SPAU338
Hearing Aids II

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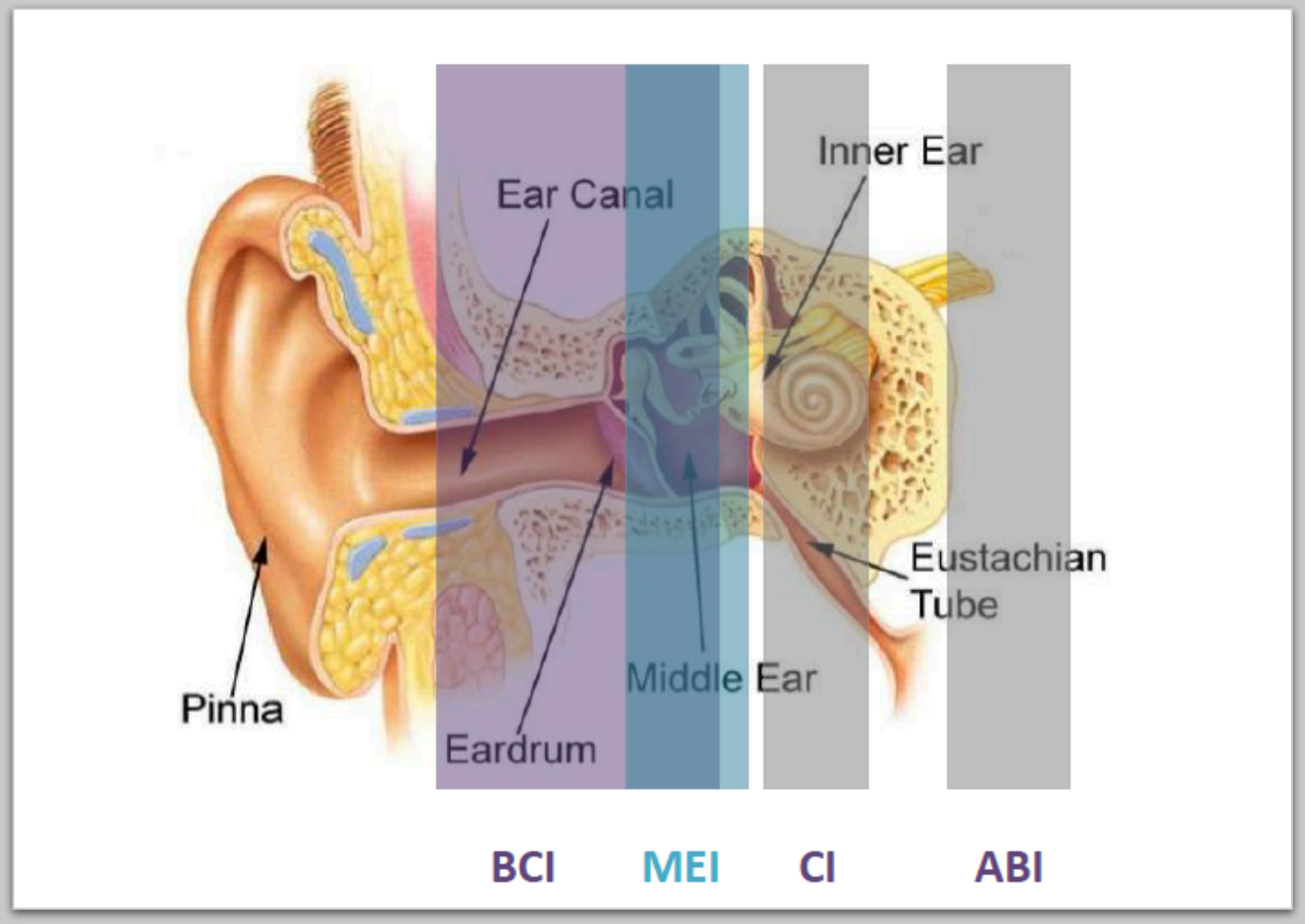
Spring 2020

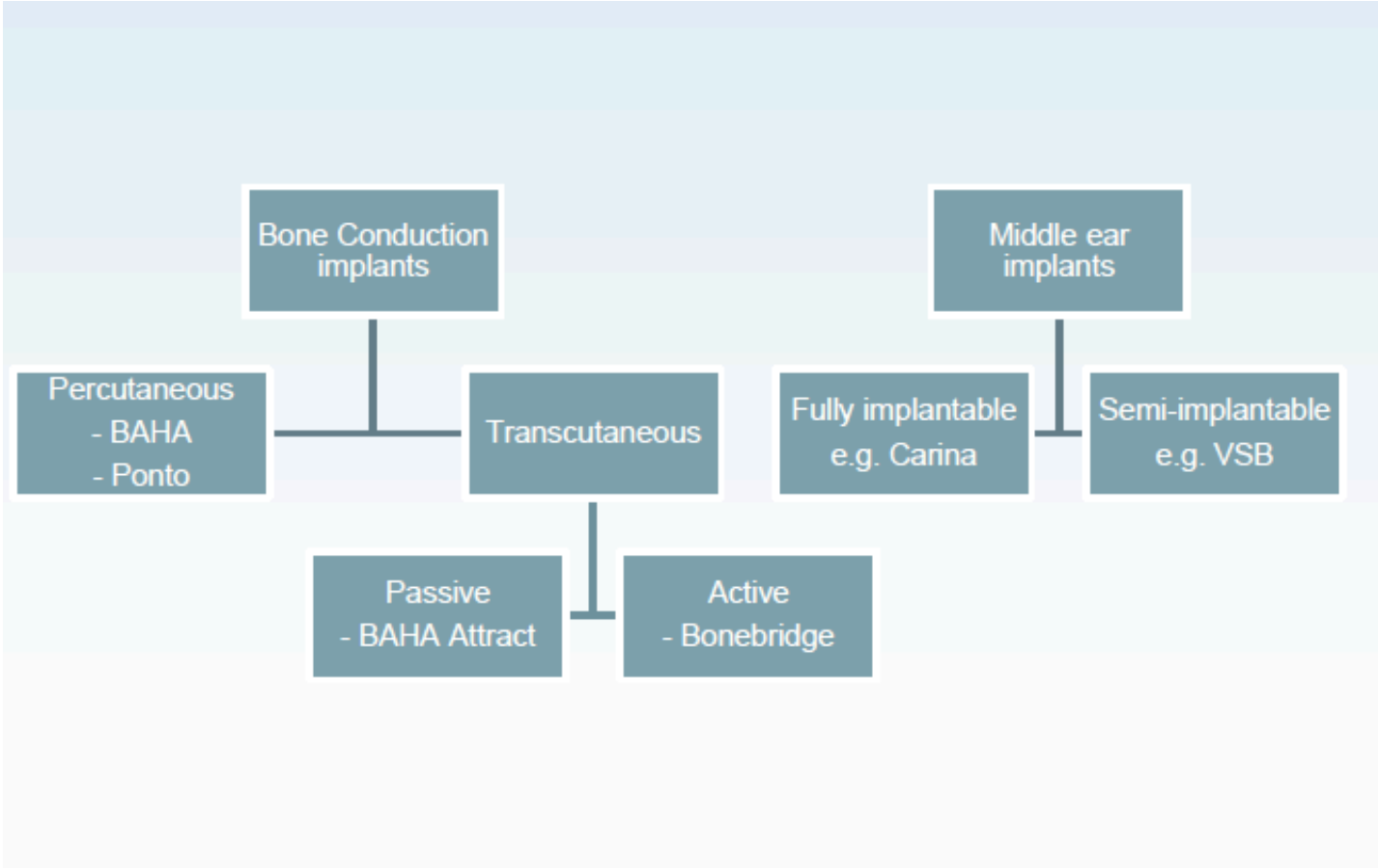
Overview on different implants

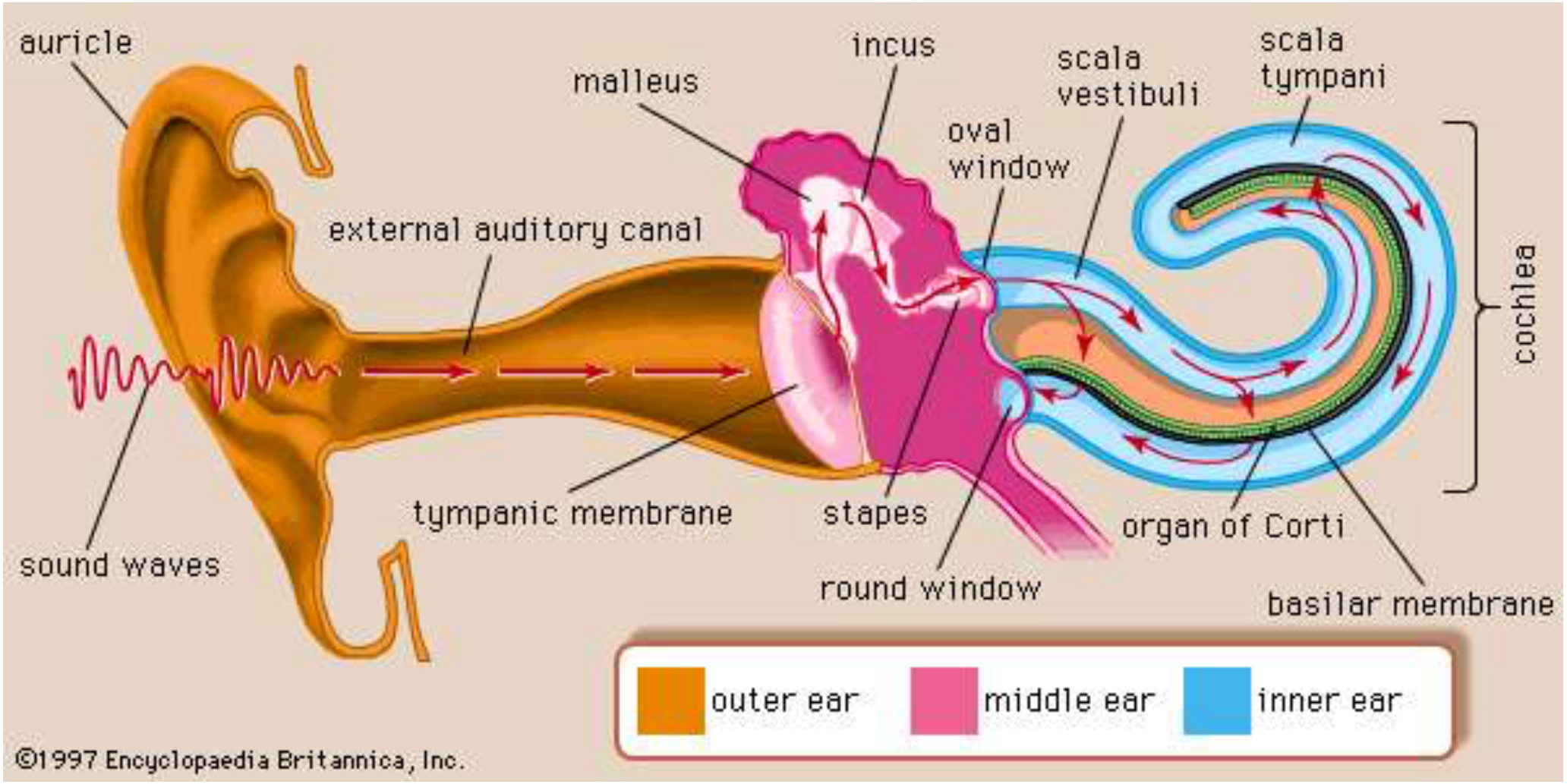


Overview on different implants

- Bone Conduction Implants (BCI)
- Middle Ear Implants (MEI)

When hearing aids are not enough… Hearing implant solutions




auricle
malleus
incus
scala vestibuli
scala tympani
oval window
external auditory canal
cochlea
tympanic membrane
stapes
organ of Corti
sound waves
round window
basilar membrane
outer ear
middle ear
inner ear
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Bone Conduction Implants (BCI)

Bone Conduction Hearing Devices (BCHD)

- We hear sound naturally in 2 ways, through AC and BC
- If the outer ear or middle ear is blocked or damaged sound cannot reach its destination. In this case the most efficient solution is to re-route the sound with a BCI
- The BCI sound processor captures sounds and directs it through a titanium implant where the body's natural ability to conduct sound via the skull bone helps direct the vibrations to the inner ear
- The BCI system works by enhancing natural bone conducted sound

Who is a candidate for a BCI?

Patients who cannot use conventional hearing aids or who are unsatisfied with them and do not achieve sufficient benefit

3 types of candidates:

- **CHL:**

  BCI bypasses the OE and/or ME problem by delivering the sound to t he inner ear via BC

- **Mixed HL:**

  BCI bypasses the OE or ME problem, so it only has to address the SN component of the hearing loss. As only addressing the SN component, less amplification needed = less distortion, less feedback

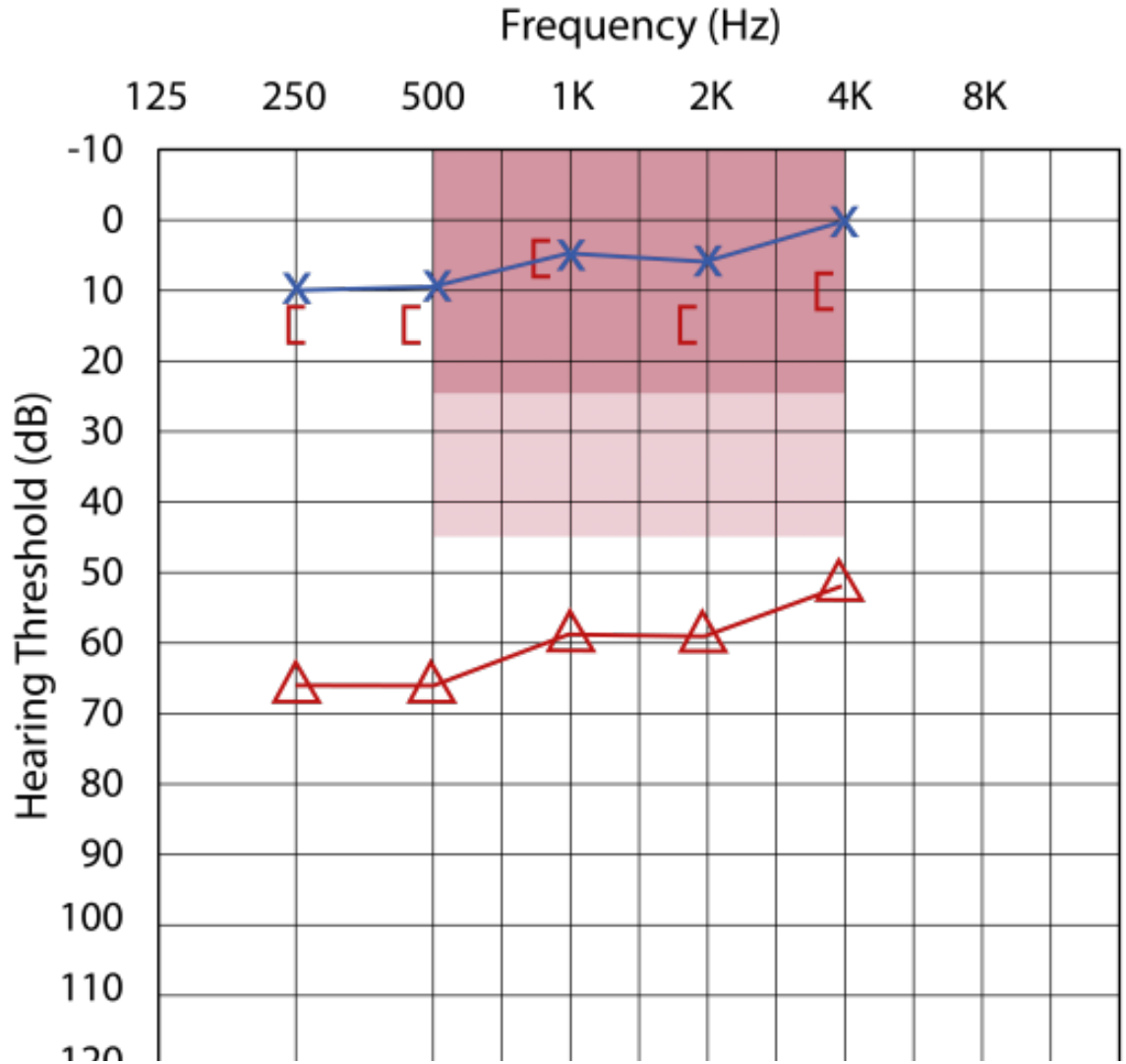
- **SSD:**

  BCI sound processor picks up sound on the deaf side and sends it via bone conduction to the contralateral intact cochlea

  – overcomes the headshadow effect

  – leads to improved speech understanding and 360˚ soundawareness

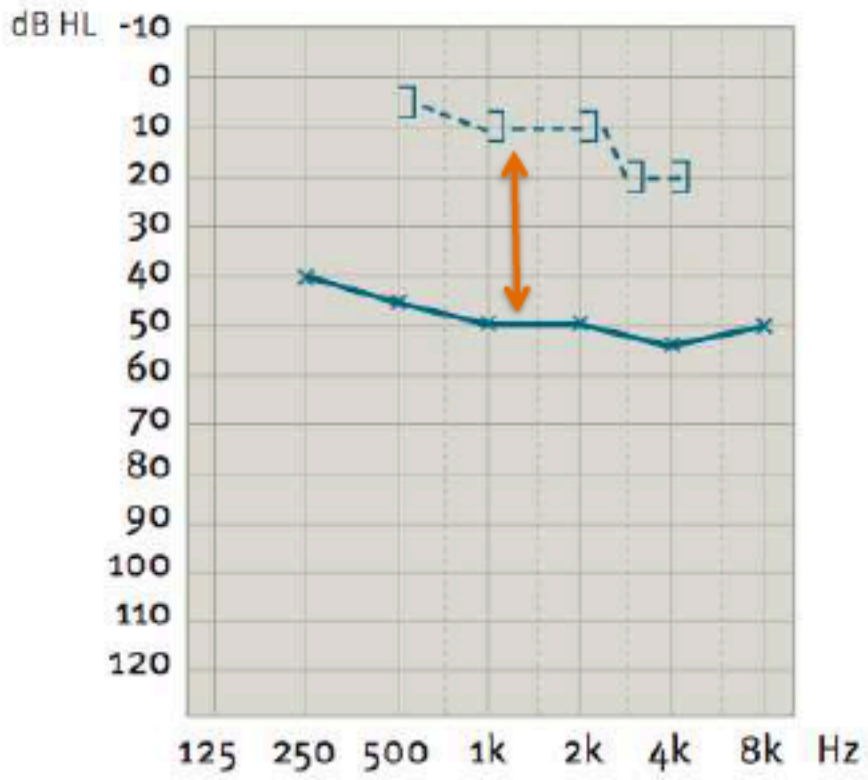
Conductive Hearing Loss



Red Triangles: Right masked AC thresholds

Conductive HL

Example: Conductive hearing loss



Is Air-Bone Gap larger than 30 dB?

ABG = ((45-5) + (50-10) + (50 – 10) + (55-20)) / 4

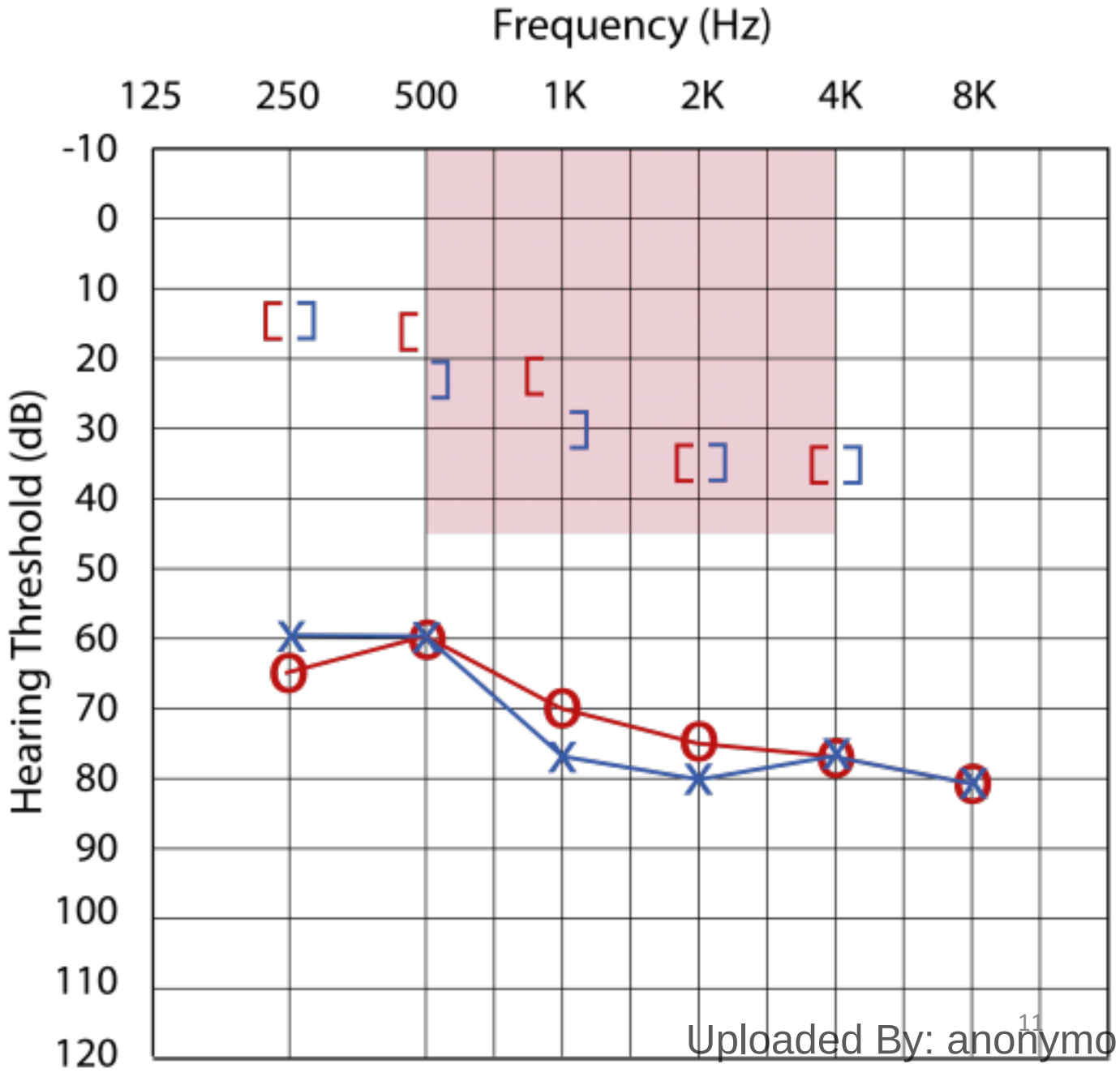
ABG = (40 + 40 + 40 + 35) / 4 = 39 dB

39 dB › 30 dB ✓

Average BC threshold is always less than 65 dB HL in conductive hearing loss

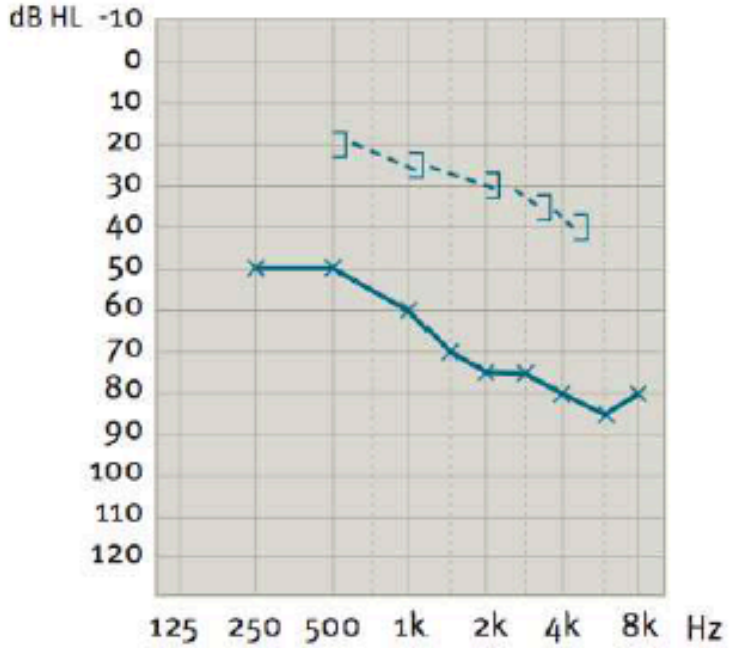
ABG >25-30dB

Mixed Hearing Loss



Mixed HL

Example: Mixed hearing loss



Is Air-Bone Gap larger than 30 dB?

ABG = ((50-20) + (60-25) + (75-30) + (80-40)) / 4

ABG = (30 + 35 + 45 + 40) / 4 = 38 dB

38 dB > 30 dB ✓

Is average BC threshold less than or equal to 65 dB HL?

Avg BC = (20 + 25 + 30 + 35) / 4 = 28 dB HL

28 dB HL ≤ 65 dB HL ✓

BC threshold ≤65dBHL

Oticon/Cochlear SuperPower

BC threshold ≤45dBHL

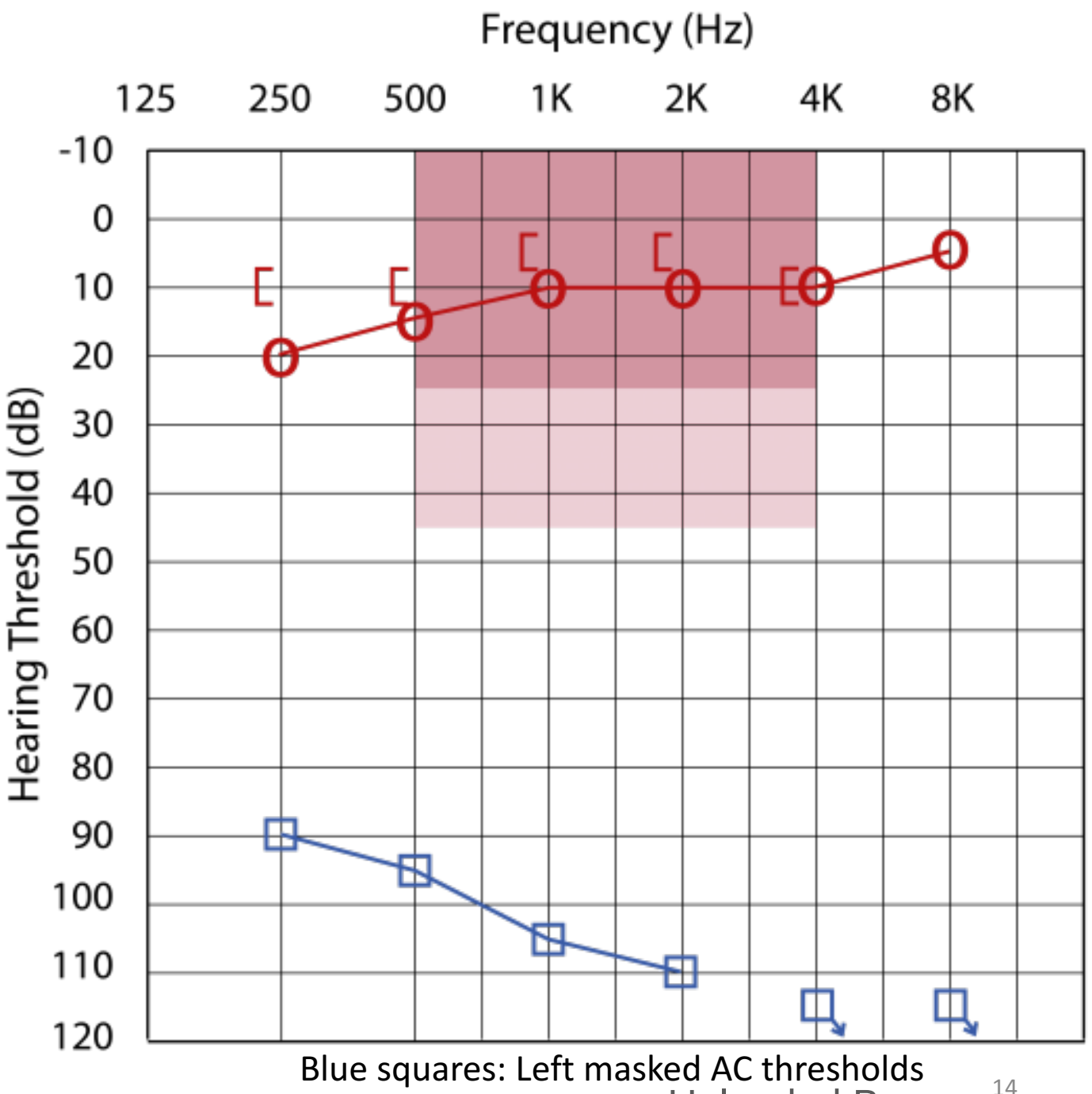
Oticon/Cochlear + Bonebridge

? Attract ? Sophono

Single-Sided Sensorineural Deafness (SSD) Candidates

- SSD refers to patients that have unilateral profound SNHL - ie. A “dead ear”, and normal hearing on the other side
- Non-traditional BCI candidate
- The BCI system is indicated for candidates with SSD and NORMAL hearing in the good ear
- The BCI sound processor picks up sound on the deaf side and sends it via bone conduction to the contralateral intact cochlea to overcome the head-shadow effect, which leads to improved speech understanding and 360^{o} sound awareness
- Tinnitus?

Single-Sided Deafness



Blue squares: Left masked AC thresholds

SSD

Example: Single-sided deafness (SSD)

Is average AC threshold in the good ear less than or equal to 20 dB HL?

Avg AC = (10 + 10 + 15 + 20) / 4 = 14 dB HL

14 dB HL ≤ 20 dB HL ✓

AC threshold ≤20dBHL*

Traditional BCI – percutaneous

('by way of the skin'/ 'penetrate the skin')

Cochlear™ BAHA

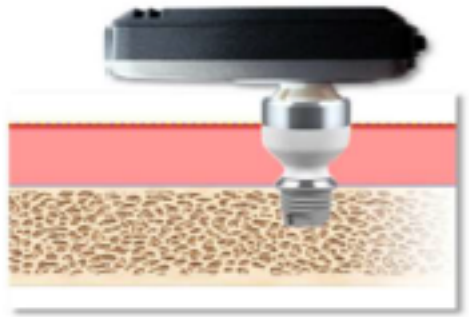
Oticon Medical™ Ponto

- The three elements of the BCI system

1) Titanium implant

2) Abutment: Connection between sound processor and implant

3) Sound processor



Baha® Connect System (Percutaneous)

- Mixed hearing loss
- SSD with large transcranial attenuation
- Candidates with progressive hearing loss
- Maximum performance and retention
- Non-surgical wearing options are also available that allow patients to trial bone conduction hearing or keep for long-term use (Sound Arc/ Softband)

Image courtesy of Cochlear™

Cochlear™ Baha® 5 Portfolio

Baha 5 Sound Processor:

- smallest bone conduction sound processor with a fitting range up to 45 dB SNHL.
- The implantable hearing industry's first Made for iPhone hearing device.

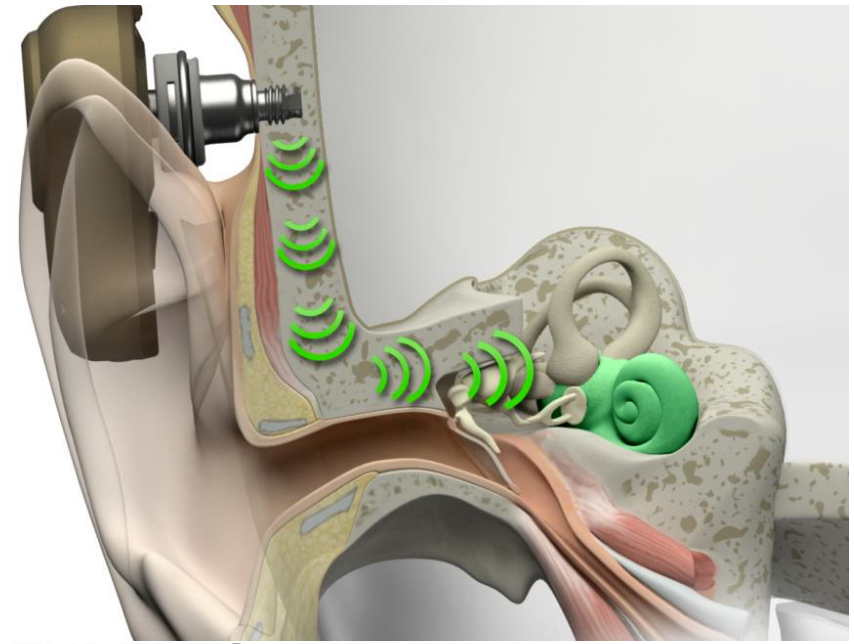
Baha 5 Power Sound Processor:

- Created for those who need additional amplification because of a greater degree of hearing loss up to 55 dB SNHL.

Baha 5 SuperPower Sound Processor:

- The strongest member of the Baha portfolio and the most powerful head-worn solution in the industry. It is also the industry's first and only behind-the-ear bone conduction solution with a fitting range up to 65 dB SNHL

Image courtesy of Cochlear™



https://www.youtube.com/watch?v=u3G6tFpXTGc

Images courtesy of Cochlear™ .

Oticon Ponto

Percutaneous BCHI

Non-surgical options

- Children under the age of 5 / those who do not want to opt for the surgical option / to trial BC devices
- Some children will use a bone anchored device for a few years while awaiting reconstructive surgery
- Other children might wear this solution while waiting for middle ear problems to subside until they outgrow their ear infections
- In the case of very tiny ear canals, as you might see in a child with Down's syndrome (oftentimes these children are not able to use traditional hearing aids because their ear canals are too small or are chronically draining or infected)
- A non-surgical option for children who should eventually grow out of middle ear problems that create a fluctuating conductive hearing loss.

* Sound passing through the skin dampens the sound vibrations so children using processors on a band should be using a powerful sound processor.

Images courtesy of Cochlear™

Baha® SoundArc

Baha® Softband

MED-EL ADHEAR (another non-surgical option)

https://www.youtube.com/watch?time_continue=23&v=t13vLzOyvMQ&feature=emb_logo

Baha® Attract System (Transcutaneous)

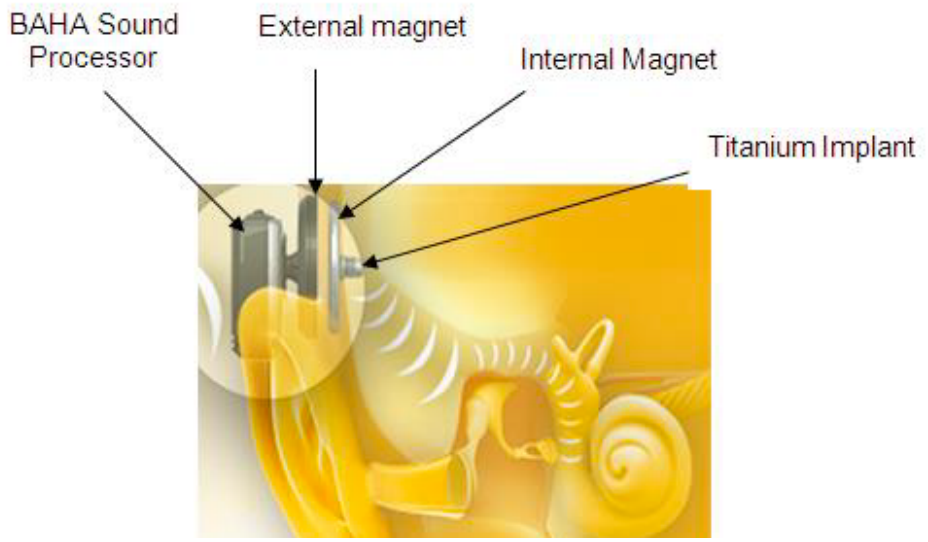
- Conductive hearing loss
- Mild mixed hearing loss
- SSD with low transcranial attenuation
- Discrete
- Easy to use
- No wound care
- Suitable for patients with poor dexterity.

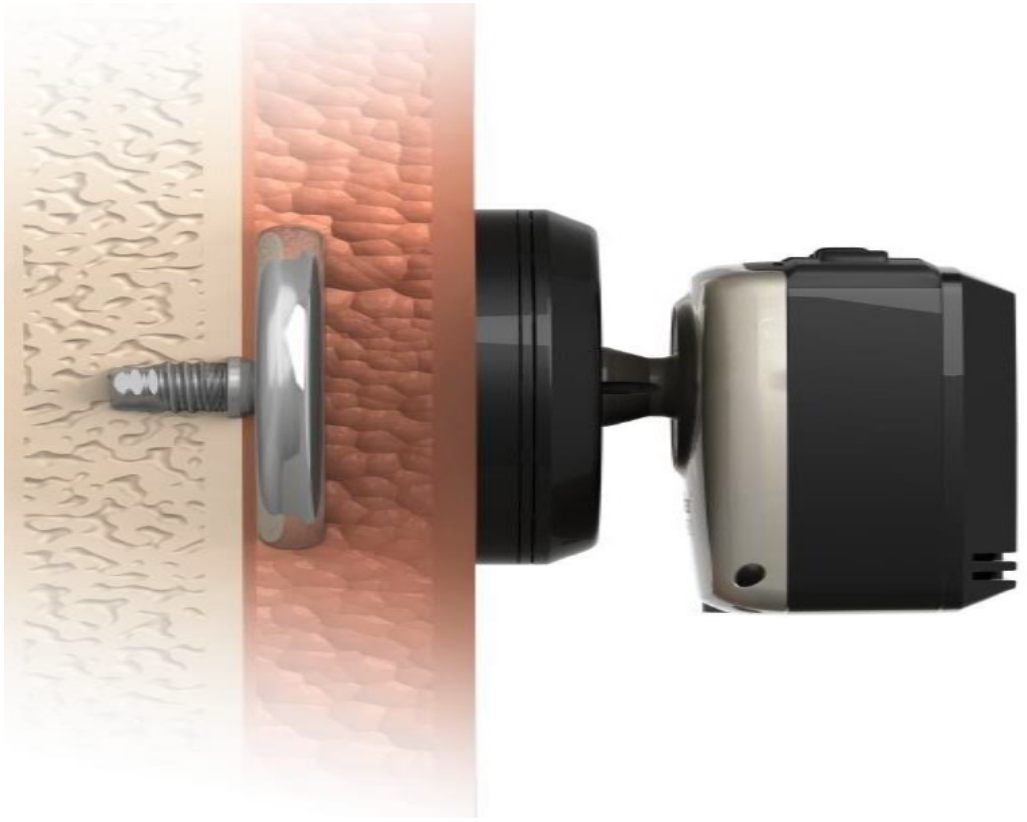
Image courtesy of Cochlear™

Cochlear Baha® Attract System

BAHA Attract New!

The externally worn BAHA sound processor is attached to an external magnet with a soft pad for wearing comfort. The BAHA sound processor converts sounds to vibrations and transmits these via the magnets to the implant. The implant sends the vibrations through the bony structures to the inner ear.





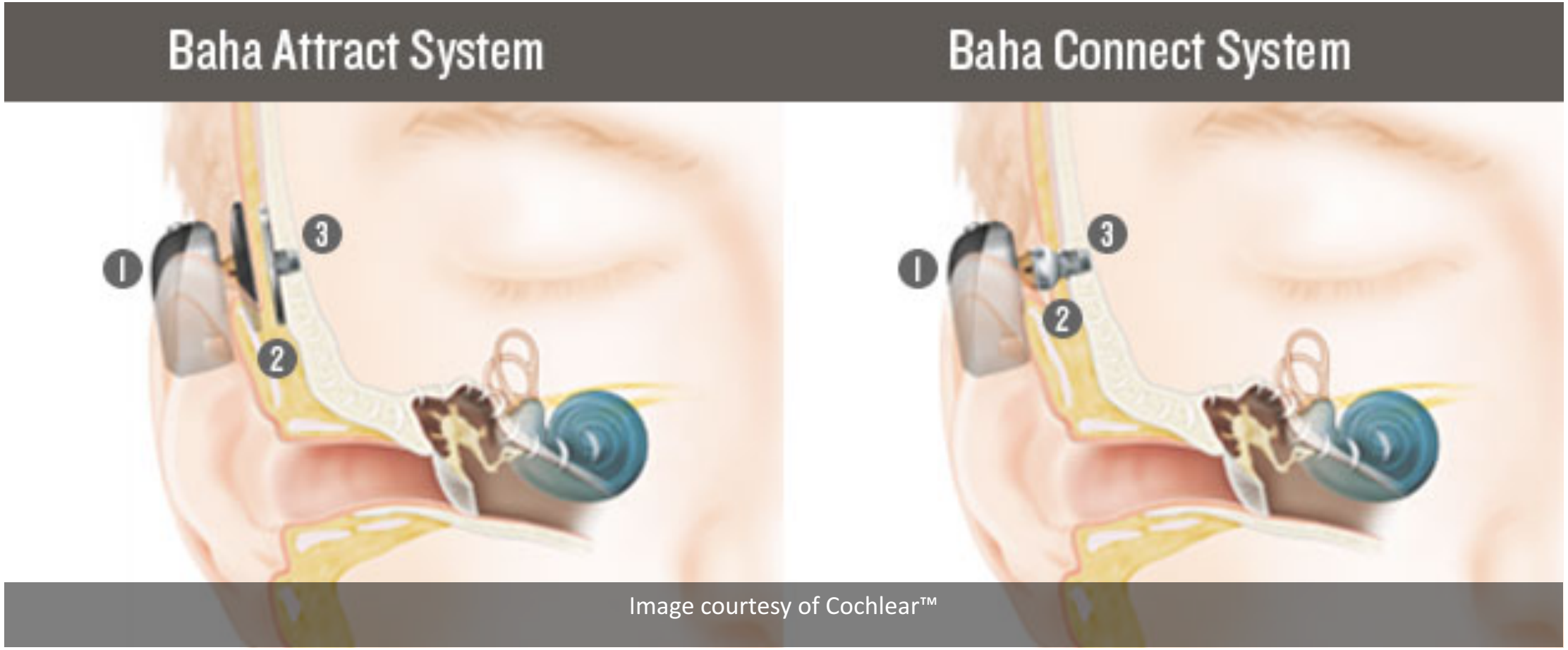


Image courtesy of Cochlear™

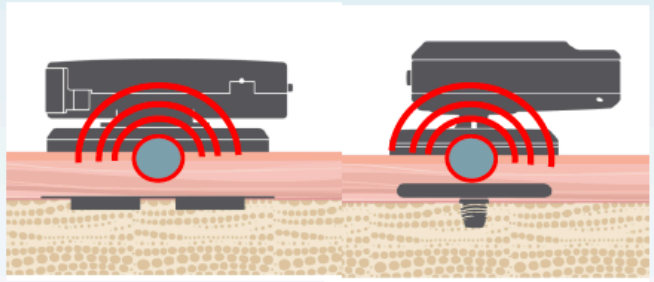
Bone Conduction Implants (BCI)

Bone Conduction Hearing Devices (BCHD)

1. Traditional BCI (Cochlear and Oticon) = Percutaneous Passive (transducer is on the outside)
2. BAHA Attract System (Cochlear) = Transcutaneous Passive (transducer is on the outside)
3. Bonebridge (Med EL) = Transcutaneous Active (transducer is on the inside)

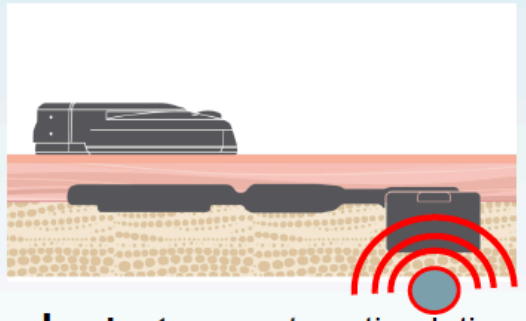
Passive vs Active – not all the same

PASSIVE solutions:
BAHA headband



- **Sound processor** generates stimulation that is applied outside (like BC headbands)
  1. Attenuates through the skin
  2. in to the bone
- Loss of output due to attenuation through skin

ACTIVE solution:
Bonebridge, Soundbridge



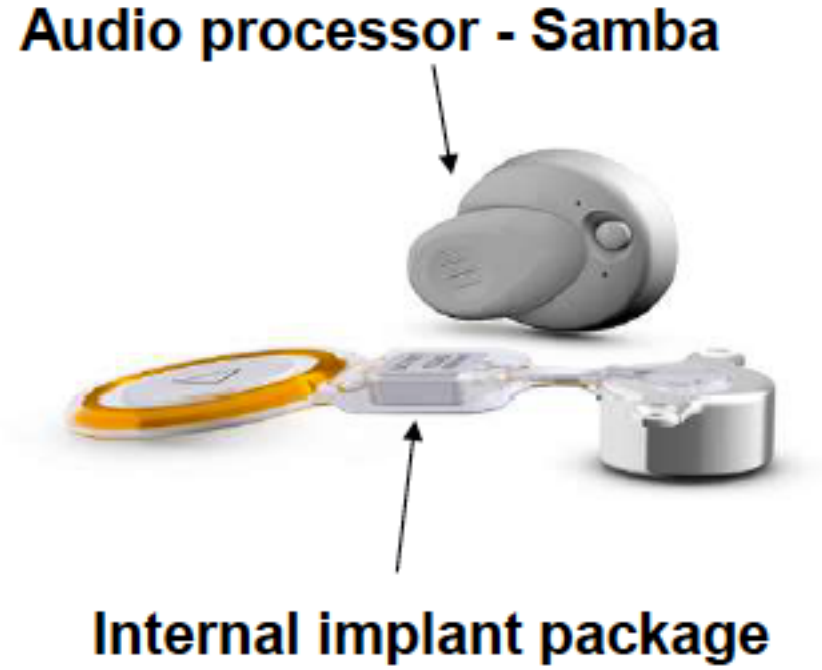
Implant generates stimulation
Directly in to the bone

Most effective BC stimulation

BCI – transcutaneous | Med El

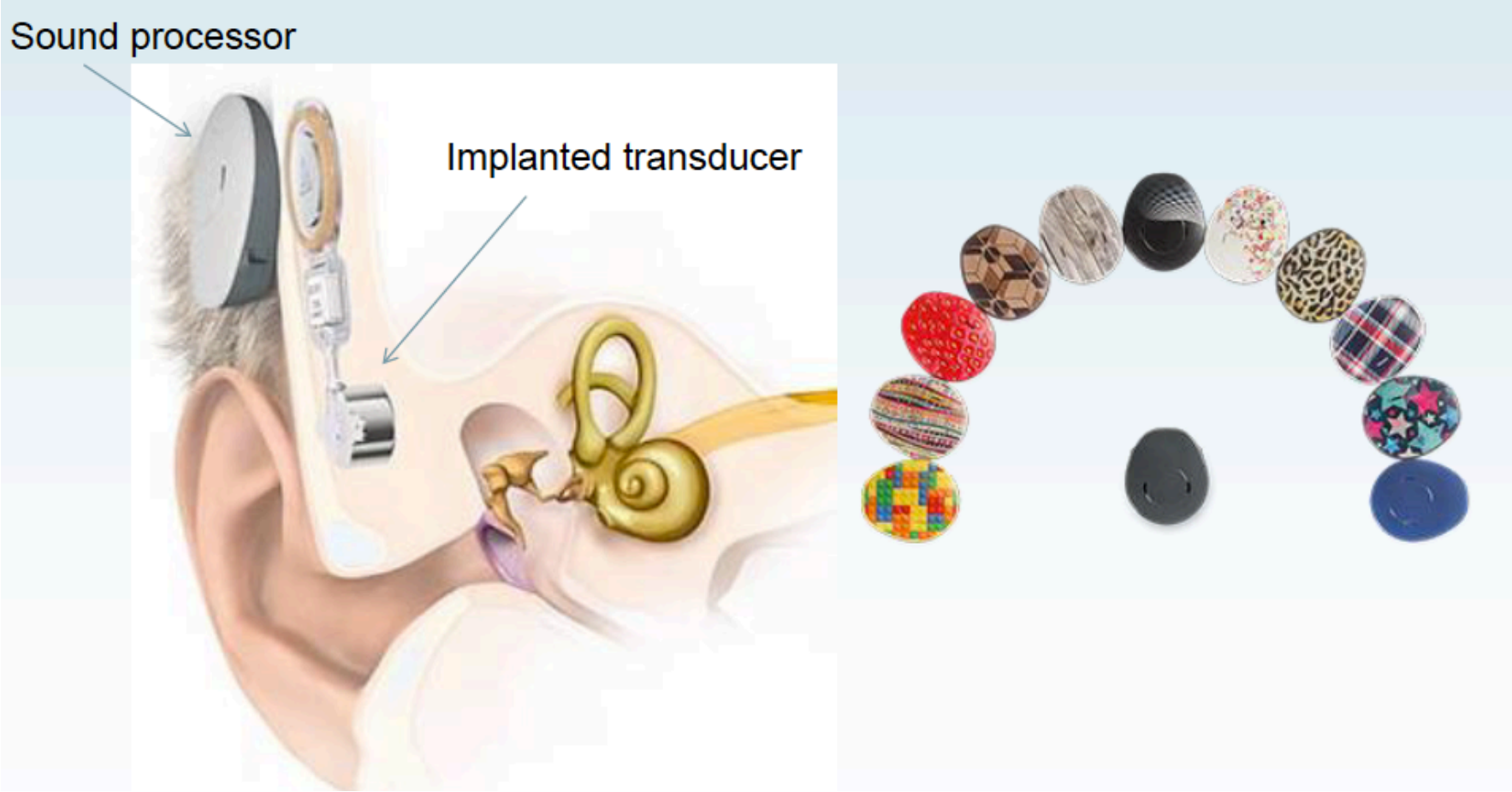
MED-EL Bonebridge System

- Uses the same bone conduction principle
- Implant package is all under the skin
- No abutment
- Size of implant makes it unsuitable for many patients (need to have enough skull space for the internal implant package)

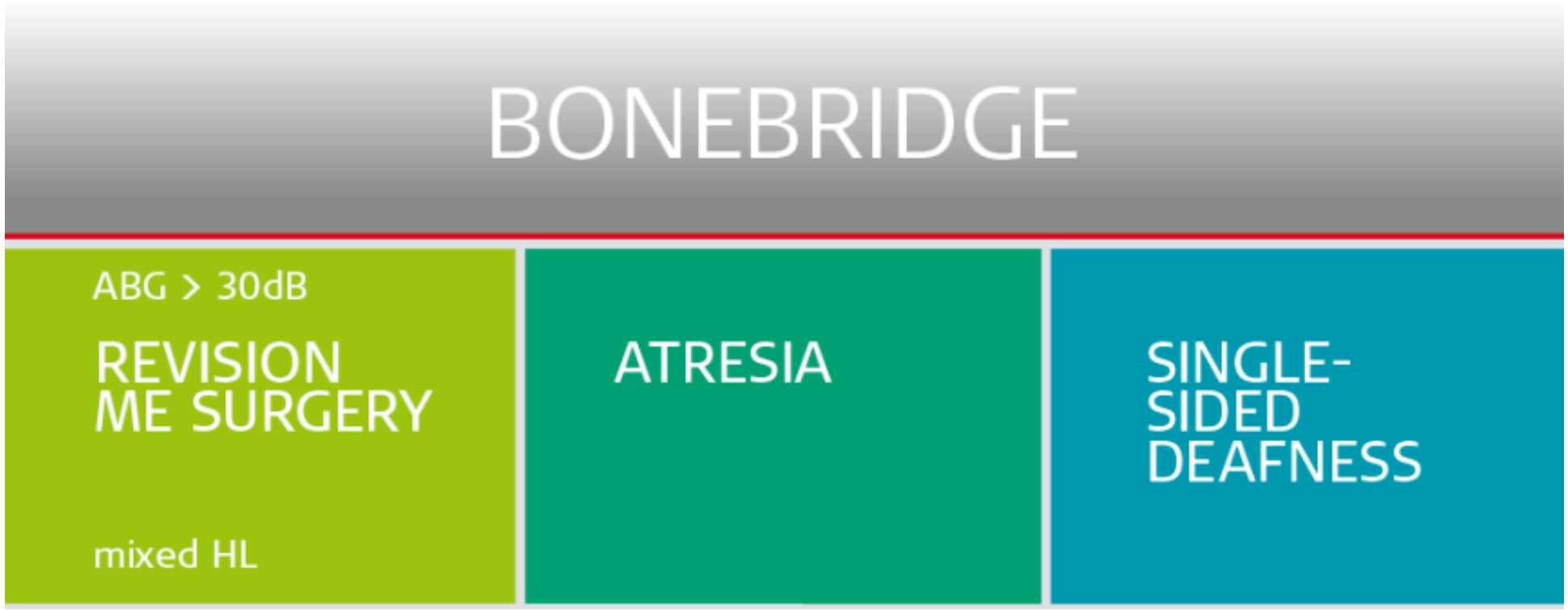


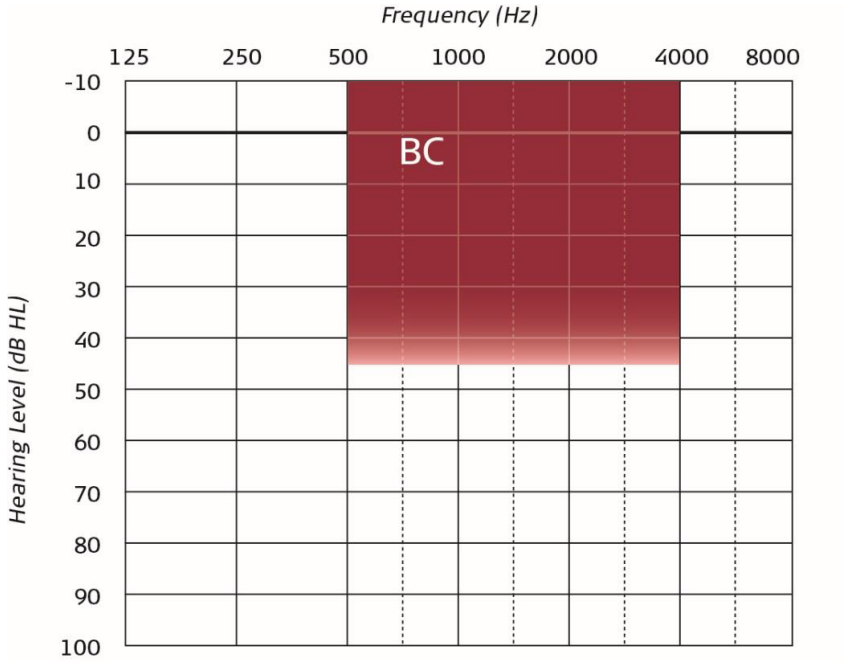
https://www.youtube.com/watch?v=R1EJkCoXlrI

Active BC device – MEDEL BONEBRIDGE™



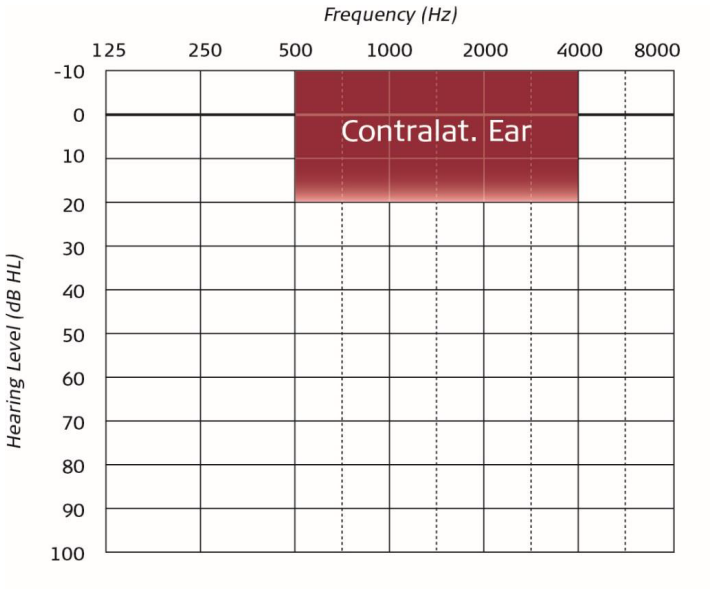
Who is suitable for a Bonebridge?





Bonebridge: Audiological Indications

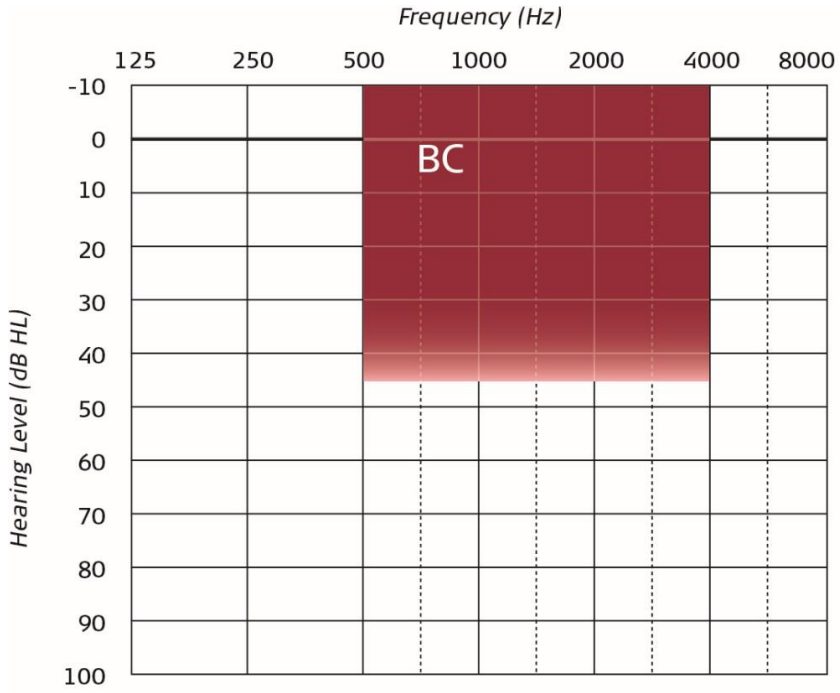
- Conductive and mixed hearing loss
- BC thresholds better than 45dB
- Where hearing aids do not provide benefit
- 5 years and older

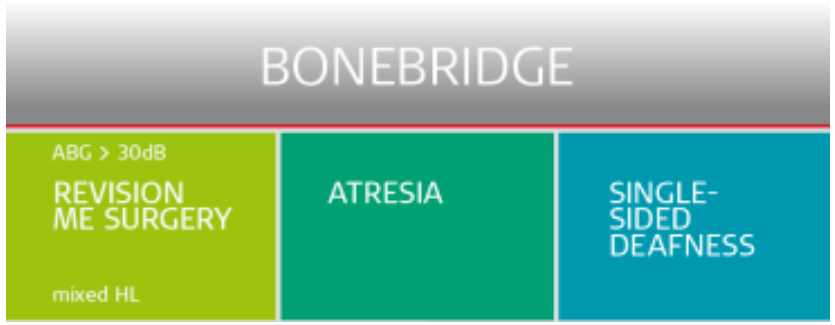


SINGLE-SIDED DEAFNESS

Bonebridge: Audiological Indications

- Severe- Profound sensorineural hearing loss in the ear to be implanted
- Normal hearing in the contralateral ear.
- 5 years and older

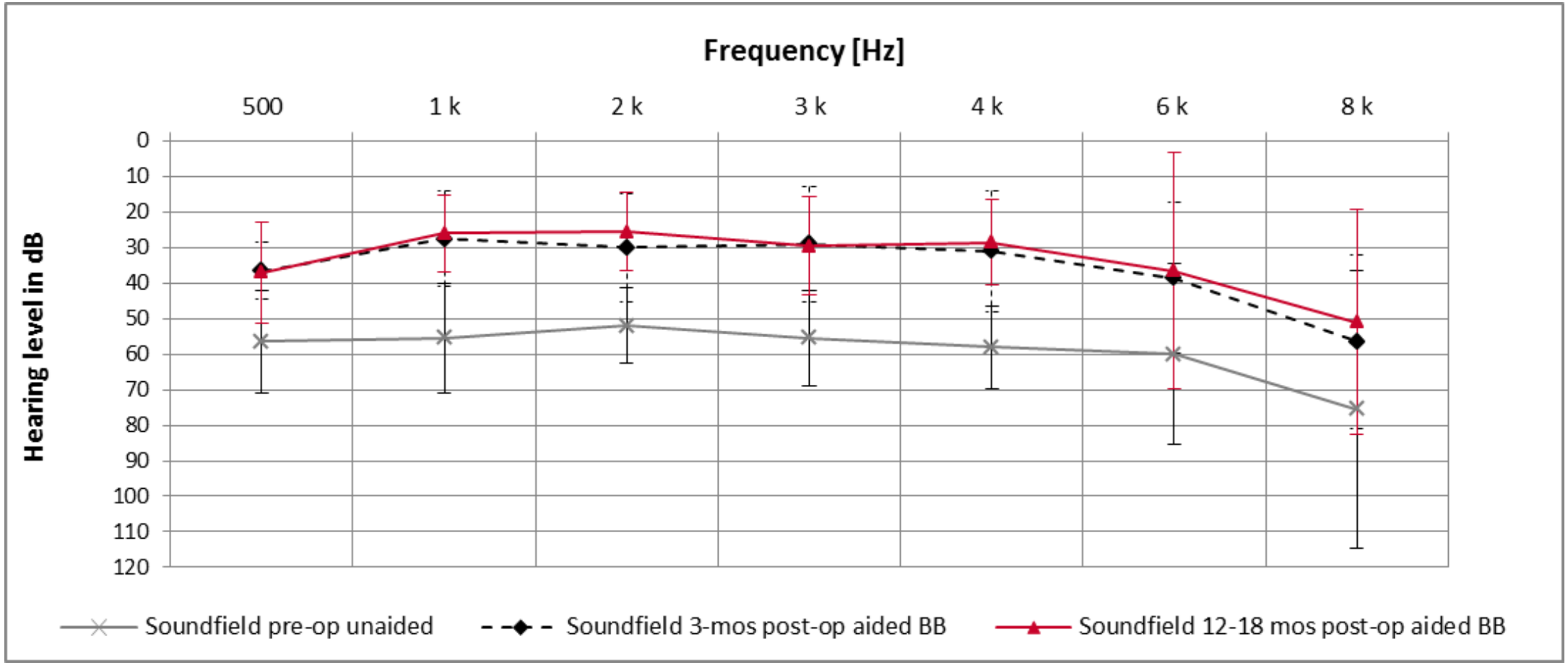




Bonebridge: Pre-Operative Considerations

- Stable BC thresholds
- **CT scan** to assess anatomical condition
- Absence of retro-cochlear disorders
- Adequately counseled patients

Soundfield Thresholds



Non-implantable BC devices

- Softband

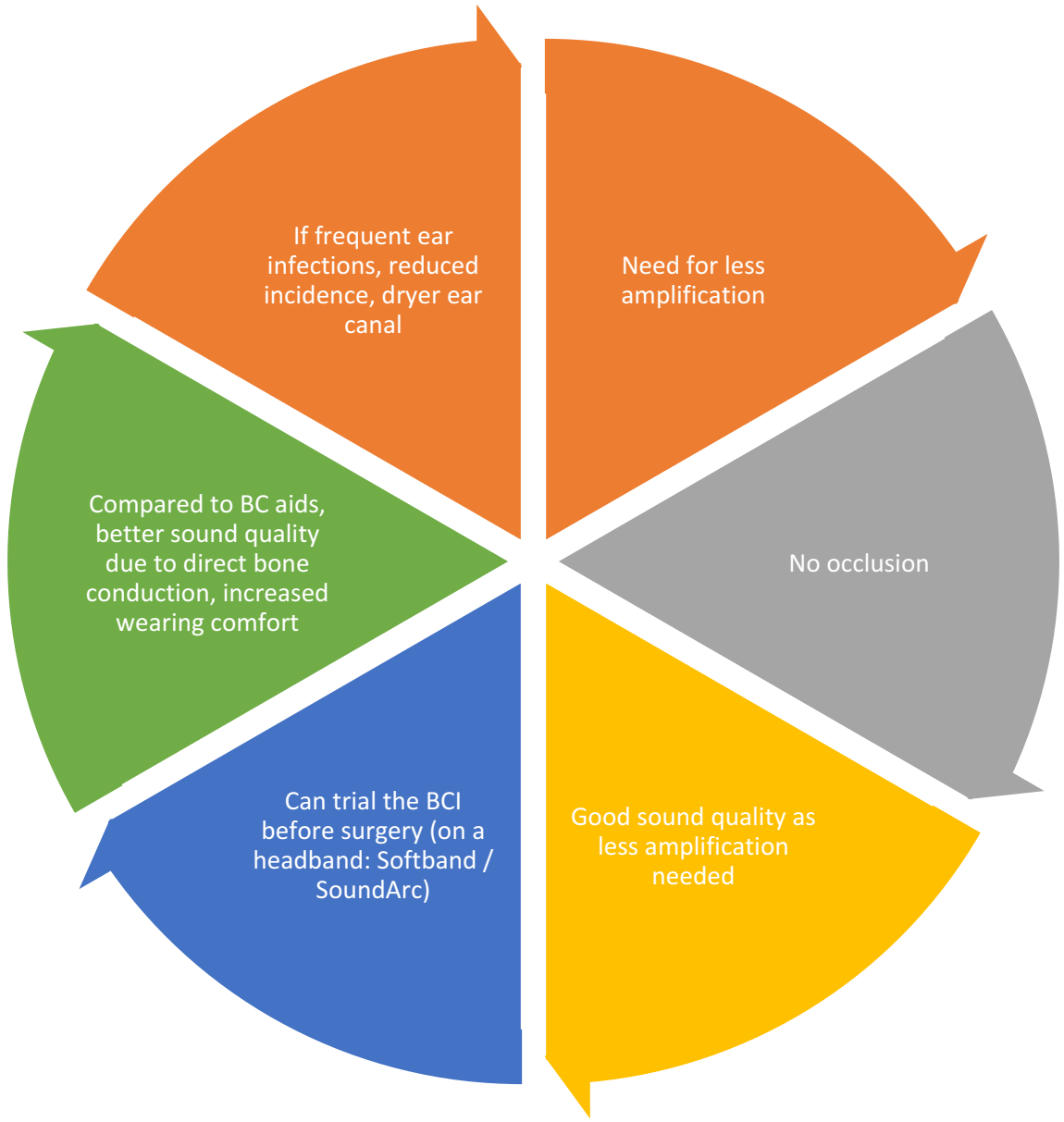
- Adhear MED-EL

- SoundArc Cochlear

Implantable options

- **Percutaneous passive**
  - – Abutment sticks through the skin
    - Oticon (Ponto)
    - Cochlear (Baha Connect)
- **Transcutaneous passive**
  - – Transducer is on the outside
    - Cochlear - Baha Attract
    - Medtronic – Sophono (not used as often anymore)
- **Transcutaneous active**
  - – Active implant (transducer) is under the skin (still requires external microphone/processor)
    - MED-EL - Bonebridge

Benefits of BCI



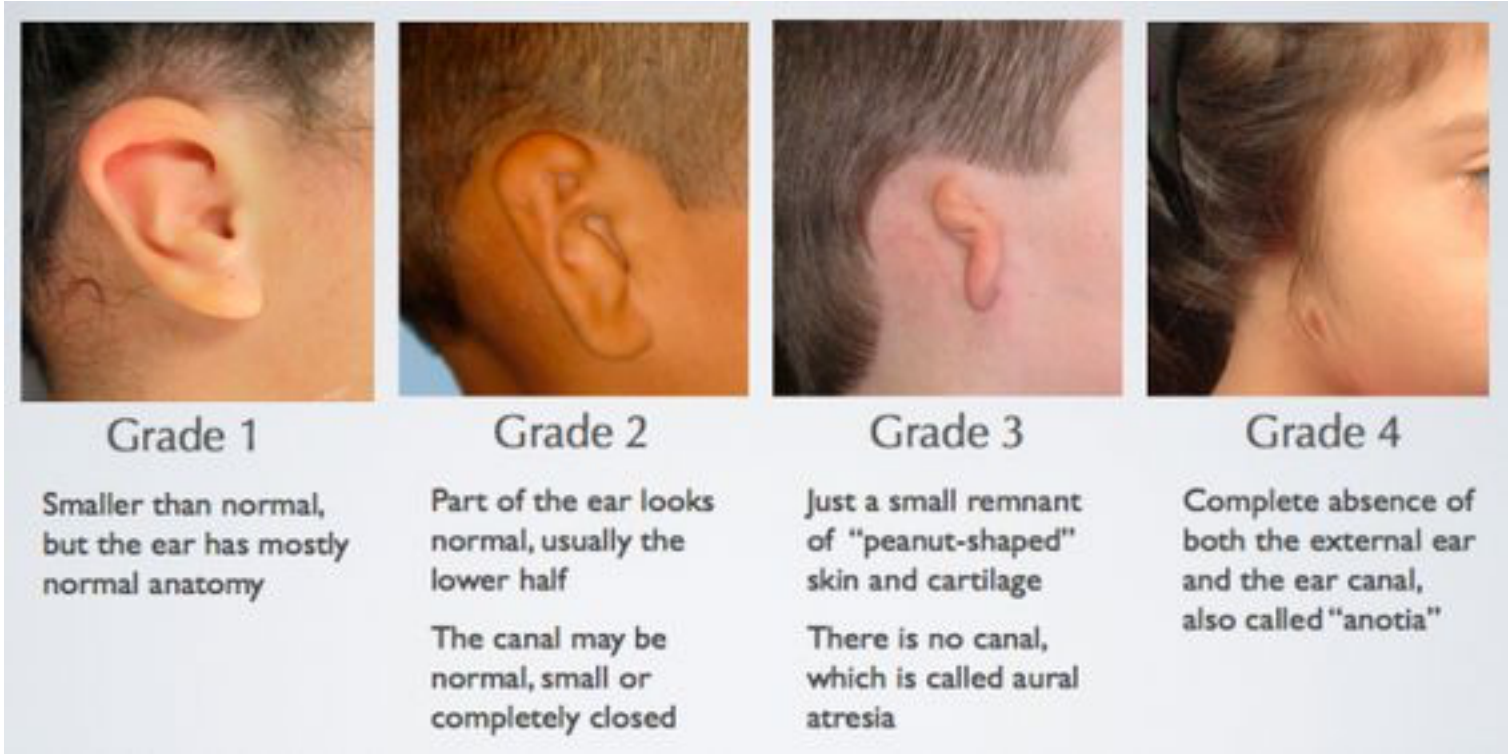
Referral Criteria for BCI

- All different reasons why a patient may have a permanent conductive/mixed loss (unilateral or bilateral) or a single-sided (unilateral) SNHL
- Includes abnormalities of the outer and/or middle ear
- For Conductive or Mixed losses as long as the BC thresholds are ≤55dBHL a BCI could be fitted
- With SSD the BC thresholds have to be normal on the good (contralateral) side

Miocrotia & Atresia

- Atresia: absence or underdevelopment of the ear canal and middle ear structures
- Microtia: usually accompanied by atresia because the outer ear and the middle ear develop from one common block of tissue at the same time of development in the womb
- The better developed the aurical the better developed the middle ear
- Incidence is estimated to be 1:5000 to 1:7000 live births depending on varying statistics in different countries and in different ethnic races

Different grading



Hearing Loss

- Atresia results in conductive hearing loss, with normal inner ear function, as the inner ear has a different embryological origin, it is normally developed in the majority of cases (90%)

- Unilateral atresia – studies with children show varying results from having to repeat a year at school to no difference in performance compared to children with normal hearing

- Intervention should be offered (binaural hearing should be achieved)

  – Evidence suggests that right-impaired children perform worse than left-impaired children

- Key is in monitoring as only have one “good” ear

- Bilateral atresia – intervention imperative

Reconstruction

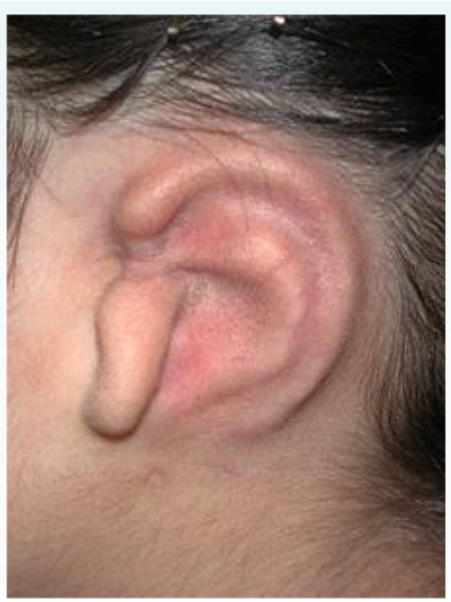
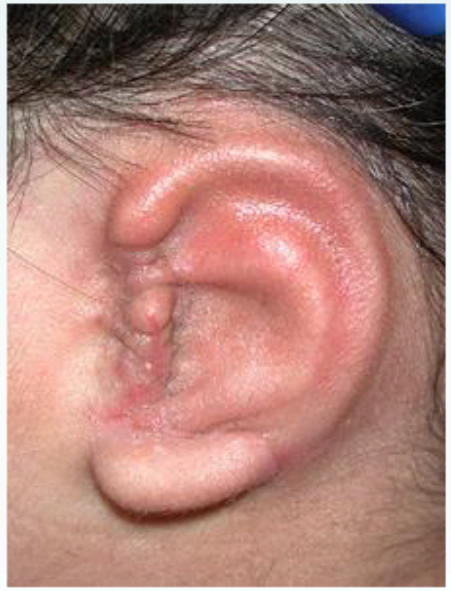
- Ear implants are performed at approximately 4-5 years of age whereas ear reconstruction typically does not happen until the child is 8-10 years old

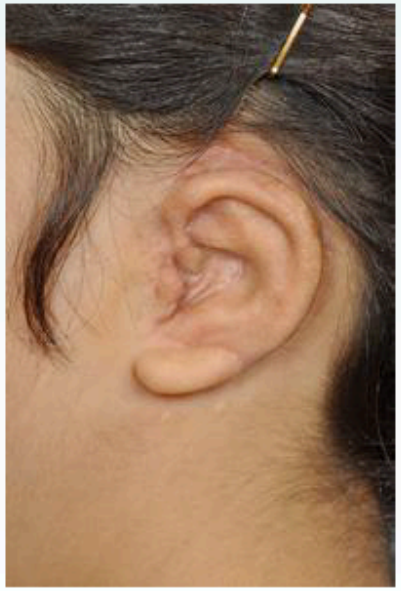
- Care needs to be taken in the implantation of hearing aid devices since inappropriate access incisions or implant positioning may compromise ear reconstruction

Reconstruction



Patient's own rib cartilage is carefully carved to make a framework that is implanted beneath the skin



http://rockymountainears.com/microtia/

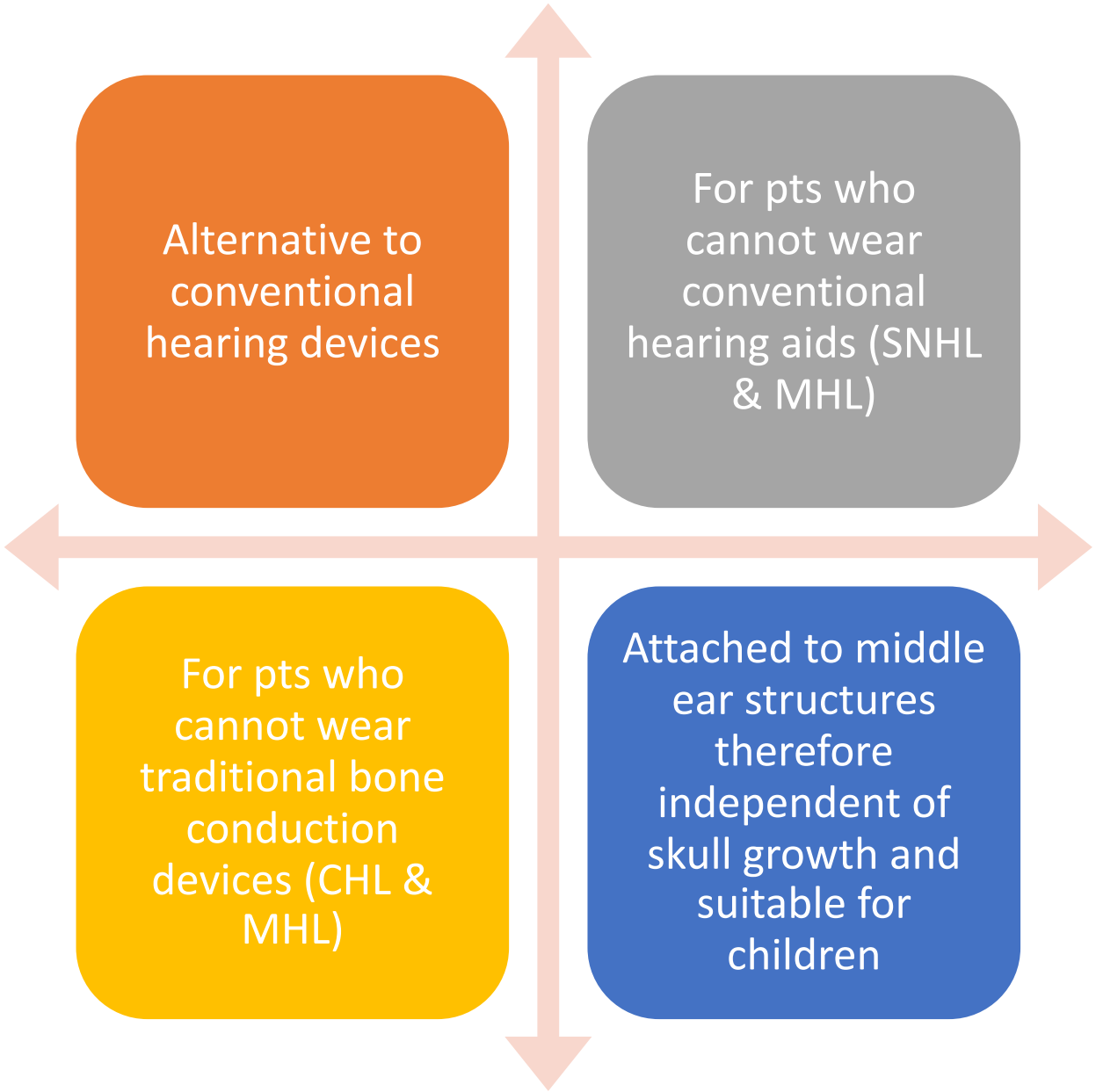
Management

- Patients born with microtia and atresia have a complex craniofacial condition that may impact on all aspects of their lives
- It is essential that these patients and their families have access to specialised teams able to provide up to date and unbiased information
- A mulitdisciplinary approach should be taken to provide individualised assessments and interventions

What is the difference between MEI and BCI?

- Bone conduction implants bypass the middle ear to directly stimulate the cochlea.
- Middle ear implants use mechanical energy to stimulate a suitable vibratory structure.
  - Uses the “natural mode of hearing”
  - Proven alternative to hearing aids

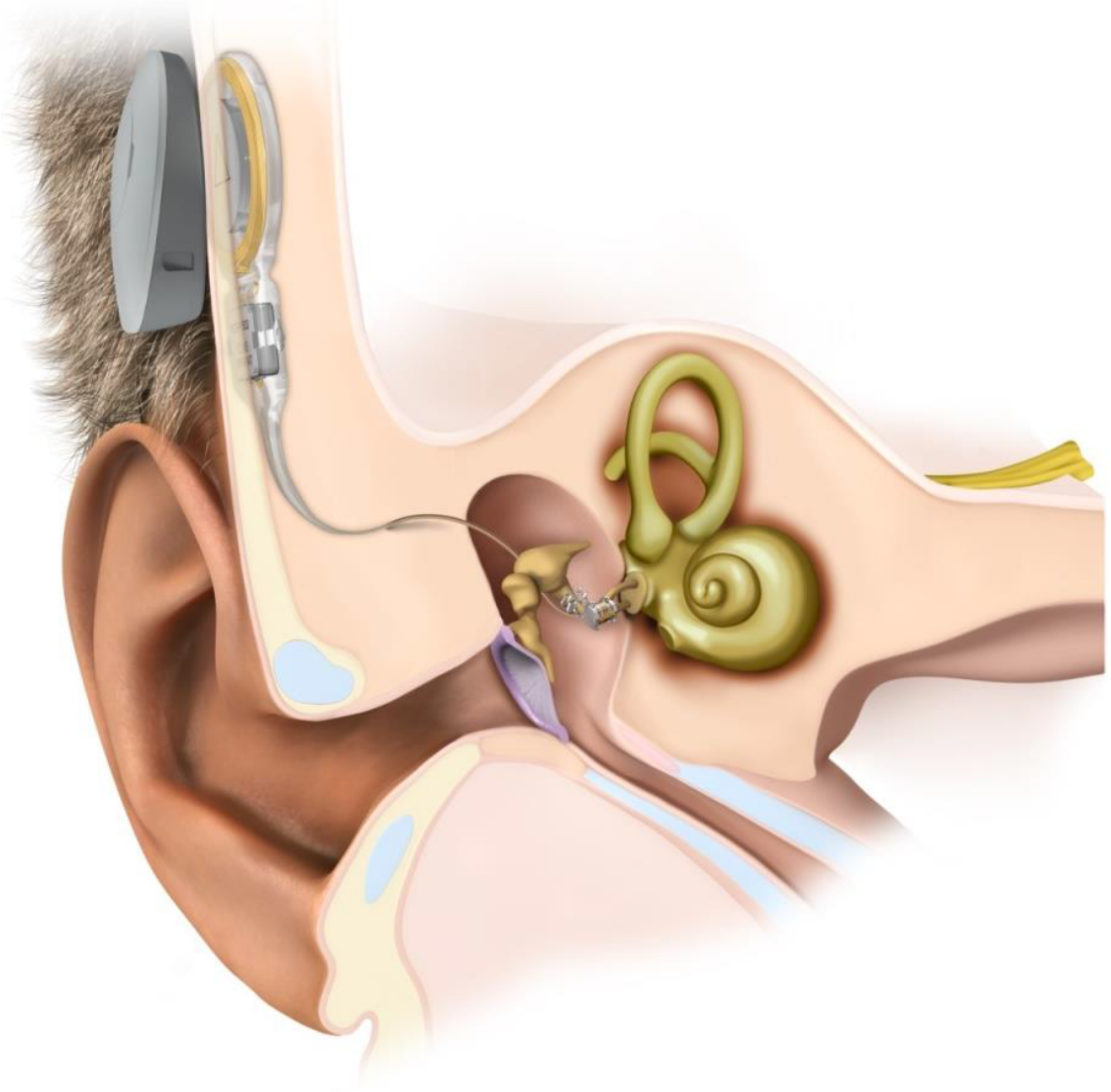
Middle Ear Implants (MEI)

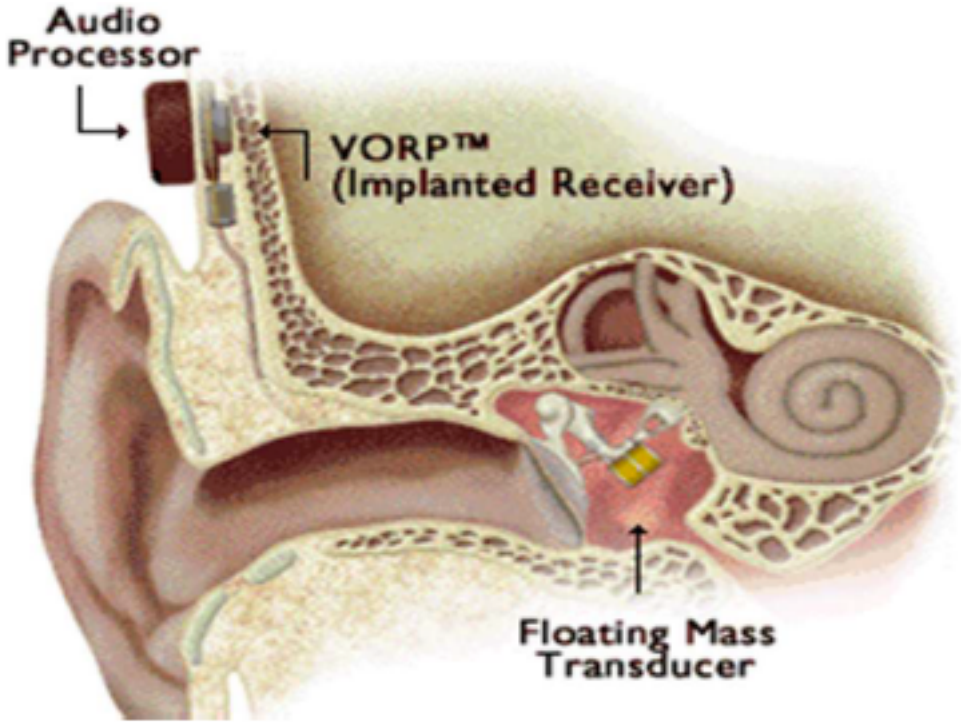


MEI (Vibrant Soundbridge)

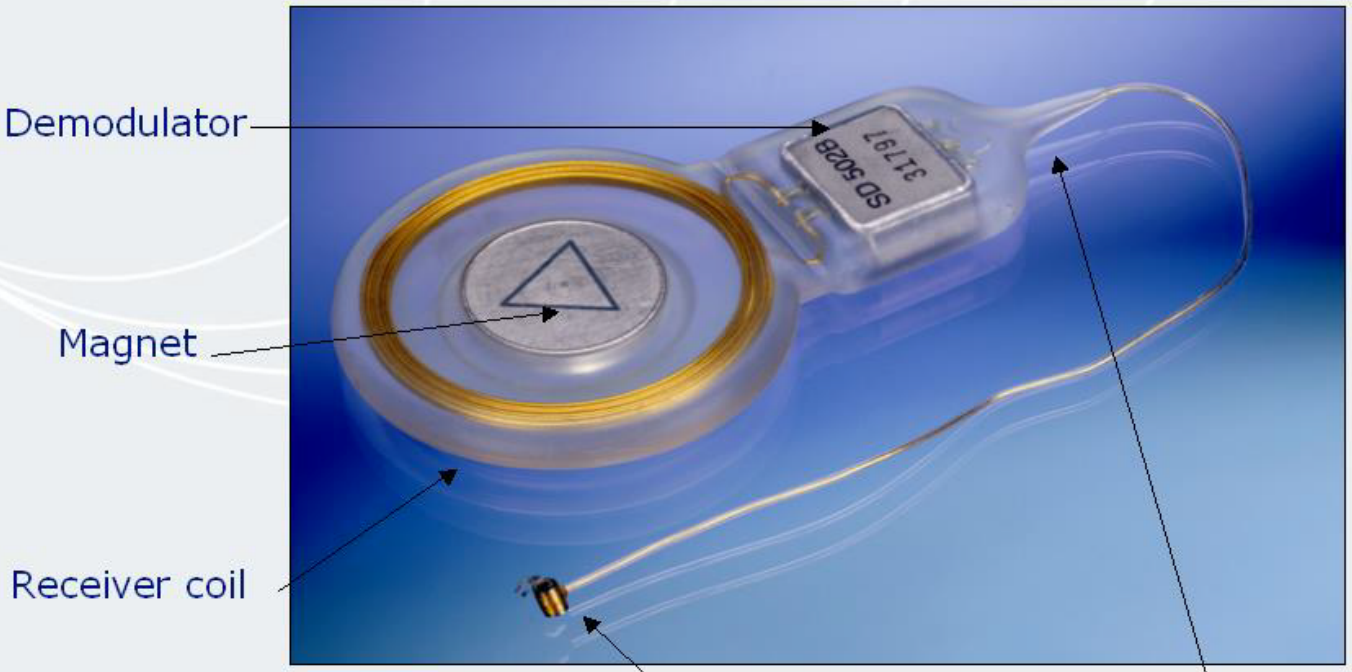
MED EL

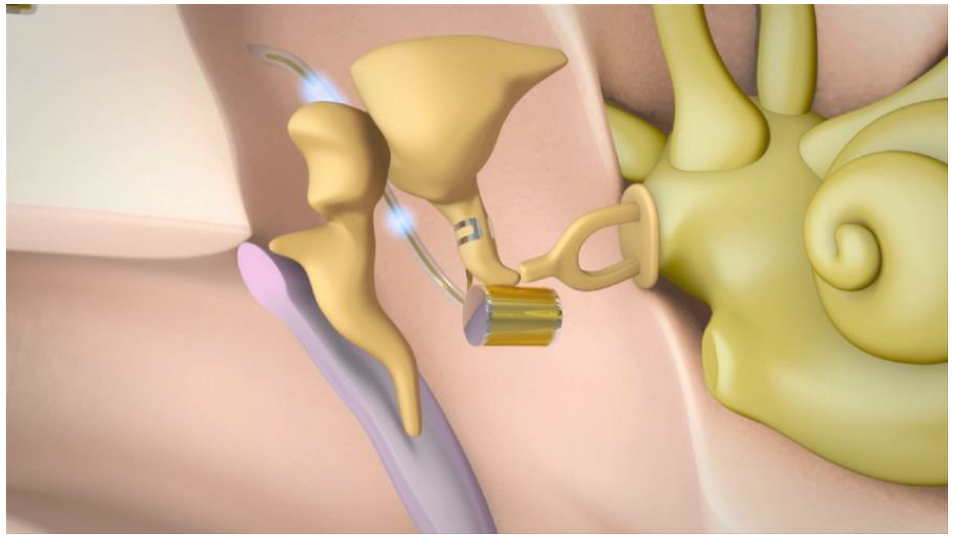
- The VSB is a direct-drive, implantable middle ear device
- Intended to provide a level of useful sound perception to individuals with hearing loss
- It converts sound into mechanical energy that is directly transferred to the ossicular chain

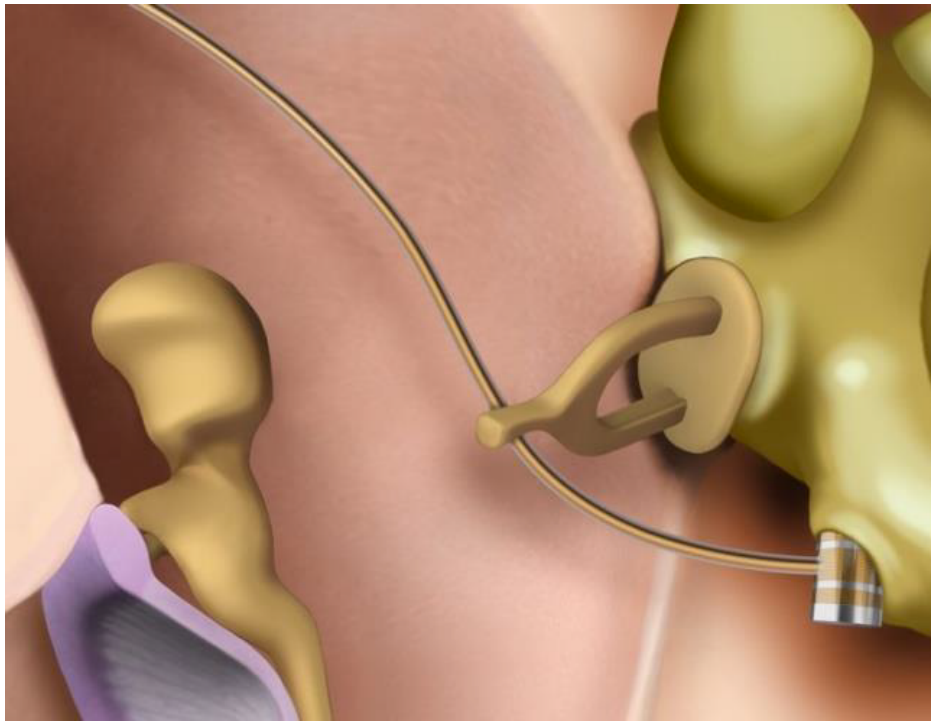




Vibrating Ossicular Prosthesis (VORP)



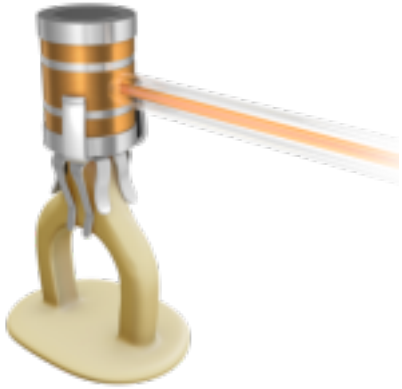




Incus Vibroplasty – long process

Incus Vibroplasty– short process

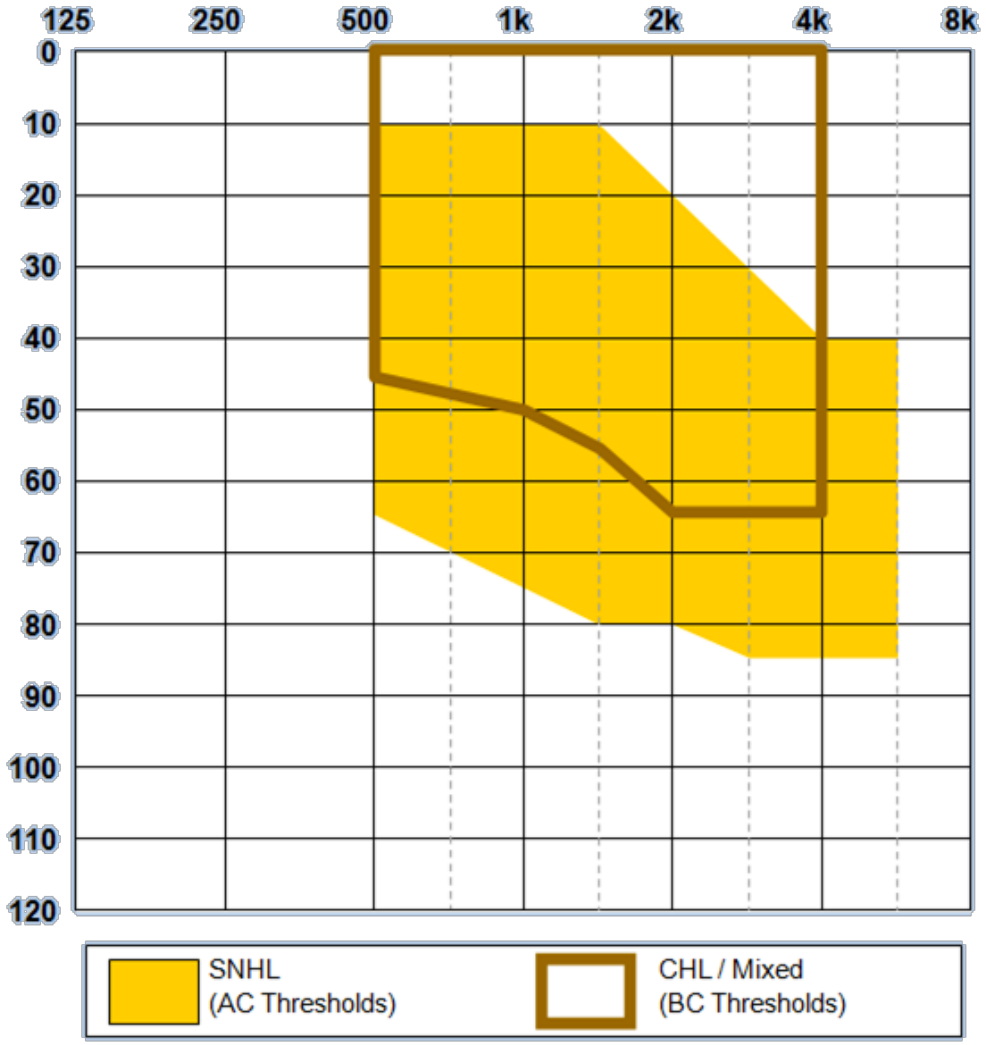
Stapes Vibroplasty

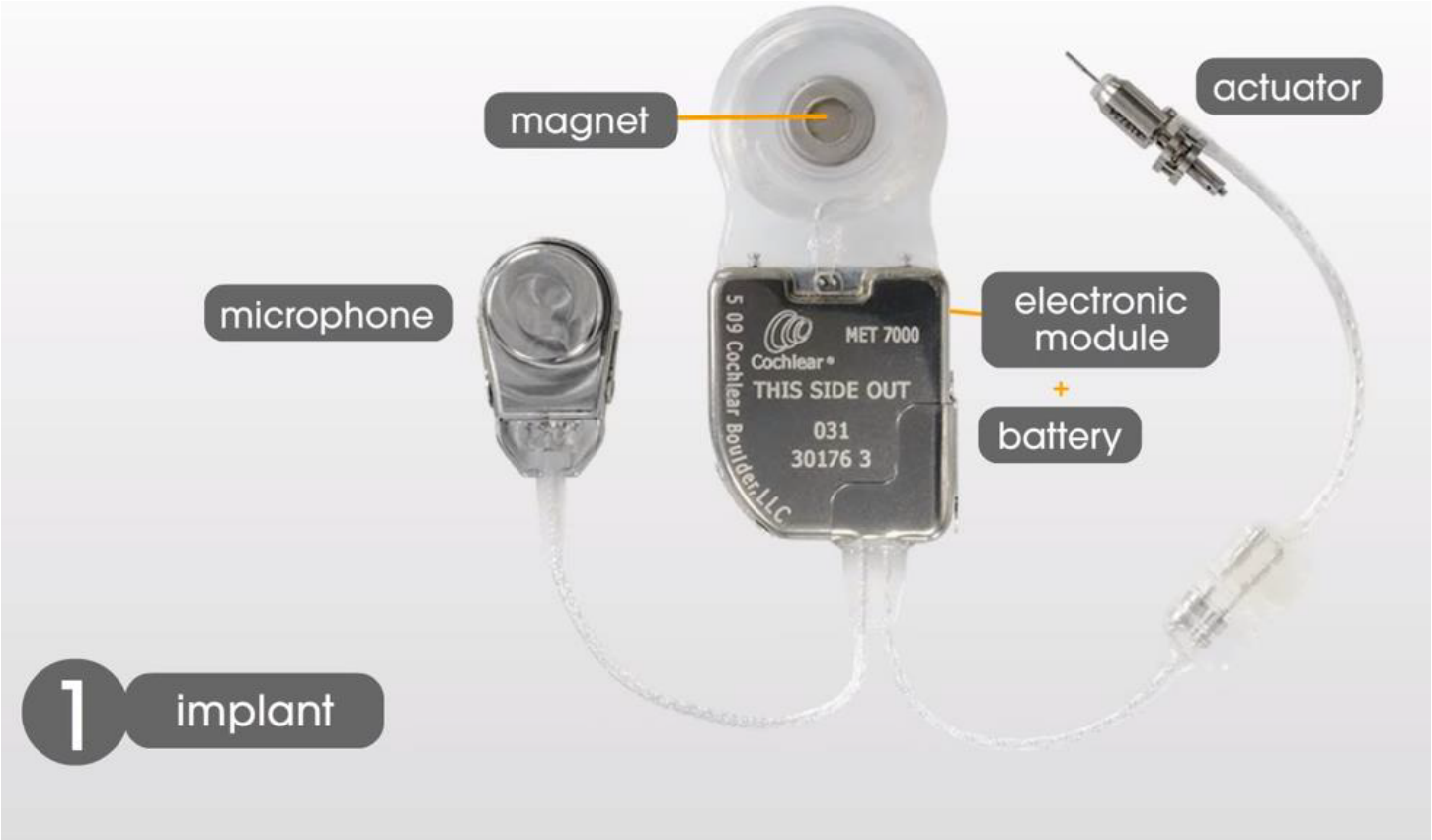


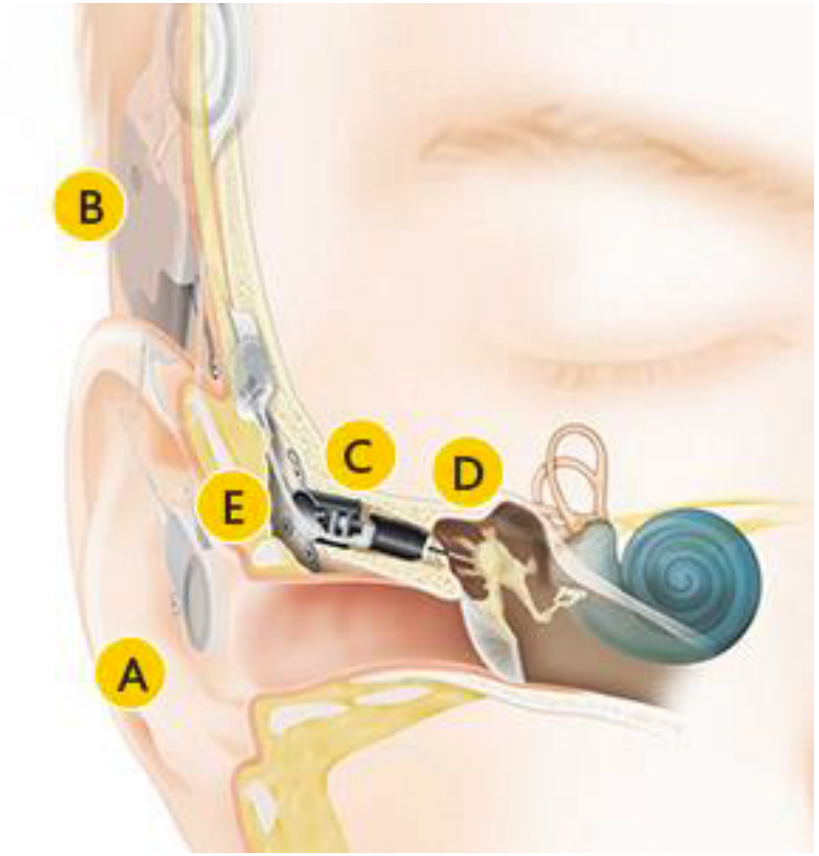
Round window Vibroplasty

MEI Referral Criteria

- Adults and children over 5 years of age
- SNHL with AC thresholds within yellow area
- Or a Mixed / CHL with BC thresholds in brown outline
- Referral criteria is different as the FMT will have a different placement which affects the overall gain of the device
- Stable hearing loss
- Ear anatomy allows the FMT to be positioned on a suitable vibratory structure
- No active ear infections or chronic ME fluid
- Preserved speech discrimination (50% on AB words)







Acoustic Implants- Cochlear Carina (fully- implantable)

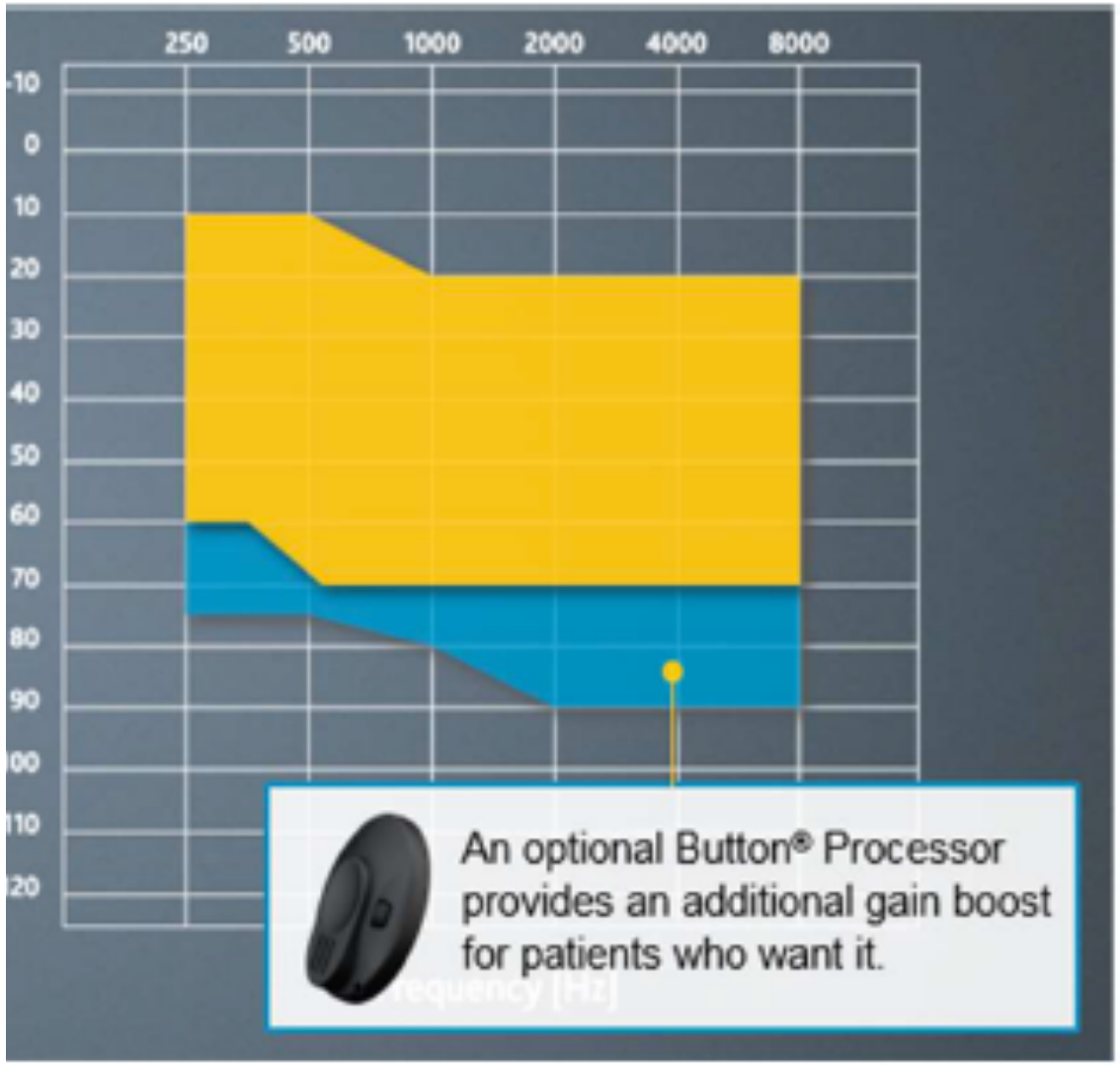
Acoustic Implants- Cochlear Carina (fully- implantable)

Indications

- Adults and children over 14 years of age
- Moderate-severe SNHL
- Mixed hearing loss
- Unable to wear conventional HA (patients who report adverse occlusion or intolerance to conventional earmoulds –otitis externa unresolved by use of non-allergic materials)

Contraindications

- Rapidly progressing or fluctuating hearing loss
- Active ME disease
- Not MRI compatible



	Partially implantable	Fully implantable
Advantages	Simple battery change or upgrade to new technical components	Cosmetically “invisible”
Disadvantages	Visible components	Battery change is only possible by surgery. Body sound problems with microphones under the skin.

*Bonebridge: Its transducer is a passive sensor and therefore does not need a battery

*Wireless charging technology is now available

MEI vs HA

MEI Benefits

- No earmould therefore ↓ otitis externa
- Less visible
- Comfortable
- No occlusion effect
- Superior high-frequency amplification without distortion
- Large frequency range
- Therefore: Better sound quality, less background noise, no feedback

Considerations

- Surgical revision possible
- MEI is not possible for many patients with abnormal middle ear anatomy
- Cost: £7000

MEI vs percutaneous BCI

MEI Benefits

- Each implant only stimulating one cochlea so ↑ chance of binaural hearing (esp. important for paeds)
- Transcutaneous - No open wound
- Aesthetics

Considerations

- Cost: £7000 (MEI) vs £3500 (BCI)
- MEI is not possible for many patients with abnormal middle ear anatomy

MEI's: To sum up…

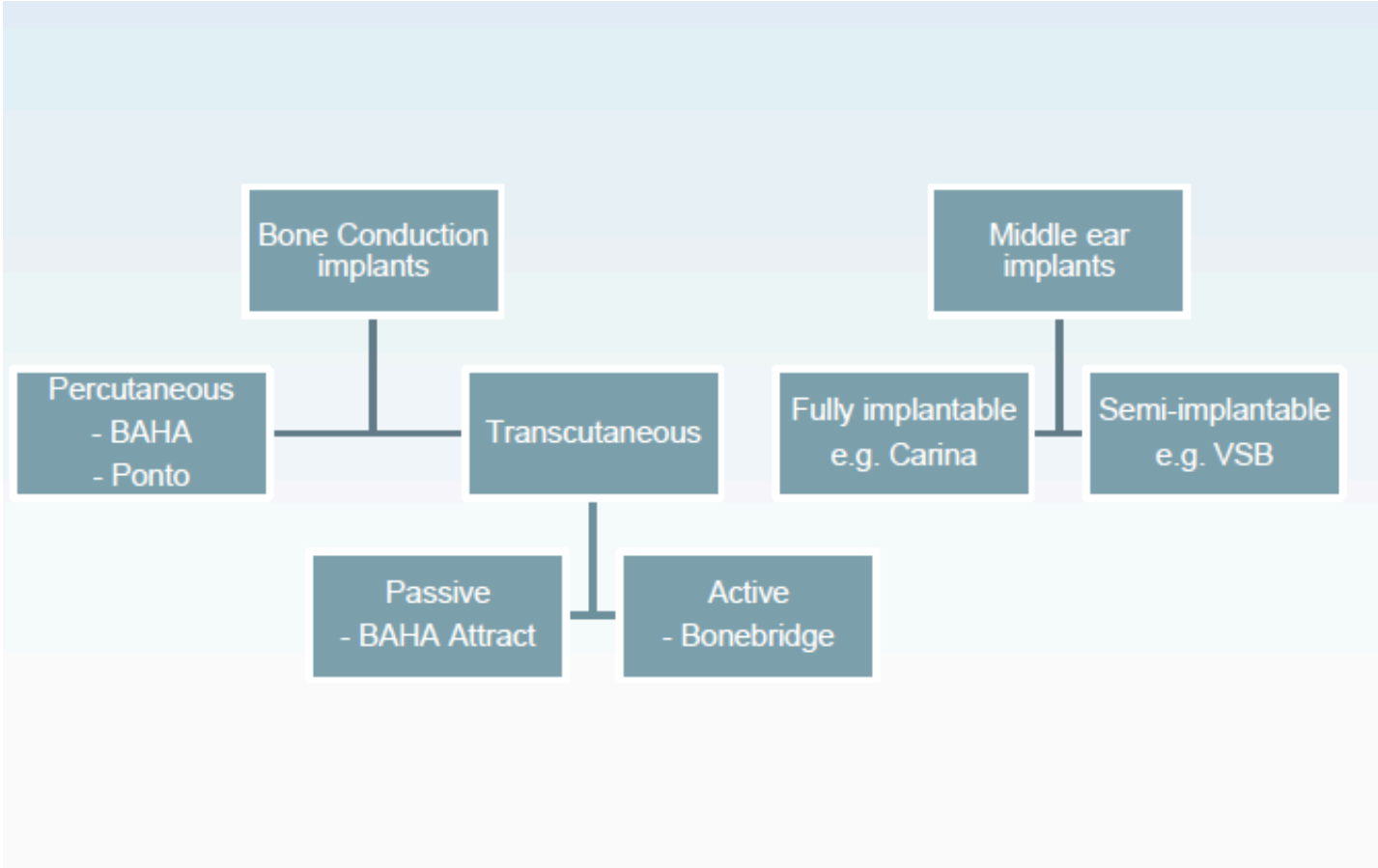
Medical: Microtia and/or atresia, recurrent otitis externa, allergies to earmold materials …

Patient's profession/ hobby: swimmers, physicians, musicians …

Possible complications

- Facial-nerve injury
- Injury to the ossicular-chain
- Imaging (MRI) restrictions (i.e. Carina)

When hearing aids are not enough… Hearing implant solutions



Conclusions

- BCI/MEI is *the* solution for patients who cannot be fitted with conventional hearing aids
- Team based approach (ENT surgeon/audiologist/ nurse/etc.) is of major importance for correct patient selection and the final result of the Baha/MEI treatment