Mouse model of cochlear implantation

Certain issues can reduce implant efficacy including intracochlear tissue response and delayed loss of residual acoustic hearing. Claussen et al., describe a mouse model of cochlear implantation with chronic electric stimulation that can be used to study cochlear implant biology and related pathologies.

Twelve normal hearing adult CBA/J mice underwent unilateral cochlear implantation and were evenly divided into one group receiving electric stimulation and one not. Serial impedance and neural response telemetry (NRT) measurements were made to assess implant functionality. Functionality was defined as having at least one electrode with an impedance ≤ 35 kOhms. Mouse cochleae were harvested for histology and 3D x-ray microscopy 21 days post-operatively, or, in case the implant was still functional, at a later time point when the implant failed. A separate experiment measured the hearing preservation rate in 7 adult CBA/J mice undergoing unilateral cochlear implantation with serial auditory brainstem response (ABR) and distortion product otoacoustic emissions (DPOAE).

Implants maintained functionality for a mean of 35 days in the non-stimulated group and 19.8 days in the stimulated group. Reliable NRT and behavioral responses to electric stimulation were recorded. A robust intracochlear peri-implant tissue response with neo-ossification was seen in all cochleae. Six of seven mice maintained intact low frequency hearing up to 6 weeks following cochlear implantation.

They demonstrate the feasibility of cochlear implantation and behaviorally significant electric stimulation in the mouse, with the potential for hearing preservation. This model may be combined with established mouse models of hearing loss and the large genetic and molecular research toolkit unique to the mouse for mechanistic and therapeutic investigations of cochlear implant biology [1].

Sixty-five C57Bl/6J mice underwent unilateral implantation with implant grade materials: 2 implant grade silicones and a third uncoated platinum wire. A sham surgery group was included as a control. Serial auditory brainstem response (ABR) thresholds and distortion product otoacoustic emissions (DPOAEs) were used to discern effects on hearing over 22 weeks. Histologic measurements of damage to the organ of Corti and spiral ganglion were correlated with degree of hearing loss and material type.

RESULTS: Organ of Corti damage correlated with rate of hearing loss soon after implantation (0-2 weeks) but not subsequently (2-22 weeks). Organ of Corti damage did not depend on implant type and was present even in sham surgery subjects when hearing was severely damaged. Spiral ganglia appeared unaffected. There was no evidence of an inflammatory or toxic effect of the materials beyond the site of implant insertion.

CONCLUSIONS: Hearing loss and cochlear damage appear to be related to insertion trauma, with minimal effect on delayed hearing loss caused by different materials. In the C57Bl/6J mouse model, the sensory epithelium appears to be the location of damage after cochlear implantation [2]

1)
Claussen AD, Vielman Quevedo R, Mostaert B, Kirk JR, Dueck WF, Hansen MR. A mouse model of cochlear implantation with chronic electric stimulation. PLoS One. 2019 Apr 18;14(4):e0215407. doi: 10.1371/journal.pone.0215407. eCollection 2019. PubMed PMID: 30998726.
2)

Kopelovich JC, Robinson BK, Soken H, Verhoeven KJ, Kirk JR, Goodman SS, Hansen MR. Acoustic Hearing After Murine Cochlear Implantation: Effects of Trauma and Implant Type. Ann Otol Rhinol Laryngol. 2015 Dec;124(12):931-9. doi: 10.1177/0003489415592162. Epub 2015 Jun 19. PubMed PMID: 26091845.