

# Implantable Microphones

## An Alternative to External Microphones For Cochlear Implants

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Pune 2017



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University Hospitals Birmingham



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# Fully Implantable CI - Advantages

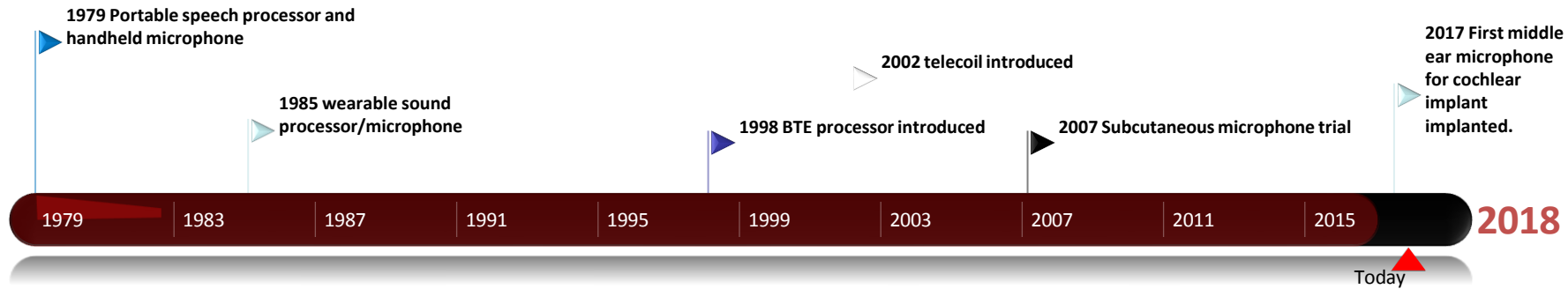
- Stigma of hearing loss
- Allows use of conventional headgear, unmodified earphones and mobile phones
- Improves comfort
- Swimming and vigorous exercise
- 24 hour hearing - wear in bed
- Processor retention in young children
- Reduces risk of physical damage, no external components
- Functional loss

Pinna shadow effect

External ear canal gain



# CI Microphone History



# Implantable Microphones

- **Site**

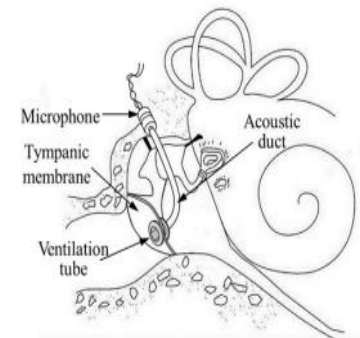
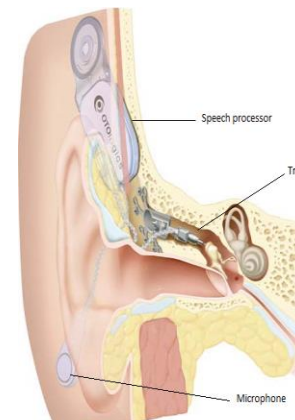
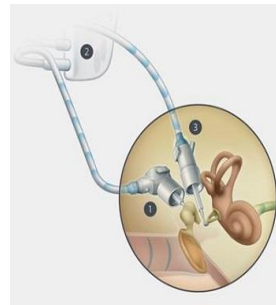
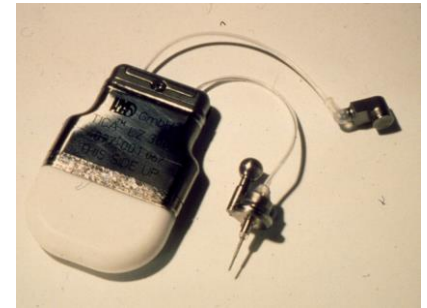
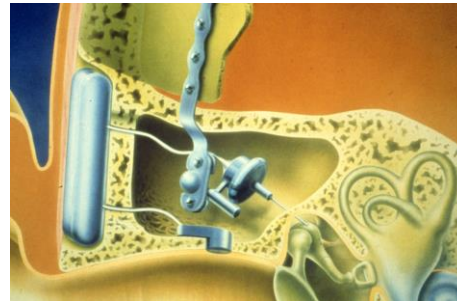
Subcutaneous  
Middle Ear  
Intra-cochlear

- **Coupling**

Free floating  
Soft tissue  
Ossicular chain

- **Method of transduction**

Piezoelectric  
Electromagnetic  
Electret / Capacitive  
Hydrophone



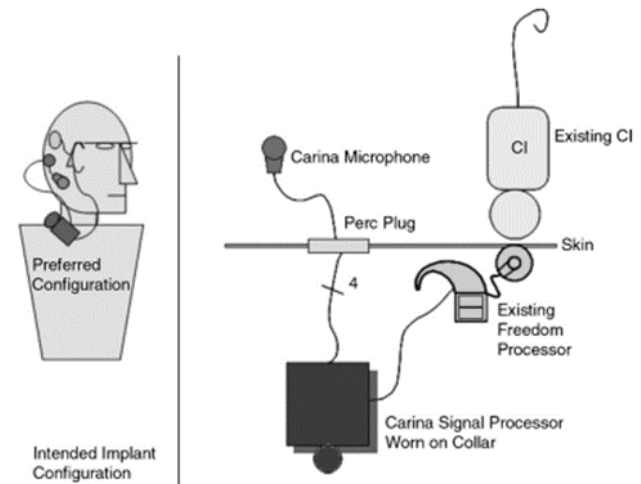
# Previous CI trials

## Subcutaneous Microphone

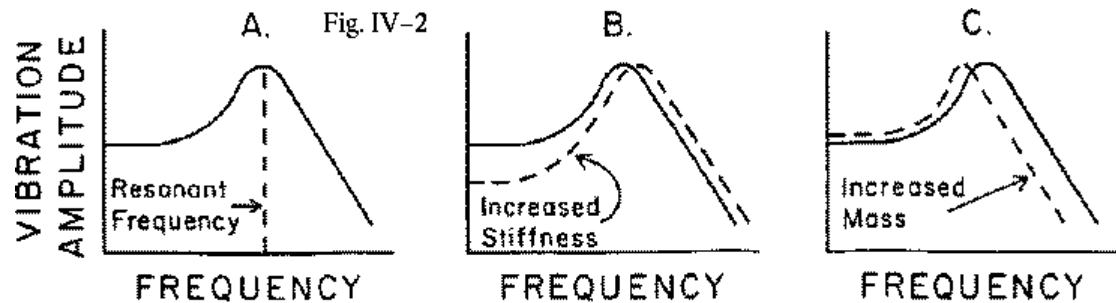
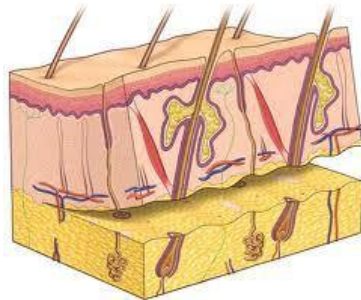
Briggs 2007



Jenkins 2012



# Subcutaneous Microphones



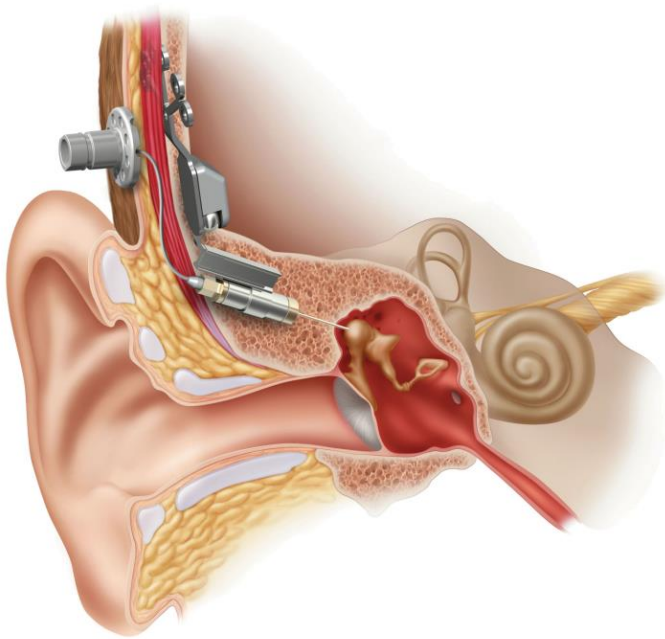
## Limitations

- Reduced sensitivity
- Body and contact noise

# Middle Ear Microphones

- Sufficiently sensitive equivalent to external microphone
- Biocompatible, robust and impervious to body fluid
- Should not greatly add to ossicular chain mass
  - 5mg results in 10dB loss at 4 KHz
- Should not greatly add to ossicular chain stiffness
  - reduces lower frequency sound transmission
- Surgery likely to be more complicated, preserve residual hearing
- Unresponsive to body noise
- Low power to maximize life of internal battery

# Tube Microphone





# Tube Microphone - Cadaveric Study

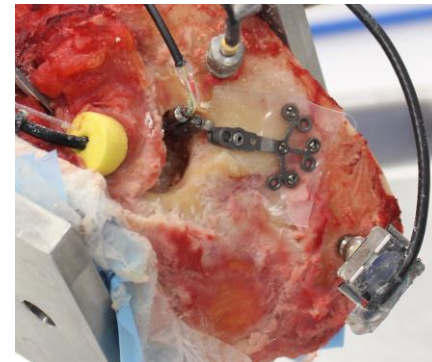
**Coupling:** ossicular chain location, loading angle, preload, coupling fixation, recess depth were investigated.

**Fixation:** Positioning of Codacs fixation device, silicone sheets to dampen body noise, and other options such as cementing the body of the microphone directly onto positions within the cortical mastoidectomy.

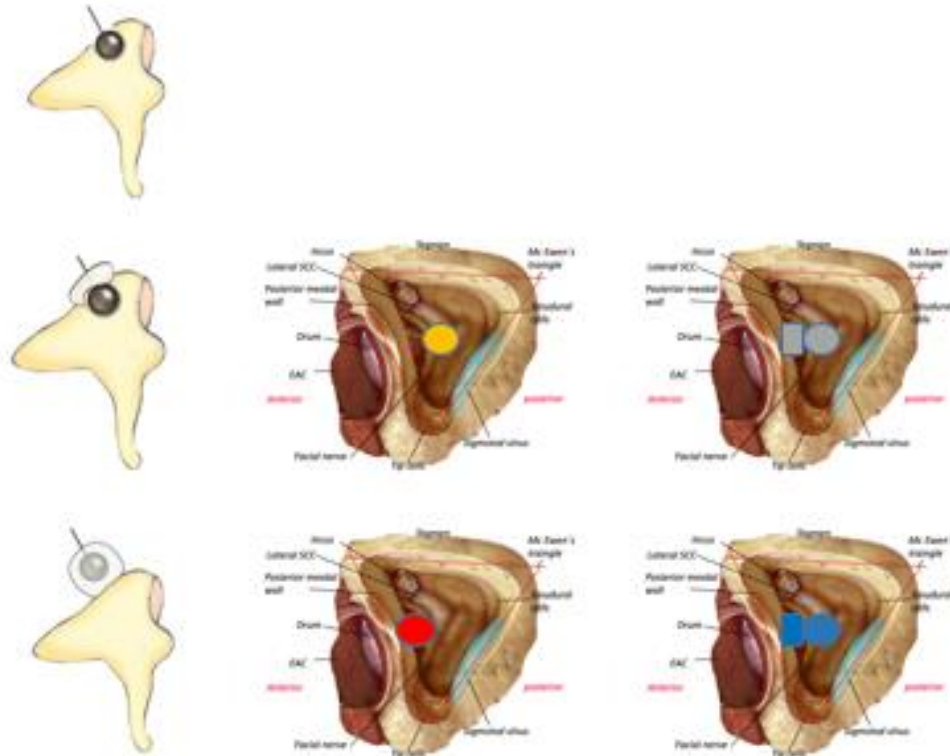
**Ambient pressure change**

## Outcomes

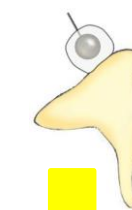
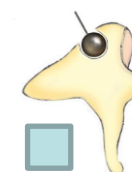
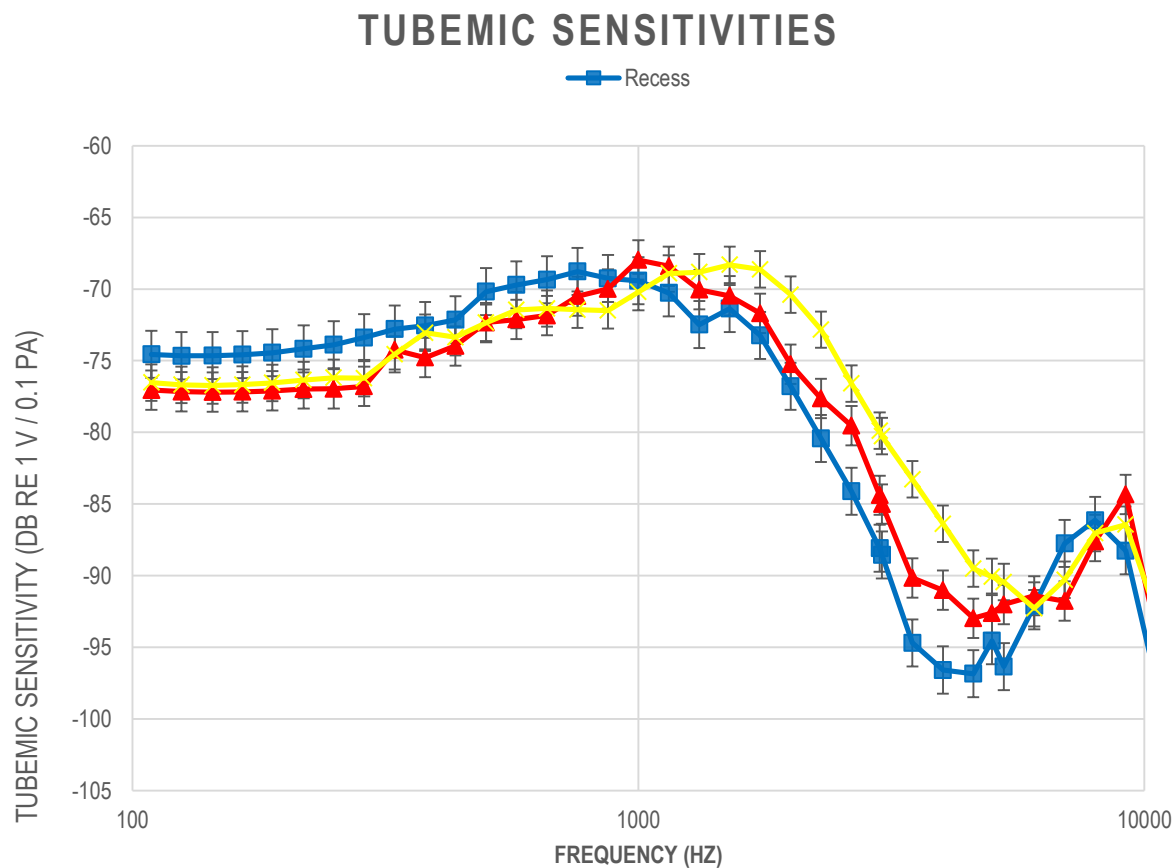
- Improve sensitivity
- Improve speech recognition
- Minimise body noise



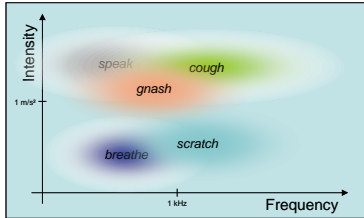
# Cadaveric Study – Fixation Options



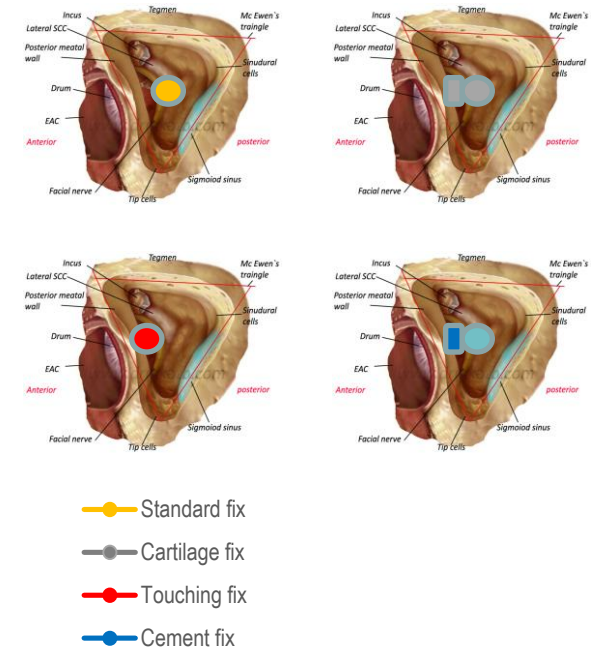
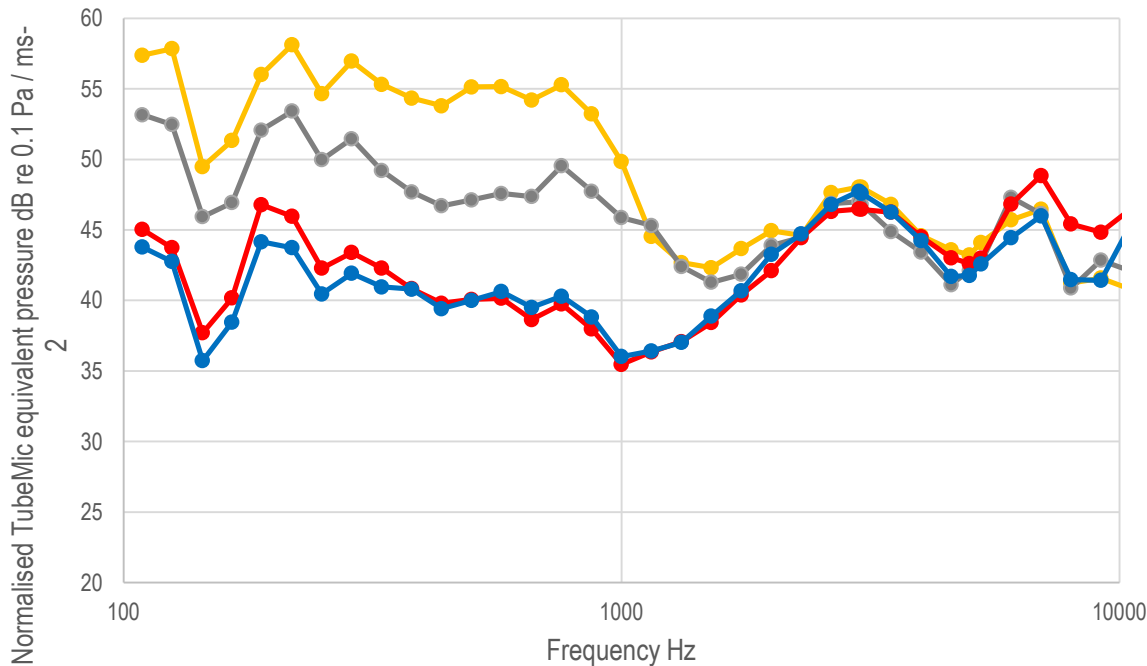
# Ossicular Coupling and Sensitivity



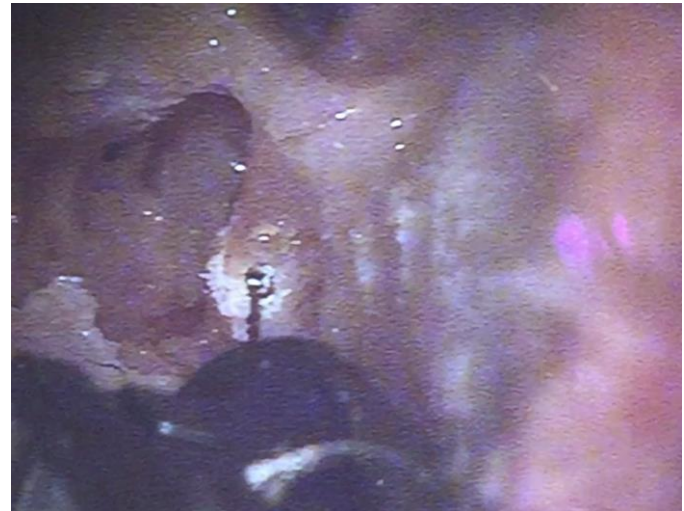
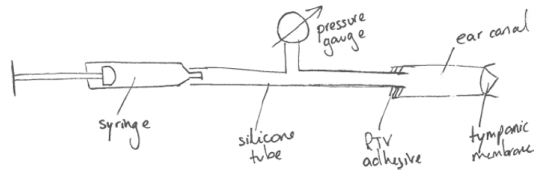
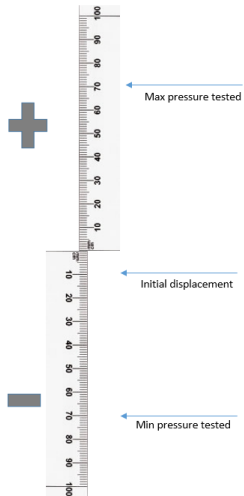
# Fixation Options and Body Noise



Mean simulated body noise for different fixation options



# Ambient Pressure Change



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# Cadaveric Study - Conclusions

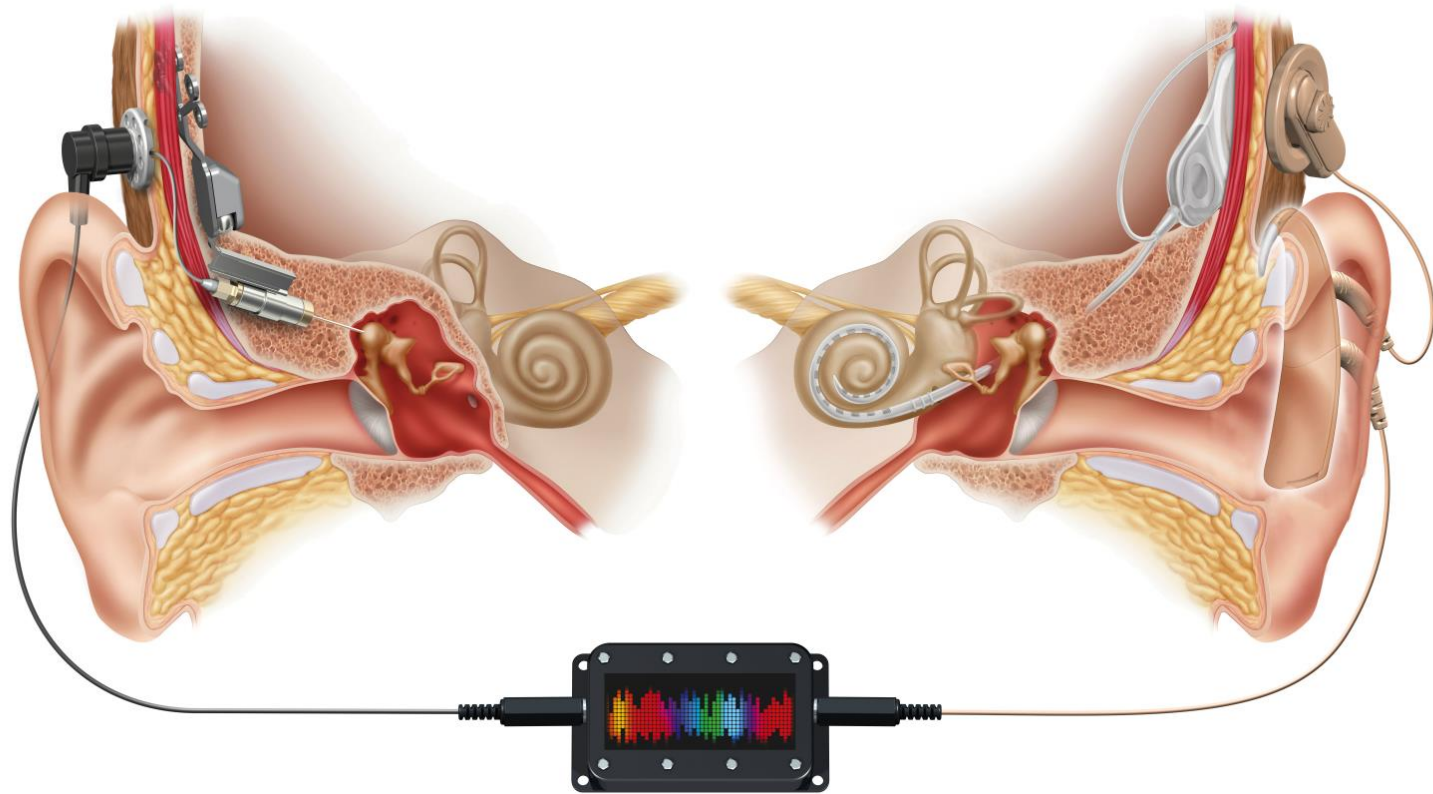
## ***Coupling***

- *A 0.9mm drilled recess*
- *Secured with cement*
- *Placed on the incus body with no preload*

## ***Fixation***

- *Microphone body touching the posterior canal wall (small cortical)*
- *Careful countersink technique for fixation*

# Clinical Study – 6 Patients



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# Surgery

- Etymotic foam tip, probe microphone and test probe in EAC
- Limited cortical mastoidectomy
- Broad exposure of incus and thin posterior canal wall.
- Fixation device attached
- Percutaneous pedestal attached
- 0.9mm recess drilled on incus
- Tube mic ball-tip placed tension free into recess then cemented in place





# Post-op Testing

## Testing months 1, 3 and 6

- Compare tube and conventional mics
- Thresholds aided and unaided
- Aided speech perception testing
- Auditory speech sound evaluation
- Subjects questionnaires



# Results – BKB Sentences (70 dB)

	Tube Mic	Conventional Mic
Patient 1	91%	93%
Patient 2	92%	93%
Patient 3	84%	87%
Patient 4	90%	88%
Patient 5	97%	99%
Patient 6	Due 16.11.17	

“I was on the train using the tube mic and for the first time in my life I could hear people sniffing and coughing. It was so annoying I don’t know how you deal with it every day” (Patient 1 end of 6 month trial)

# The Future



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# Acknowledgements

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