

Influence of the insertion speed during a straight electrode array implantation, a numerical study

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Abstract

Approximately 466 million people worldwide suffer from some type of hearing loss. About ninety-three percent of them are adults, aged over 15 years (World Health Organization 2018). Profound hearing loss in children lead to a deficient development of spoken language, resulting in a negative impact on daily communication. On the other hand, in adults which have acquired the profound hearing loss after having developed spoken language and cognitive abilities are able to use these skills with the help of a cochlear implant, as mentioned by Jorgensen et al. (Jorgensen et al. 2018).

Cochlear implant is an electronic device implanted into the cochlea to directly stimulate the auditory nerve. This device is particularly implanted in patients with severe-to-profound hearing loss (Khater and Mohammad 2017). The surgery is safe, but involves some risks, such as infections, device malfunction which can lead to poor hearing outcome (Loundon et al. 2010). Future improvements in cochlear implant surgery will necessarily involve the decrease of the intra-cochlear damage, thus preserving the patient's residual hearing. The mechanical properties of the electrode array components, the geometrical shape, the processor and the surgical techniques are some of the aspects that can be optimized in order to help the patients to recover their normal hearing capacities.

In this work, the influence of the insertion speed during a cochlear implantation was studied. A straight electrode array was initially modelled. Many authors indicate as being the less traumatic type of cochlear implant. The electrode array was meshed with linear hexahedral elements, with reduction integration, whereas the cochlear wall was modelled with 4-node shell elements. Four different insertion speeds: 0.25, 0.5, 1 and 2m/s were investigated. The numerical simulations of the cochlear implantation carried out in Abaqus software showed the same pattern of the insertion force against insertion depth, thus indicating the different phases of the implantation. Results demonstrated that lower insertion speeds, led to a reduction on the contact pressure and insertion force. It is then expected that a lower insertion speed will allow to increase the residual hearing while reducing surgical complications.

Keywords. cochlea, electrode array, intra-cochlear damage, finite element method.

References

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