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Abstract	
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Objective measures to assess direct acoustic cochlear implant functioning: artifact characterization and intra-operative ABR and ASSR measurements

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Direct Acoustic Cochlear Implants (DACIs) are used to treat severe to profound mixed hearing loss. An actuator in the middle ear is coupled via a stapes prosthesis to the inner ear, and directly vibrates the cochlear fluid. Confirming proper DACI coupling, crucial for its functioning, is challenging for ENT surgeons. Currently, the movement of the actuator is verified intra-operatively using laser doppler vibrometry (LDV), requiring specific technical skills. Furthermore, LDV movement measures at the actuator rod do not confirm correct DACI coupling or adequate auditory processing.

In [1], it was shown that auditory brainstem responses (ABR) and steady-state responses (ASSRs) can be obtained post-operatively from DACI subjects. ABRs and ASSRs could possibly be used intra-operatively, to verify correct DACI functioning and coupling. If ABRs and ASSRs can be recorded, the DACI is effectively stimulating the cochlear fluid, and auditory processing beyond the periphery is confirmed. However, the radiofrequency (RF) link between the DACI's external and internal parts causes electrical artifacts, obscuring the ABR and ASSR. The actuator possibly also causes electrical artifacts, obscuring the EEG, although it was shown in [1] that the actuator did not cause visible artifacts in a simple bench set-up.

The aim of the current study is to characterize the DACI artifacts, and to use ABRs and ASSRs intra-operatively to confirm correct DACI coupling and evaluate auditory processing beyond the periphery.

In this study, the electrical artifacts resulting from DACI stimulation were measured on a fresh-frozen cadaver head, with the aim of better characterizing, modeling and removing DACI artifacts. In this realistic set-up, it was possible to disentangle RF and actuator artifacts, and no background brain noise or evoked responses were present. Measurements show that both the RF and the actuator cause electrical artifacts, although actuator artifacts are of negligible size for intermediate stimulation levels.

Furthermore, ABRs and ASSRs were measured in three subjects under general anesthesia, immediately after DACI implantation. Click stimuli were presented directly to the implant with stimulation frequencies in the 40Hz and 90Hz range at various stimulation levels. For stimulation in both frequency ranges, clear ABR peaks V were observed and ABR thresholds could be estimated. Significant steady-state responses were measured for 33Hz stimulation and for 90Hz stimulation, allowing electrophysiological threshold estimation.

In this study, we obtained reliable electrophysiological responses beyond the periphery intra-operatively to confirm DACI coupling.

References:

[1] Verhaert, Nicolas, Michael Hofmann, and Jan Wouters. "Transient and Steady State Auditory Responses With Direct Acoustic Cochlear Stimulation." *Ear and hearing* 36.3 (2015): 320-329.

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