Cochlear Fibrosis

The aim of a retrospective case review was to determine the incidence of cochlear fibrosis after the middle fossa approach for vestibular schwannoma between 2013 and 2018, they had complete pre- and post-audiometric testing, and had a clinical follow-up with magnetic resonance imaging (MRI) for at least 1 year after surgery were included.

The review was conducted in a tertiary care academic medical center.

The main outcome of this study was cochlear fibrosis as assessed by MRI 1 year after surgery.

Fifty-one patients underwent VS resection via MCF technique during the study period. Of 31 patients with AAO-HNS class A or B preoperative hearing ability, 18 (58.0%) maintained class A, B, or C hearing postoperatively. Of 16 patients who lost hearing and had MRI 1 year after surgery, 11 (61.1%) had MRI evidence of fibrosis in at least some portion of the labyrinth and 4 (22.2%) showed evidence of cochlear fibrosis. Of 16 patients with preserved hearing and MRI 1 year after surgery, 4 (25%) had fibrosis in some portion of the labyrinth, with no fibrosis in the cochlea.

In patients who lose hearing during VS resection with the MCF approach, there is usually MRI evidence of fibrosis in the labyrinth 1 year after surgery. However, there is also, but less commonly, fibrosis involving the cochlea. It is unclear if this will affect the ability to insert a cochlear implant electrode array [1)].

Increases in electrode impedances have been associated with delayed loss of residual acoustic hearing, suggesting a possible role of intracochlear inflammation/fibrosis as reported by Scheperle et al. (Hear Res 350:45-57, 2017) and Shaul et al. (Otol Neurotol 40(5):e518-e526, 2019). These studies measured only total impedance. Total impedance consists of a composite of access resistance, which reflects resistance of the intracochlear environment, and polarization impedance, which reflects resistive and capacitive properties of the electrode-electrolyte interface as described by Dymond (IEEE Trans Biomed Eng 23(4):274-280, 1976) and Tykocinski et al. (Otol Neurotol 26(5):948-956, 2005). To explore the role of access and polarization impedance components in loss of residual acoustic hearing, these measures were collected from Nucleus EAS CI users with stable acoustic hearing and subsequent precipitous loss of hearing. For the hearing loss group, total impedance and access resistance increased over time while polarization impedance remained stable. For the stable hearing group, total impedance and access resistance were stable while polarization impedance declined. Increased access resistance rather than polarization impedance appears to drive the increase in total impedances seen with loss of hearing. Moreover, access resistance has been correlated with intracochlear fibrosis/inflammation in animal studies as observed by Xu et al. (Hear Res 105(1-2):1-29, 1997) and Tykocinski et al. (Hear Res 159(1-2):53-68, 2001). These findings thus support intracochlear inflammation as one contributor to loss of acoustic hearing in our EAS CI population [2)].

Intracochlear fibrosis following CI represents a significant limiting factor for the success of CI users. Several strategies have been employed to mitigate the foreign body response within the cochlea including drug delivery systems and modifications in surgical technique and electrode design. A better understanding of the FBR has the potential to improve CI outcomes and the next generation of

cochlear prostheses [3].

Carswell et al. examined when cochlear fibrosis occurs following a translabyrinthine approach for vestibular schwannoma resection, and to determine the safest time window for potential cochlear implantation in cases with a preserved cochlear nerve.

Methods: This study retrospectively reviewed the post-operative magnetic resonance imaging scans of patients undergoing a translabyrinthine approach for vestibular schwannoma resection, assessing the fluid signal within the cochlea. Cochleae were graded based on the Isaacson et al. system (from grade 0 - no obstruction, to grade 4 - complete obliteration).

Results: Thirty-nine patients fulfilled the inclusion criteria. The cochleae showed no evidence of obliteration in: 75 per cent of patients at six months, 38.5 percent at one year, and 27 percent beyond one year. Most changes happened between 6 and 12 months after vestibular schwannoma resection, with cases of an unobstructed cochlear decreasing dramatically, from 75 per cent to 38.5 per cent, within this time

Conclusion: The progress of cochlear obliteration that occurred between 6 and 12 months following vestibular schwannoma [4].

Developing materials that reduce or eliminate fibrosis encapsulation of neural prosthetic implants could significantly enhance implant fidelity by improving the tissue/electrode array interface. Here, we report on the photografting and patterning of two zwitterionic materials, sulfobetaine methacrylate (SBMA) and carboxybetaine methacrylate (CBMA), for controlling the adhesion and directionality of cells relevant to neural prosthetics. CBMA and SBMA polymers were photopolymerized and grafted on glass surfaces then characterized by X-ray photoelectron spectroscopy, water contact angle, and protein adsorption. Micropatterned surfaces were fabricated with alternating zwitterionic and uncoated bands. Fibroblasts, cells prevalent in fibrotic tissue, almost exclusively migrate and grow on uncoated bands with little to no cells present on zwitterionic bands, especially for CBMA-coated surfaces. Astrocytes and Schwann cells showed similarly low levels of cell adhesion and morphology changes when cultured on zwitterionic surfaces. Additionally, Schwann cells and inner ear spiral ganglion neuron neurites aligned well to zwitterionic patterns [5].

1)
Shapiro S, Kemper N, Jameson A, Lipschitz N, Hazenfield M, Zuccarello M, Samy R. Cochlear Fibrosis after Vestibular Schwannoma Resection via the Middle Cranial Fossa Approach. Audiol Neurootol. 2022 Apr 4:1-6. doi: 10.1159/000520782. Epub ahead of print. PMID: 35378528.
2)
Tejani VD, Yang H, Kim JS, Hernandez H, Oleson JJ, Hansen MR, Gantz BJ, Abbas PJ, Brown CJ. Access and Polarization Electrode Impedance Changes in Electric-Acoustic Stimulation Cochlear Implant Users with Delayed Loss of Acoustic Hearing. J Assoc Res Otolaryngol. 2022 Feb;23(1):95-118. doi: 10.1007/s10162-021-00809-z. Epub 2021 Oct 22. PMID: 34686938; PMCID: PMC8782980.
3)
Foggia MJ, Quevedo RV, Hansen MR. Intracochlear fibrosis and the foreign body response to cochlear implant biomaterials. Laryngoscope Investig Otolaryngol. 2019 Nov 13;4(6):678-683. doi: 10.1002/lio2.329. PMID: 31890888; PMCID: PMC6929576.
4)
Carswell V, Crowther JA, Locke R, Taylor W, Kontorinis G. Cochlear patency following translabyrinthine

vestibular schwannoma resection: implications for hearing rehabilitation. J Laryngol Otol. 2019 Jul;133(7):560-565. doi: 10.1017/S0022215119001087. Epub 2019 Jul 3. PMID: 31267888.

5) Leigh BL, Cheng E, Xu L, Andresen C, Hansen MR, Guymon CA. Photopolymerizable Zwitterionic Polymer Patterns Control Cell Adhesion and Guide Neural Growth. Biomacromolecules. 2017 Aug 14;18(8):2389-2401. doi: 10.1021/acs.biomac.7b00579. Epub 2017 Jul 24. PMID: 28671816; PMCID: PMC6372952.