiveness endpoints were 1) the improvement in functional gain (difference between unaided and aided hearing thresholds) defined as Pure Tone

Average across 500-4000 Hz; and 2) the improvement in the Speech Reception Threshold (SRT; Oldenburger Satztest (OLSA)) from pre-operative baseline to post-operative aided condition after completion of the 12-month study.

Effectiveness results

The results from BB 001 and BB 002 studies demonstrate the following benefits for subjects with the MHL and CHL:

1. There was statistically and clinically significant benefit (average 63.3% improvement ($p < 0.001$); 62.9% for adults and 65.2% for children) from use of the device at the study endpoint interval (12-month) in speech recognition over the baseline unaided performance using the Freiburger Monosyllable Word recognition. The primary effectiveness endpoint was met.

Freiburger	Total (N=52)			Adult (N = 44)			Pediatric (N=8)		
Word Recognition Score	Score [%]	Std.	N	Score [%]	Std.	N	Score [%]	Std.	N
pre-operative	19.57	21.70	46	20.00	21.64	39	17.14	23.60	7
12 months post-operative	82.90	18.10	50	82.91	18.68	43	82.86	15.24	7

2. Two secondary effectiveness endpoints were also met with statistical and clinical significance:

   a. Mean 28.9 dB (28.4 dB for adults and 30.2 dB for children) improvements in aided thresholds or functional gain from the 500-40000 Hz frequency range with the BONEBRIDGE implant system compared to their unaided and air conduction hearing aid levels ($p < 0.001$);

WT	Total (N=52)			Adult (N = 44)			Pediatric (N=8)		
Warble tones	dB HL	Std.	N	dB HL	Std.	N	dB HL	Std.	N
pre-operative	56.94	12.57	50	57.64	12.89	42	53.28	10.75	8
12 months post-operative	29.33	8.89	50	29.71	9.11	43	26.96	7.56	7

   b. Mean 24.0 dB improvement (23.1 dB for adults and 29.8 dB for children) from use of the device at the study endpoint interval (12-month) in speech recognition over the baseline unaided performance using the speech reception threshold (SRT) measured by Oldenburger sentence test (OLSA) ($p < 0.001$).

OLSA	Total (N=52)			Adult (N = 44)			Pediatric (N=8)		
Speech Reception Threshold	dB SPL	Std.	N	dB SPL	Std.	N	dB SPL	Std.	N
pre-operative	63.69	11.81	42	62.21	11.69	36	72.60	8.70	6
12 months post-operative	39.71	8.84	48	39.19	9.09	41	42.80	7.01	7

The results from BB 003 demonstrate the following benefits for subjects with SSD:

Measurements were taken in the unaided and aided BONEBRIDGE conditions in three different test scenarios: 1) signal and noise coming from the front, 2) noise coming from the front and signal coming to the normal hearing ear, and 3) noise coming from the

front and signal coming to the implanted ear. Speech understanding in noise was evaluated by signal to noise ratio (SNR) using the OLSA at 65 dB SPL noise for 50 % correct understanding of sentences. There were no significant differences between aided vs. unaided speech recognition performance in scenarios 1 and 2, indicating that there is no detrimental effect of BONEBRIDGE amplification to the implanted ear on overall speech recognition performance. Significant benefit (1.56 dB SNR difference at 12 months) was observed in scenario 3 where the speech is presented to implanted ear and noise is presented to the contralateral ear with normal hearing (Note:1 dB SNR improvement is equivalent to 10% speech perception improvement from unaided to aided condition).

Signal to Noise Ratio	Unaided			aided		
(SNR | S_0 N_{90})	dB SNR	Std.	N	dB SNR	Std.	N
Baseline	-2.82	1.37	13	-4.33	1.94	13
12 months post-operative	-3.09	1.48	10	-4.65	1.73	10

Overall, the primary effectiveness endpoint was met by all three studies and two secondary endpoints were met by the BB001 and BB 002 studies. The data supports that the BONEBRIDGE system provides significant benefit for speech understanding in quiet and noise compared to the preoperative unaided condition.

Additional patient-reported outcome measures:

Positive perceived benefits (e.g., improved speech understanding in quiet and in noise, and improved functional gain) and satisfaction in their daily lives with the aided condition when compared to the subject's own preoperative unaided condition were measured by the Hearing Device Satisfaction Scale (HDSS) questionnaires in the BB 001 and BB 002 studies and the Speech Spatial Qualities-Benefit Questionnaire (SSQ-B) in the BB 003 study.

Results demonstrated that 1) of all subjects completing the HDDS questionnaire, 87.9% children and 79.6% of adults indicated an increase in satisfaction at the 12 months follow-up visit when compared to the preoperative baseline condition; 2) there was 25.7% improvement in score of SSQ-B questionnaire at 12 months from the unaided to the aided condition (Note: a score improvement of 10% or more indicates that patients will accept and use a device).

Safety results

BB001 and BB0002 studies

1. A total of 31 Adverse Events, one temporary loss of residual hearing and one serious adverse event unrelated to the procedure or the device were reported up to 12 months after implantation. The temporary loss of residual hearing was recovered at a later time point. One serious adverse event unrelated to the device reports on ear canal inflammation with subsequent cholesteatoma removal surgery and antibiotic treatment. Eighteen adverse events occurring in 15 subjects were reported as related to either the device or the procedure, with two reported as SADE (Device related Serious Adverse Events), 4 reported as device related Adverse Events and 12 reported as procedure related Adverse Events. One subject who experienced a SADE on skin infection and subsequent explantation was excluded from the study analysis as the inclusion criteria were not met from the beginning (the patient's skin was too thin already preoperatively). Details on the type and number of device and procedure related adverse events can be found below:

Events Reported as Device- or Procedure-Related for 52 subjects	No. of Events	No. of Subjects	% of Subjects	% Resolved
Itching at the implant side	1	1	1.89 %	100 %
Skin irritation at the implant side	3	3	5.66 %	100 %
Skin infection at the implant side	2	2	3.77 %	100 %
Headaches	1	1	1.89 %	100 %
Headaches and Skin irritation	1	1	1.89 %	100 %
Pain at the implant side	2	2	3.77 %	100 %
Pain at the implant side and skin infection	1	1	1.89 %	100 %
Pain due to post-operative scar formation	1	1	1.89 %	100 %
Occasional pain due to skin nerve cut	1	1	1.89 %	0 %
Postoperative subcutaneous seroma	1	1	1.89 %	100 %
Revision surgery to thin out the subcutaneous fascia.	1	1	1.89 %	100 %
Vertigo	1	1	1.89 %	100 %
Tinnitus	1	1	1.89	100

2. There was no more than mean 10 dB change in bone and air conduction thresholds captured by PTA across 500-4000Hz, indicating stable inner and middle ear function 12 months after implantation.

BC	Total (N=52)			Adult (N = 44)			Pediatric (N=8)		
Bone Conduction thresholds	dB HL	Std.	N	dB HL	Std.	N	dB HL	Std.	N
pre-operative	16.03	9.70	52	17.41	9.57	44	8.44	6.71	8
12 months post-operative	17.03	10.24	50	18.11	10.25	43	10.36	7.83	7
AC	Total (N=52)			Adult (N = 44)			Pediatric (N=8)		
Air Conduction thresholds	dB HL	Std.	N	dB HL	Std.	N	dB HL	Std.	N
pre-operative	59.12	14.76	51	59.68	15.08	43	56.09	13.34	8
12 months post-operative	58.21	16.45	49	58.32	16.84	42	57.50	15.02	7

BB03 study

A total of 2 procedure related adverse events were reported up to twelve months following baseline testing.

Events Reported as Device- or Procedure-Related for 513 subjects	No. of Events	No. of Subjects	% of Subjects	% Resolved
Wound Healing Problems	1	1	7.69 %	100 %
Occasionally local swelling at the implant site in the evening resolving in the morning	1	1	7.69 %	reoccurring

Pediatric Extrapolation

In this De Novo request, existing clinical data was leveraged to support the reasonable assurance of safety and effectiveness of the proposed device in the pediatric sub-population of adolescent patients.

Adult data on both safety (as measured by the safety endpoints) and effectiveness (as measured by the effectiveness endpoints) from the clinical studies submitted by MED-EL (BB001, BB002 and BB003) and real-world data on BONEBRIDGE recipients were extrapolated. This was a partial extrapolation, as the clinical studies included 6 adolescent patients and the real-world data included information on 210 adolescent patients. Extrapolation of the effectiveness data was appropriate for this device and indications for use because effectiveness endpoints showed similar patterns between the adolescent and adult age groups. Extrapolation of the safety data was appropriate for this device and indications for use because of similarity in bone volume in adult and adolescent age groups.

LABELING

The labeling satisfies the requirements of 21 CFR 801.109 Prescription devices. Labeling includes implant and software instructions for use, an audio processor user manual, and a surgical guideline with detailed instructions on how to implant the device. The implant instructions for use contain a detailed summary of the clinical testing conducted with the device, including complications and adverse events. Device components that are provided sterile include labeling with a shelf life.

The labeling for this device includes instructions to perform a pre-operative CT scan to determine whether a patient's anatomy is adequate to enable placement of the implanted component of the device.

Patient labeling is also included that follows the principles identified in FDA's guidance entitled "Medical Device Patient Labeling" (April 2001). The labeling includes a summary of the clinical studies, instructions for fitting and everyday use of the audio processor, and information related to electromagnetic compatibility. Because the BCI component cannot be self-removed, a patient card is required that can be carried with the patient to provide information about the device.

RISKS TO HEALTH

Table 11 below identifies the risks to health that may be associated with use of an active implantable bone conduction hearing system and the measures necessary to mitigate these risks.

Table 11 – Identified Risks to Health and Mitigation Measures

Identified Risk	Mitigation Measures
Dural erosion or compression resulting from failure to confirm adequate thickness and consistency of bone and related anatomy	Labeling
Surgical complications leading to • Bleeding/hematoma • Seizures • CSF leak • Implant damage or migration leading to revision/explantation	Clinical performance testing Labeling
Device software failure	Software verification, validation, and hazard analysis
Implant failure due to: • Fatigue • Damage/breakage • Loss of hermeticity	Clinical performance testing Non-clinical performance testing
Device failure to compensate for hearing loss	Clinical performance testing Non-clinical performance testing
Interference with other devices	Electromagnetic compatibility testing Wireless coexistence testing Electrical safety testing Labeling
Adverse tissue reaction	Biocompatibility evaluation Labeling
Infection	Sterilization validation Shelf life testing Labeling

SPECIAL CONTROLS

In combination with the general controls of the FD&C Act, the active implantable bone conduction hearing system is subject to the following special controls:

1. Clinical performance testing must characterize any adverse events observed during implantation and clinical use, and must also demonstrate that the device performs as intended under anticipated conditions of use.

2. Non-clinical performance testing must demonstrate that the device performs as intended under anticipated conditions of use, including the following:
    a. Performance data must validate force output in a clinically relevant model.
    b. Impact testing in a clinically relevant anatomic model must be performed.
    c. Mechanical integrity testing must be performed.
    d. Reliability testing consistent with expected device life must be performed.

3. The patient-contacting components of the device must be demonstrated to be biocompatible.

4. Performance data must demonstrate the sterility of the patient-contacting components of the device.

5. Performance data must support the shelf life of the device by demonstrating continued sterility, package integrity, and device functionality over the identified shelf life.

6. Performance data must demonstrate the wireless compatibility, electromagnetic compatibility, and electrical safety of the device.

7. Software verification, validation, and hazard analysis must be performed.

8. Labeling must include the following:
    a. A summary of clinical testing conducted with the device that includes a summary of device-related complications and adverse events;
    b. Instructions for use;
    c. A surgical guide for implantation, which includes instructions for imaging to assess bone dimensions;
    d. A shelf life, for device components provided sterile;
    e. A patient identification card; and
    f. A patient user manual.

BENEFIT/RISK DETERMINATION

The risks to health from this device are described above. The following adverse events were observed in the prospective study for adults and children with mixed or conductive hearing loss, and the prospective study for single-sided deafness. Only one explantation occurred among the 65 patients analyzed in these two studies, no device failures were reported and only two serious adverse device events were reported. In total, only five device-related adverse events were reported for 66 patients, for an adverse event rate of 7.57 % (N= 5/66). Procedure-related events are also listed below. Rates are given for patients that were in the inclusion criteria (N=65) and for all subjects plus one excluded subject that was out of inclusion criteria (N=66). This adverse event was the only one that involved explantation of the device and that was reported in the prospective studies with 12 months or longer of follow-up data. Only one procedure related Adverse Event on itching at the audio processor site was reported for the pediatric population.

Table 12: Adverse Events Reported in Prospective Studies

Adverse Events	Recommended Mitigation Measures	Occurrence Rate		
		N	N=65	+ Excluded Subject N=66
Explantation due to poor skin condition	N/A – patient-specific issue	1	*	1.52 %
Surgery to thin the skin flap	Labeling Implant IFU, Too thick. Skin Flap gauge 7, EDC-1703 and 2142	1	1.54 %	1.52 %
Pain around the implant site or scar	Implant IFU EDC-2142	5	7.69 %	7.58 %
Vertigo	N/A – patient-specific issue	1	1.54 %	1.52 %
Skin infection	N/A – OR issue	1	1.54 %	1.52 %
Tinnitus	N/A – patient-specific issue	1	1.54 %	1.52 %
Pruritus	N/A – patient-specific issue	1	1.54 %	1.52 %
Skin irritation or redness	Implant IFU EDC-2142	3	4.62 %	4.55 %
Headache	N/A – patient-specific issue	1	1.54 %	1.52 %
Seroma	N/A – patient-specific issue	1	1.54 %	1.52 %
Premature discharge from hospital	N/A – OR issue	1	1.54 %	1.52 %
Itching	N/A – patient-specific issue	1	1.54 %	1.52 %
Wound healing problems	Implant IFU EDC-2142	2	3.08 %	3.03%

*This subject was excluded from the study due to device explantation

No device failures were reported. The rate of device related serious adverse events that occurred in these studies was extremely low (3.03 %; N= 2/66).

Benefit summary:
Overall, the primary effectiveness endpoint was met by all three studies (BB001, BB002, and BB003) and two secondary endpoints were met by the BB001 and BB 002 studies. The clinical data supports that the BONEBRIDGE system provides significant benefits in terms of speech understanding in quiet and noise compared to the preoperative unaided condition. Additionally, patient-reported outcomes also demonstrate positive perceived benefit (e.g., improved speech understanding in quiet and in noise, and improved functional gain) and satisfaction in patients' daily lives with the aided condition when compared to their own preoperative unaided condition measured by the HDSS and SSQ-B questionnaires.

<u>Patient Perspectives</u>
Patient perspectives considered for the BONEBRIDGE included:

- Positive perceived benefits (e.g., improved speech understanding in quiet and in noise, and improved functional gain)

- Satisfaction in daily lives

with the aided condition when compared to the subject's own preoperative unaided condition based on the Hearing Device Satisfaction Scale (HDSS) questionnaires and the Speech Spatial Qualities-Benefit Questionnaire (SSQ-B).

Benefit/Risk Conclusion

In conclusion, given the available information above, the data support that the benefits outweigh the risks of the BONEBRIDGE System. The device provides benefits and the risks can be mitigated by the use of general controls and the identified special controls.

CONCLUSION

The De Novo request for the BONEBRIDGE System is granted and the device is classified under the following:

Product Code: PFO
Device Type: Active implantable bone conduction hearing system
Class: II
Regulation: 21 CFR 874.3340