On the benefit of ultra-slow insertion speed: reduced insertion forces in cochlear implantation surgery.

Th. S. Rau, S. Hügl, Th. Lenarz, O. Majdani

HNO-Klinik und Deutsches HörZentrum Hannover (DHZ)
der Medizinischen Hochschule Hannover (Direktor: Prof. Th. Lenarz)

Introduction

Preservation of residual hearing in cochlear implantation surgery requires atraumatic insertion which is associated with low insertion forces. Therefore, reduction of insertion forces is a dominant aim in development of improved electrode arrays (EA) as well as surgical technique. We wanted to investigate whether performing the insertion of an electrode array in a very slow, manually no longer feasible, manner can solely reduce insertion forces.

Methods

Three commercially available, straight electrode arrays (slim straight electrode, Cochlear Ltd., Sydney, Australia) were inserted in a custom-made artificial cochlear model (made of Teflon; representing an average human scala tympani [1], filled with soap solution) using our automated insertion test bench [2]. This setup consists of a motorized linear translation stage (LTM-80M-270, Owis GmbH, Staufen, Germany) equipped with a surgical forceps (KARL STORZ GmbH & Co. KG, Tuttlingen, Germany) to grip the electrode arrays. Three different insertion speeds were investigated in this initial study: 2.0 mm/s, 0.4 mm/s and 0.03 mm/s. Insertion forces were measured using a load cell with 0.5 N nominal force (K3D35, ME-Meßsysteme GmbH, Henningsdorf, Germany). Each electrode was inserted nine times with different order of speed values (Table 1). Finally, the maximum force of each insertion was determined.

Results

The mean maximal insertion force (arising at the point of maximal insertion depth) was 18.7 mN ± 5.1 mN for an insertion speed of 2.0 mm/s, 18.7 mN ± 2.4 mN in case of 0.4 mm/s and goes down significantly to 12.7 mN ± 2.1 mN when the insertion was performed with ultra-slow speed of 0.03 mm/s. Figure 1 depicts the insertion process. In Figure 2 our results are visualized.

Table 1: Order of insertion speed used for each test sample. Speed values in mm/s.

	order of insertion								
sample	1	2	3	4	5	6	7	8	9
EA 1	0.03	0.40	2.00	0.03	0.40	2.00	0.03	0.40	2.00
EA 2	0.40	2.00	0.03	0.40	2.00	0.03	0.40	2.00	0.03
EA 3	2.00	0.03	0.40	2.00	0.03	0.40	2.00	0.03	0.40

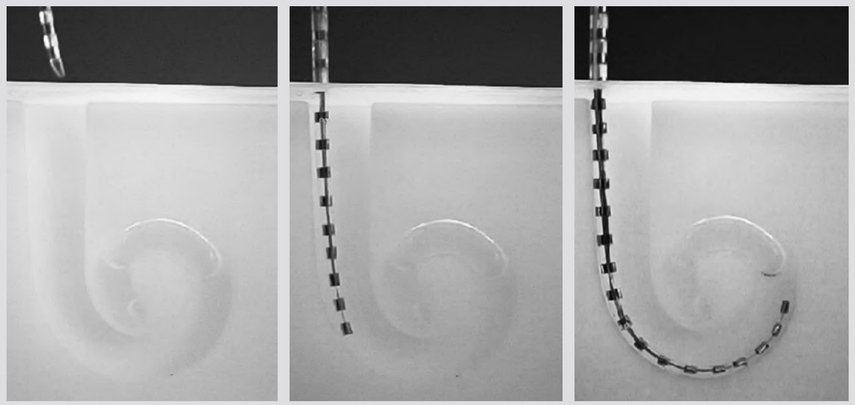

Figure 1: Visualization of the insertion process from the beginning (left) to the point of first contact (middle) to full insertion depth (right). At that point maximum insertion force was measured.

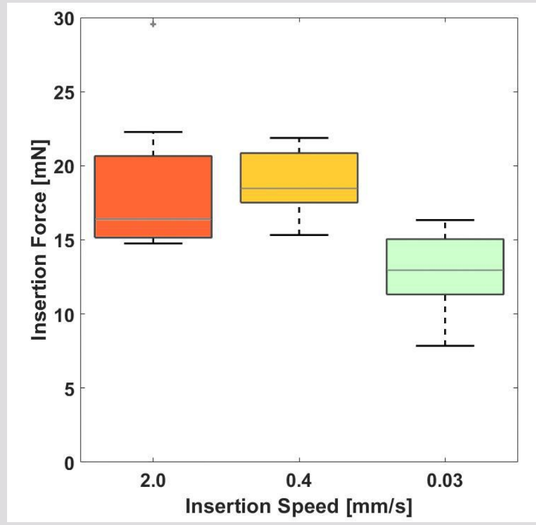

Figure 2: Maximum insertion forces for different speed values.

Conclusions

Our results indicate that insertion forces can be significantly reduced if only the insertion is conducted very slowly. This finding discloses a high potential to improve residual hearing preservation as it goes without change in the design of the electrode array. However, further studies are necessary to confirm that effect also in cochlea specimens as well as with electrode arrays of different manufacturers.

References

[1] Cohen L. T., Xu J., Xu S. A., Clark G.M. (1996): Improved and simplified methods for specifying positions of the electrode bands of a cochlear implant array. Am J Oto 17:859-865.

[2] Hügl S., Rülander K., Lenarz Th., Majdani O., Rau Th. S. (2017): Impact of insertion velocity on insertion forces in cochlear implantation surgery. In: Biomedical Engineering: Joint Journal of the German Society for Biomedical Engineering in VDE and the Austrian and Swiss Societies for Biomedical Engineering. Bd. 62 (2017), S1, S167, 10.-13.09., Dresden.