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COCHLEAR IMPLANT

Large cohort analysis over clinical objective measurements, fittings and manufacturers of cochlear implants

Astrid Klinge-Strahl, Jenny Blum, Nicola Strenzke, Dirk Beutner

UNIVERSITÄTSMEDIZIN GÖTTINGEN : UMG
Klinik für Hals-Nasen-Ohrenheilkunde
Germany

Abstract

Aims:
Objective measures (OM) such as impedances, electrically evoked stapedial reflexes (ESRT) and electrically evoked compound action potentials (ECAP) that were obtained during and after cochlear implantation may be used to adjust stimulation levels in patients who are not able to communicate their subjective hearing level. However, not all OMs are equally well suited for fitting the stimulation levels. The aim in this retrospective data analysis is to compare intra- and postoperative ESRTs and ECAP thresholds as well as electrode impedances and to compare them to the behaviorally obtained stimulation profiles. We will evaluate whether one can infer postoperative ESRTs from intraoperative ESRTs by correlating individually matched intra- and postoperative thresholds. Furthermore, the reported data may be used as a guideline for which parameters and values we should expect depending on operative mode and manufacturer. **NOTE** that all ECAP and ESRT values are depicted in nano Coulomb (nC) as the SI unit for electric charge to be able to compare values between manufacturers.

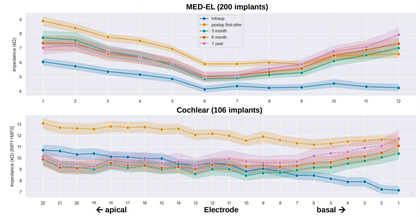
Results:
Mean impedances are intraoperatively lower than postoperatively. At initial stimulation, impedances in implants from Cochlear increase noticeably more than those from MED-EL implants but in later measurements almost return to intraoperative values whereas in MED-EL implants impedances don't increase as much at first stimulation and don't return to intraoperative values. Mean ECAP and ESRT thresholds are intraoperatively higher than postoperatively. However, the magnitude of the delta (intraop minus postop) depends on the threshold level, with larger deltas between intra- and postoperative ESRTs for higher intraoperative threshold levels. Similar dependencies are found for ECAPs. The best correlation between OMs and fitting maps was found between postoperatively obtained ESRT levels and behaviorally determined maximum stimulation levels in both manufacturers. Generally, the behaviorally obtained maximum comfort levels (MCLs) with MED-EL implants are significantly higher than comfort levels of Cochlear implants, minimum stimulation levels are similar to each other.

Interpretation:
In general, impedance values are substantially higher in implants from Cochlear compared to MED-EL implants despite mostly using lateral wall electrodes. ECAPs and ESRTs from both manufacturers are comparable in their profile along the electrode array but differ in their overall threshold level due to differences in stimulation parameters.

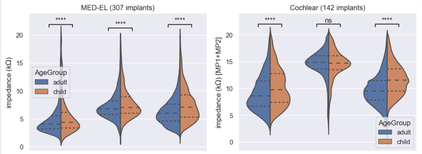
Conclusion:
The best OM for use in fitting the speech processor is the postoperatively obtained ESRTs for both manufacturers. Intraoperative ESRTs are suitable for fitting as well, however, a correction factor for high thresholds has to be applied.

Results

Impedances



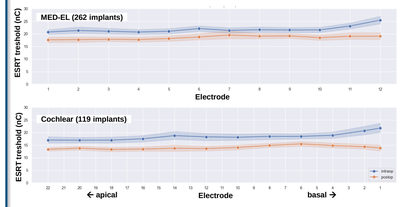
Comparison of impedance values across all electrodes from intraoperative measurements to measurements just before first activation to measurements taken at 3, 6 and 12 months follow ups. **Note the difference between both manufacturers in impedances after first activation:** Impedances in Cochlear decrease almost back to intraoperative values. Impedances in MED-EL implants never go back to intraoperative values. Furthermore important, impedances in more basal electrodes increase over time.



Comparison of impedances between adults (blue) and children (orange) during intraoperative measurement, measurement just before first activation and all postop measurements together (left: MED-EL, right: Cochlear). Dashed lines mark the quartiles (25%,50%, 75%). Except for the first postop activation measurement in Cochlear, the **impedances in children are always significantly higher** than in adults.

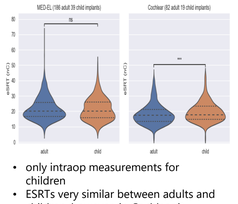
ESRTs

Comparison across electrodes



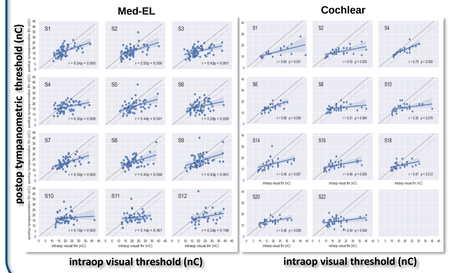
- intraop > postop ESRTs
- significant difference between Med-El and Cochlear → might partially be explained by difference in interphase gap (2.1µs vs. 7µs, e.g. Prado-Guitierrez et al. 2006 for ECAPs) and difference in pulse rate (2000 pps vs. 900 pps)
- intraop ESRTs of basal electrodes with notable increase

Comparison with children data



- only intraop measurements for children
- ESRTs very similar between adults and children, however, in Cochlear it appears to be a significant difference

Comparison between individual intra- and postop data



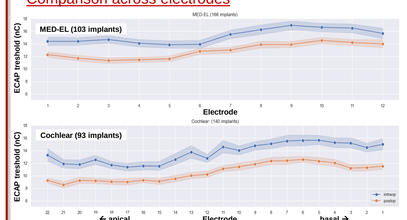
Each data point represents the intraop ESRT (x-Axis) and the corresponding postop ESRT (y-Axis) of one electrode from one individual.

Important to see is that intraop thresholds are not generally - across all intraop levels - higher than postop thresholds but only some thresholds deviate.

Possible reasons for the high intraop thresholds, that do not correlate well with the postop thresholds, could be that the movements of the stapedial tendon is too small to be visible through the microscope or obscured/impeded by fluid or the different type of measurement (visual vs. tympanometric).

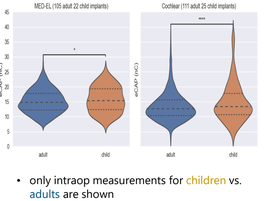
ECAPs

Comparison across electrodes



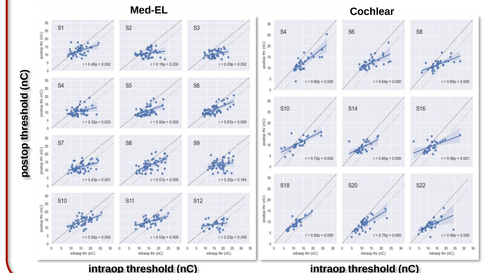
- intraop ECAP thresholds > postop ECAP thresholds in both, MED-EL and Cochlear
- ECAP thresholds basal region > apical region in both, MED-EL and Cochlear
- Med-El ECAP thresholds > Cochlear ECAP thresholds (sig., about 2 nC), but profiles very similar

Comparison with children data



- only intraop measurements for children vs. adults are shown
- ECAPs (like ESRTs) also very similar in adults and children, yet the small difference is statistically significant higher in children

Comparison between individual intra- and postop data



Each data point represents the intraop ECAP threshold (x-Axis) and corresponding postop ECAP threshold (y-Axis) of one electrode from one individual.

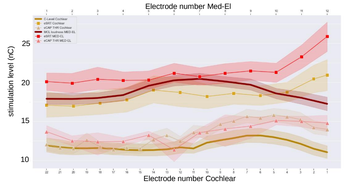
Here, the deviation from the diagonal (same intra- and postop data) is not as pronounced, most data points are on or near the diagonal line.

A possible reason for this could be the same recording technique intra- as well as postop, thus, differences between intra- and postop ECAP thresholds rely on different reasons.

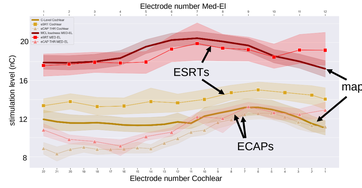
Objectives

Objective measures (OM) such as impedances, electrically evoked stapedial reflexes (ESRT) and electrically evoked compound action potentials (ECAP) may be used to adjust stimulation levels in patients who are not able to communicate their subjective hearing level. The aim in this retrospective data analysis is to compare these OMs intra- and postoperatively, between the two manufacturers MED-EL and Cochlear and to compare them to the behaviorally obtained stimulation profiles. Furthermore, we want to evaluate which OM is best to use for fitting purposes in which manufacturer.

Comparison fitting maps (at 3 months postop) to intraop ESRTs and ECAPs



Comparison fitting maps (at 3 months postop) to postop ESRTs and ECAPs



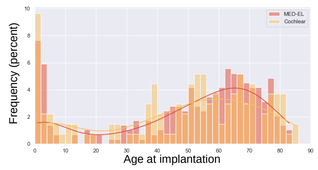
Conclusion

- **The values of some objective measures differ and of some OMs are similar between the two manufacturers**
  - **impedances** in Cochlear implants are much higher than in MED-EL implants despite both being mostly lateral-wall electrodes and using similar measuring mode.
  - **ECAP** thresholds similar and only slightly lower in Cochlear than in MED-EL despite utilizing different measuring methods (alternating polarity (MED-EL) vs. forward masking (Cochlear)) as well as different threshold picking methods).
  - **ESRTs** differ due to different stimuli used (IPG and stimulation rate)
- **The best objective measure for fitting purposes is the postop ESRT in both manufacturers (Cochlear with an offset)**
- **Thus, it is important to meticulously measure ESRTs and ECAPs postop!**

Methods

- The cohort includes 264 adults and 47 children with implants from the manufacturers MED-EL and Cochlear that were implanted at our center between 2009 and 2023. The majority of electrode types implanted at our center were lateral wall electrodes for both manufacturers.
- Clinical routine measurements at our center include impedance, ESRT and ECAP measurements intra- and postoperatively. For this data analysis, only AutoART measurements were analysed for the MED-EL patients, which ensures an objective threshold detection algorithm.
- Postoperative ECAP and ESRT measurements are usually only performed once during the initial fitting session (children usually only ECAPs). Further fitting sessions are at 2 and 6 weeks, 3, 6 and 12 months and yearly afterwards. Data is presented from initial fitting sessions, 3 months, 6 months and 1 year after initial fitting sessions.
- The data of the OMs and the fitting maps (only maximum stimulation levels presented here) were extracted from the clinical databases of the two manufacturers and compared.
- Data processing and analysis was done using Python scripts.

Age distribution of our implantees: Med-El 288 implants since 2009, Cochlear 135 implants since 2013



References

- Baysal, E., Karatas, E., Deniz, M., Baglam, T., Durucu, C., Karatas, Z.A., Mumbuc, S., Kanlikama, M. (2012) Intra- and postoperative electrically evoked stapedius reflex thresholds in children with cochlear implants. International Journal of Pediatric Otorhinolaryngology 76: 649–652
- Gordon K.A., Papsin, B.C., Harrison, R.V. (2004) Toward a battery of behavioral and objective measures to achieve optimal cochlear implant stimulation levels in children. Ear & Hearing 25: 447–463
- Hu, H.C., Chen, J.K., Tsai, C.M., Chen, H.Y., Tung, T.H., Li, L.P.H. (2017) Evolution of impedance field telemetry after one day of activation in cochlear implant recipients. PLoS One 12(3): e0173367
- Hughes, M.L., Vander Werff, K.R., Brown, C.J., Abbas, P.J., Kelsay, D.M.R., Teagle, H.F.B., Lowder, M.W. (2001) A Longitudinal Study of Electrode Impedance, the Electrically Evoked Compound Action Potential, and Behavioral Measures in Nucleus 24 Cochlear Implant Users. Ear & Hearing 22: 471-486
- Prenzler, N.K., Kappelmann, C., Steffens, M., Lesinski-Schiedat, A., Lenarz, T., Warnecke, A. (2018) Single Intravenous High Dose Administration of Prednisolone Has No Influence on Postoperative Impedances in the Majority of Cochlear Implant Patients. Otology & Neurotology 39: e1002-e1009
- van den Borne, B., Snik, A.F.M., Mens, L.H.M., Brokx, J.P.L., van den Broek, P. (1996) Stapedius Reflex measurements during surgery for cochlear implantation in children. The American Journal of Otology 17: 554-558
- Wei, J.J.F., Tung, T.H., Li, L.P.H. (2021) Evolution of impedance values in cochlear implant patients after early switch-on. PLoS ONE 16(2): e0246545