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COCHLEAR IMPLANT

Evaluating changes in ECAP thresholds from morning to evening in a longitudinal study

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MED EL

WCA World Congress of Audiology

Abstract

Aims:

The aim of this exploratory study is to evaluate whether there is variation throughout the day in the objective measure "electrically evoked compound action potentials (ECAP)". ECAPs are a measure of the synchronized firing of cochlear nerve fibers in response to electrical stimulation and are an important objective measure for evaluating the functionality of the cochlear nerve and for fitting the cochlear implant.

Results:

We confirmed earlier reports by showing significantly increased impedance values in the morning compared to noon and evening while there was no significant difference in impedance between noon and evening. Importantly, we found a significant difference between ECAP thresholds obtained in the morning compared to those at noon or in the evening. However, effect size was very small and thus, this difference is irrelevant in the clinical routine. Interestingly, ECAP thresholds in the morning were lower than later in the day, in contrast to the impedance. A correlation analysis between impedances and ECAPs revealed a moderate negative correlation. Analyses of the questionnaires and a closer look at individual measurements will elucidate possible relations between each other.

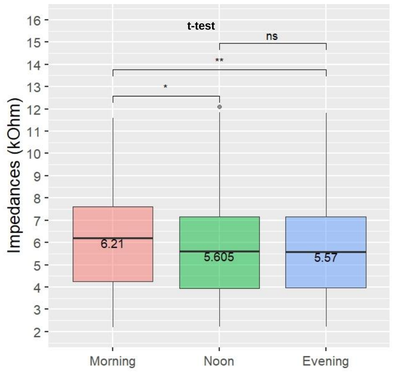
Interpretation:

It will be discussed whether the lower threshold values of the ECAPs in the morning are a result of either non-stimulation during the night and thus a higher sensitivity of nerve fibers to stimulation or a lower noise floor in the measurement or whether other factors come into play.

Conclusion:

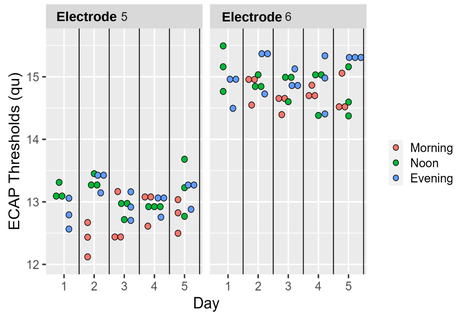
Although we found a significant difference between morning and noon/evening ECAP measurements, it was clinically irrelevant. Thus, for fittings of the speech processor in people who are not able to communicate their subjective hearing level, there is no threat of using too low or high values from ECAP measurements obtained at different times of the day.

Higher Impedances in the morning

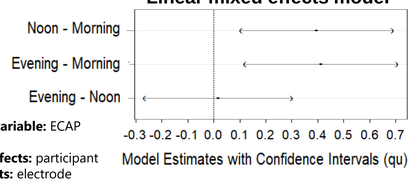


Impedances are significantly higher in the mornings compared to noon or evening. With these finding we could confirm results from the literature (Mushtaq et al. 2022). The higher impedances in the morning is true for every electrode contact.

ECAPs – example of individual measurement

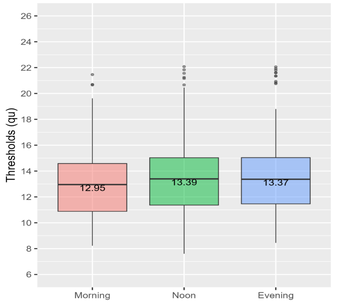


Linear mixed effects model



Response variable: ECAP thresholds
Random effects: participant
Fixed effects: electrode contact, time of day

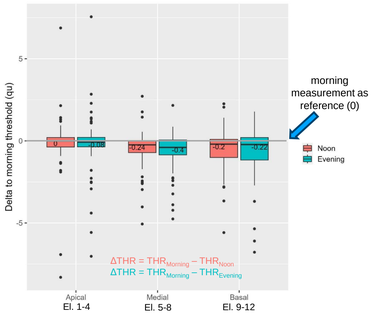
Lower mean ECAPs in the morning



→ ECAP thresholds were lower in the morning compared to noon/evening.

→ time of day only has a low statistical effect size
→ clinically irrelevant

Difference larger in medial and basal electrodes



→ Tendency to larger differences between morning and noon/evening measurements towards medial/basal electrodes

Objectives

In a recent study, Mushtaq et al. (2022) showed small but significantly higher electrode impedance values in the morning compared to those in the evening. Causes for an increase in impedance values may be (physiological) changes in the cochlea during the period of non-usage during the night or fluctuations in physiological parameters throughout the day. The aim of this exploratory study is to evaluate whether there is variation in another objective measure – the electrically evoked compound action potentials (ECAP). As ECAPs are an important measurement for fitting the cochlear implant it needs to be evaluated whether there are significant value differences throughout the day.

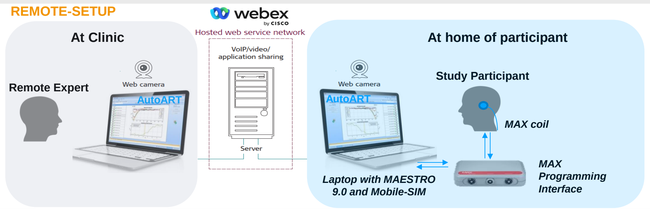
Conclusion

- Physiological processes such as layering of proteins onto the implant and subsequent inflammatory processes (Tang & Eaton 1999) are thought to increase the impedance of cochlear implants. These processes happen in times of non-usage, and even maybe in such short durations of non-usage during the night, as the study of Mushtaq et al. (2022) and our study suggest. These increases in impedance, however, are reversible due to usage of the implant during the day.
- **For ECAPs we found the reverse effect with lower thresholds in the mornings compared to noon/evening with a tendency of larger differences in medial and basal electrodes.** This has not been reported before. However, these differences are clinically irrelevant. A possible explanation may be a higher sensitivity of neurons after a "down time".

Methods

- Ten subjects wearing a MED-EL cochlear implant (implanted between 8 months and 12 years) were included (7m 3f, mean age: 64 y).
- Using MAESTRO clinical software, we measured impedances and ECAPs in the morning, at noon and in the evening on five consecutive days during remote sessions, meaning that the subject was at home, connected via the video conferencing system Webex with the technician at the clinic. Subjects were introduced to remote measurements during an initial session at which the technician visited the subject at home and assembled the necessary equipment there.
- Subjects were instructed to keep the speech processor off in the morning until measurements started.
- Each session included: 1) first impedance measurement, 2) three repetitions of ECAP measurements at 6 electrode contacts (2 basal, 2 middle and 2 apical) and 3) a second impedance measurement, resulting in 30 impedance and 45 ECAP measurements per subject. Prior to each session, subjects filled in a questionnaire regarding their physical/mental fitness, hearing related changes and medications.

Sessions (5 consec. days)	measurements
morning	1 IFT, 3 x AutoART, 1 IFT
noon	1 IFT, 3 x AutoART, 1 IFT
evening	1 IFT, 3 x AutoART, 1 IFT



References

- Mushtaq F, Soulby A, Boyle P, Nunn T and Hartley DEH (2022). Self-assessment of cochlear health by cochlear implant recipients. Front. Neurol. 13:1042408.doi: 10.3389/fneur.2022.1042408
- Tang L and Eaton JW (1999). Natural responses to unnatural materials: A molecular mechanism for foreign body reactions. Mol. Med. 5: 351-358