P109 Uniklinikum Würzburg

Investigating the Impact of Electrical Cochlear Stimulation Level and Site on the Electrically Evoked Auditory Brainstem Response in Long Electrode Array Cochlear Implant Recipients

D. P. Herrmann[1], C. Köstler[1], J. Voelker[1], S. Hackenberg[1], K. Rak[1], M. Cebulla[1]
[1]Department of Otorhinolaryngology, Plastic, Aesthetic and Reconstructive Head and Neck Surgery, University Hospital Würzburg, Germany

Aims

Previous studies report that the latency of the electrically evoked auditory brainstem response (eABR) in cochlear implant (CI) users is influenced by the position of the stimulating contact [1, 2, 3, 4]. This means, basally positioned electrode contacts evoke longer latencies of wave eV than contacts deeper inserted into the cochlea. However, this was only tested with CI electrodes up to 25 mm in length, which reach approximately the lower half of the middle cochlear turn. In CI users implanted with longer electrodes measuring 28 mm or more, stimulation of the apical region of the cochlea is possible. This study aims to investigate the effect of intra-cochlear site of stimulation in CI users implanted with electrodes with a length of 28 mm or 31.5 mm. Additionally, the study explores how the stimulation level influences the eABR.

Population

- Participants: 29 unilaterally and 3 bilaterally implanted adult CI recipients (total: 35 data sets)
- Gender and Age: 17 women, 15 men, aged 41-81 years (mean age = 65.1)
- All participants received a MED-EL CI system (Innsbruck, Austria) with electrode length ≥ 28 mm
  - 21 with a 31.5 mm electrode array (Standard/FLEXsoft)
  - 14 with a 28 mm electrode array (FLEX28)

Material and Methods

- Test Setup (see Fig. 1):
  - Stimulation: Research Interface Box 2 (Dep. of Ion Physics and Applied Physics at University of Innsbruck, Innsbruck, Austria)
  - Recording: Eclipse AEP System (Interacoustics A/S, Middelfart, Denmark)
  - Control/Storage: PC running Matlab (The MathWorks Inc., Natick MA, USA)
- Recording Procedure:
  - eABR recorded intraoperatively immediately after CI implantation
  - Biphasic pulses (phase duration = 40 µs) with alternating polarity; stimulation levels in current units (CU) with 1 CU ≅ 1 µA
  - Stimulated via apical, medial, and basal electrode contacts
  - Stimulation levels: initial levels set to eCAP threshold; levels varied to elicit three categories of eABR (low, middle, high) with maximum at eCAP threshold level +50%
- Postoperative Medical Imaging:
  - Flat-panel volume computed tomography scans with secondary reconstructions (fpVCT$_{SECO}$; Siemens Healthineers AG, Erlangen, Germany) slice thickness < 0.5 mm
  - Determination of electrode contact insertion depths and cochlear duct lengths (CDL) using OTOPLAN (CAScination AG, Bern, Switzerland)
- Data Analysis:
  - Latency of wave eV extracted from eABR recordings
  - Electrode insertion depths were calculated as percentage of the CDL and divided into four cochlear quadrants (see Fig. 2).

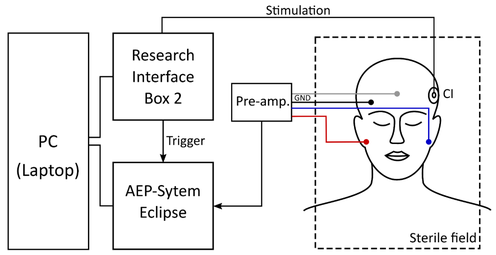


Fig. 1: Test setup for the eABR measurements.

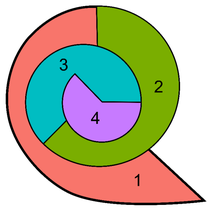
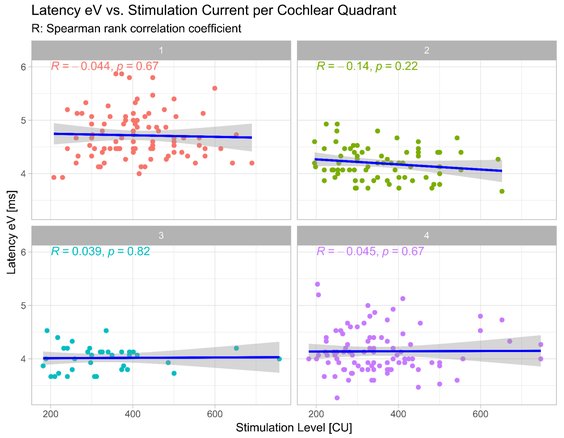
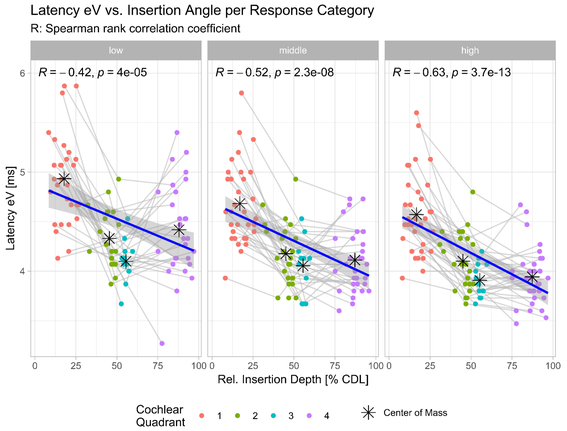


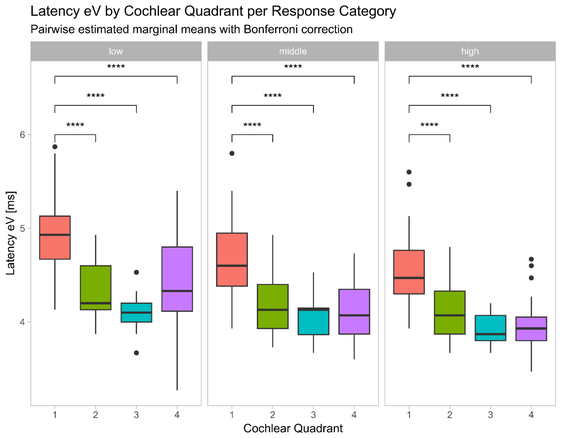
Fig. 2: Schematic illustration of the cochlea divided into four equal quadrants based on its CDL, colors represent 0-25%, 26-50%, 51-75%, and 76%-100%.

Results





- A linear mixed-effects model followed by an ANOVA was used to examine the effects of stimulation level and cochlear quadrant on the latency of wave eV. The results revealed a significant effect of cochlear quadrant on latency ($F(3, 281.36) = 5.95$, $p < 0.001$), while the effect of stimulation level and the interaction between both factors were not statistically significant.
- Spearman rank correlation showed a significant negative correlation between latency of eV and the relative insertion depths for each eABR category.
- Post-hoc pairwise estimated marginal means testing indicated that the latency of eV in cochlear quadrant 1 was significantly different from the latencies in the other quadrants.



Conclusion

- The stimulation level seems to have less effect on the latency of wave eV than the relative insertion depth of the stimulating contact.
- Wave eV latency decreases significantly from basal to apical regions in recipients of long CI arrays (≥ 28 mm).
- The methodology presented here could offer the possibility to estimate the position of the CI electrode by means of a electrophysiological measurement.

References:

[1] Abbas, P. J., & Brown, C. J. (1988). Electrically evoked brainstem potentials in cochlear implant patients with multi-electrode stimulation. Hearing Research, 36(2), 153–162. https://doi.org/10.1016/0378-5955(88)90057-3

[2] Shallop, J. K., Beiter, A. L., Goin, D. W., & Mischke, R. E. (1990). Electrically evoked auditory brain stem responses (EABR) and middle latency responses (EMLR) obtained from patients with the nucleus multichannel cochlear implant. Ear and hearing, 11(1), 5–15.

[3] Abbas, P. J., & Brown, C. J. (1991). Electrically evoked auditory brainstem response: Growth of response with current level. Hearing Research, 51(1), 123–137. https://doi.org/10.1016/0378-5955(91)90011-w

[4] Firszt, J. B., Chambers, R. D., Kraus, N., & Reeder, R. M. (2002). Neurophysiology of Cochlear Implant Users I: Effects of Stimulus Current Level and Electrode Site on the Electrical ABR, MLR, and N1-P2 Response. Ear and Hearing, 23(6), 502–515.

Contact:
Herrmann_d@ukw.de