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Perspective

Brief Note on Cochlear Implantation in Mouse Model

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DESCRIPTION

Cochlear Implants (CI) have been proven to be a safe and effective treatment option for adults and children with severe to profound sensorineural hearing loss. In many patients with functional low frequency hearing, advances in electrode design and 'soft' surgical procedures have enabled combined electrical and acoustic stimulation, which improves music perception, speech in noise interpretation, and sound localization. The possibility to implant patients with intact low frequency hearing has considerably increased the potential CI candidate population.

Although improvements in electrode design and speech processors have improved CIs, there are still a number of difficulties that limit their effectiveness. The predicted advantages of hearing preservation over conventional CIs relies, at least in part, on the preservation of functional (hearing aid-compatible) low frequency hearing, which allows for combined electric and acoustic stimulation. However, a small percentage of patients report residual acoustic hearing loss following implantation. Immediate post-operative hearing loss is thought to be caused by insertion trauma, but delayed post-activation hearing loss is thought to be caused by multiple factors such as inflammation, neurosensory cell death, strial alterations, or excitotoxicity caused by overstimulation. In some cases, delayed residual acoustic hearing loss may be secondary to intracochlear conductive hearing losses associated with the foreign body tissue response to the electrode array, according to temporal bone histopathology from a single hybrid CI patient, which is consistent with previous modelling predictions. A similar tissue response around the electrode array was observed in several human temporal bone histology series. Inflammatory cells and regions of neo-ossification were detected in 57-96.4 percent of cases of conventional cochlear implantation, together with a foreign body granulomatous reaction.

To explore both intracochlear and auditory pathway responses to cochlear implantation and electric stimulation, several animal models of cochlear implantation have been established. Cats, guinea pigs, and rats are some of the animals that have been studied. In addition to giving typical histopathology data, CI models have aided the study of behavioral and neurological responses to acute and chronic electric stimulation. Several labs have used the guinea pig and rat models to examine intracochlear changes related with conventional and hearing preservation cochlear implantation on a gross anatomic, cellular, and gene expression level. These studies have suggested that CI insertion trauma contributes to the intracochlear tissue response, described associated inflammatory gene expression changes, established a link to electrode impedance changes, and demonstrated the potential for steroid therapy to mitigate the intracochlear tissue response. Animal models have proven to be useful in CI biology for hypothesis creation and testing, as well as offering a pre-clinical model for assessing treatment techniques for concerns including peri-implant tissue response and residual acoustic hearing loss.

A method for passive cochlear implantation without electric stimulation has previously been described. Previous studies suggest that electric current flow patterns and excitotoxic overstimulation may change intracochlear responses to cochlear implantation, hence including electric stimulation in any CI model is important. The capacity to employ clinical CI software to gather impedance data, Neural Response Telemetry (NRT), and induce behavioral changes corresponding with stimulus presentation, suggesting sensory perception of the electric stimulus, is described in this research. The strong genetic and molecular tools unique to the mouse could be used in future trials to examine pertinent themes such as peri-implant tissue response and loss of residual hearing following CI. In a separate series of tests, we show that hearing preservation CI surgery is possible in a mouse model utilizing a similar CI electrode array.

CONCLUSION

The potential for hearing preservation implantation in a mouse model of cochlear implantation with persistent electric stimulation is described. The intracochlear tissue response reported in some human temporal bones is well-replicated, allowing for further mechanistic and therapeutic research. In addition to the radiologic, histologic, and objective measurements methodologies discussed here, the mouse has molecular and genetic research capabilities that provide it a distinct edge over other model species in CI biology studies. To better mimic human cochlear implantation recipients, future investigations with this model should use proven mouse models of hearing loss.

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