Validation of PTFE Artificial Cochlea Model for Insertion Force Measurements

Rolf Salcher[1], Martina Nullmeier[2], Jakob Cramer[2], Nick Pawsey[2], Thomas Lenarz[1], Thomas S. Rau[1]

1 Department of Otorhinolaryngology and DFG Cluster of Excellence, Hannover Medical School, Hannover, Germany

2 Cochlear Limited, Sydney, Australia

Objective

One of the standard procedures in developing and characterizing cochlear implant electrodes is the measurement of insertion forces, as they are assumed to be correlated with trauma.

Although human cadaveric cochlea specimens are the most realistic models of the patient's cochlear geometry and friction conditions, in order to produce a reproducible test setup an artificial cochlea model (ACM) is used. Typically these ACMs are made of an easy to process and smooth material, like polytetrafluoroethylene (PTFE), and combined with various lubricants in the insertion force measurements.

Temporal bone ? ACM

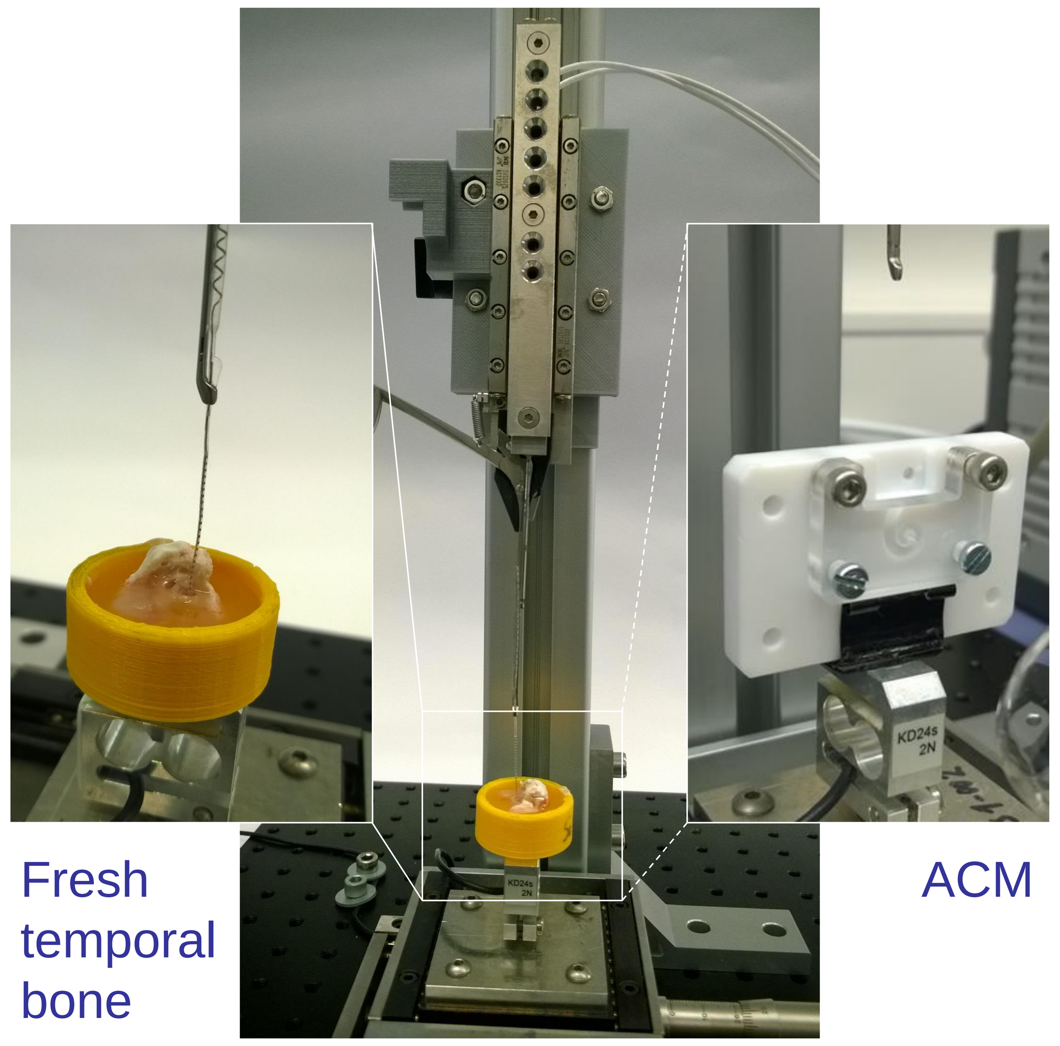
Until now the question of how well PTFE represents the conditions inside the cochlea has not been addressed. As the friction conditions inside a living cochlea are currently not easily measurable this is a comparison study between temporal bones and ACMs.

The use of fresh never frozen temporal bones is the best easily available approach. Porcine cochlea specimen are used because it is similarly proportioned to the human, provides straightforward surgical access and is readily available.

The insertion forces measured in fresh cochlea specimens and in PTFE ACMs of matching cochlear geometry are compared using different lubricants.

Methods

- Fresh, never frozen temporal bones were cut down to a small piece and fixed on a sample holder
- Two-dimensional ACMs matching the size and shape of the porcine cochlea were built based on CBCT scans (on Poster PS62)
- Non-functional Cochlear Slim Straight electrodes were inserted to a depth of 15 mm
- The insertion was done automated by a linear positioner with a speed of 0.5 mm/s
- The insertions were repeated 3 times in the porcine specimen and 6 times in the ACMs
- The porcine specimen were kept wet with saline solution during the whole process
- Different lubricants were used in the PTFE model: saline solution, saline solution and additional Healon on the electrode, and soap solution (10% soap)
- µCT scans were performed after insertion to check for damages

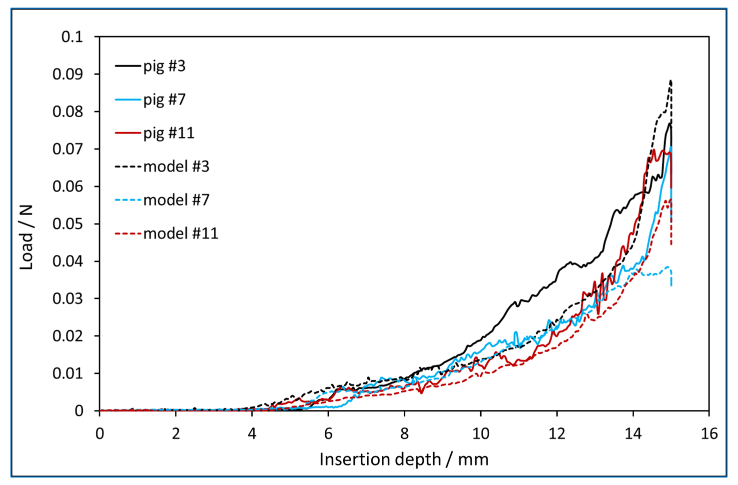


Fresh temporal bone

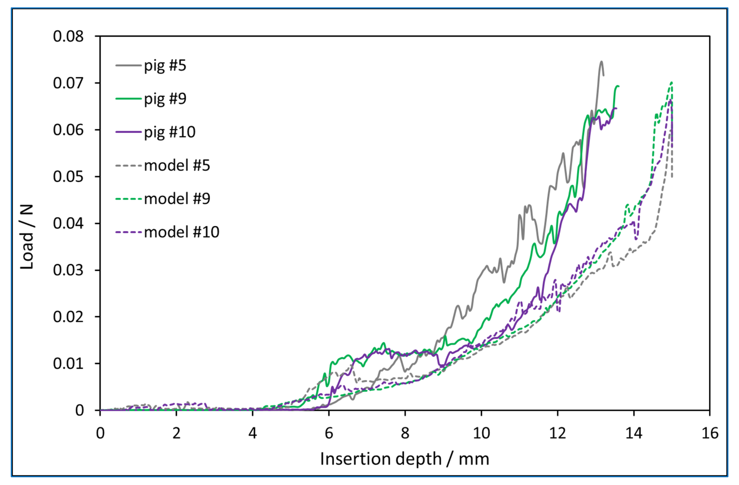
ACM

Results

A good correlation between the insertion forces was found in a number of the specimens when saline solution was used as a lubricant in the PTFE model:

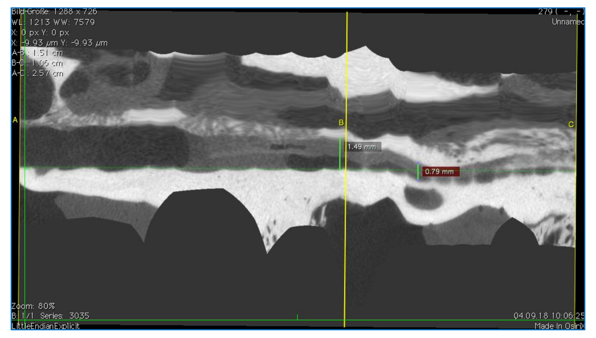


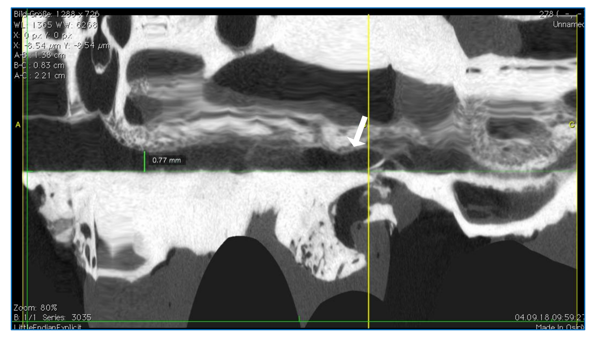
However, there are also specimens with a poorer correlation match to forces in the corresponding PTFE model:



Geometrical variations like the sizes and the height of the cochlea could be excluded as the reasons for this discrepancy.

Dislocation or anatomical malformations in the porcine temporal bones might be the reason for the difference in the insertion force curves. Some hints to prove that theory could be found in µCT scans of the porcine bones after the insertion force measurements. The unrolled scala view shows some features inside the cochlea:
(left: good match, right: bad match)



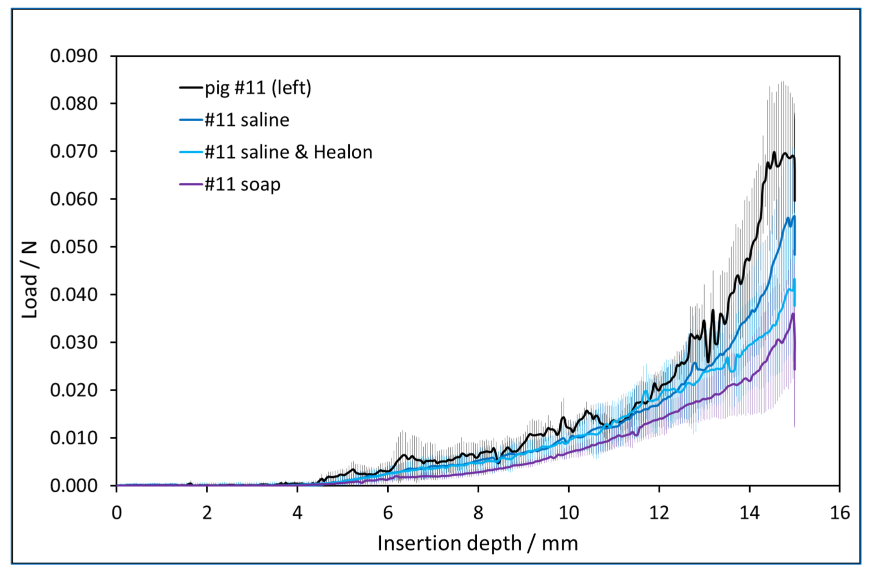


Conclusion

A good correlation between the insertion forces was found in a number of the specimens when saline solution was used as a lubricant in the PTFE model. Additional measurements are planned to prove the theory of dislocations. These dislocations might come from the fact that the electrodes used in this study are made for humans and not for pigs.

However, the question of how well does the insertion force curve in the PTFE model with different lubricants match the insertion force curve in porcine temporal bones could be answered.

Additional lubrication with Healon or soap solution produced lower insertion forces than were measured in the porcine bones.



Based on this results ACMs made out of PTFE with saline solution as a lubricant are a suitable model for reproducible test setups.

With this method also other materials can be checked for use in ACMs to represent the cochlea.

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Department of Otorhinolaryngology and German Hearing Center (DHZ) at Hannover Medical School, Carl-Neuberg-Str. 1, 30625 Hannover, Chairman: Prof. Prof. h.c. Dr. med. Thomas Lenarz, www.mhh-hno.de, www.hoerzentrum-hannover.de