Magnetic resonance fingerprinting enables high-resolution joint morphometry and relaxometry of the inner ear

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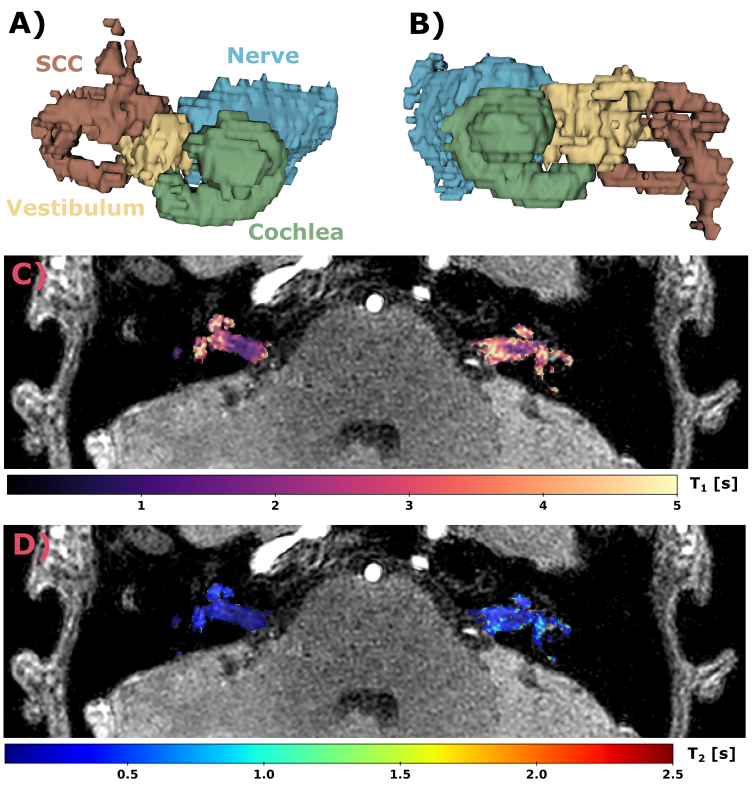
Introduction: Pathologies of the inner ear (IE) - including sensorineural hearing loss, tinnitus, vertigo, and Meniere's disease - present significant diagnostic challenges with conventional MRI [1,2]. Quantitative MRI (qMRI) offers a potential alternative, but current studies are limited. In this work, we developed a high-resolution 3D magnetic resonance fingerprinting (MRF) sequence for joint morphometry and relaxometry of key IE structures.

Methods: The IE-MRF sequence was implemented using the open-source Pulseq framework [3] and based on an Inversion-Recovery FISP readout [4]. Isotropic resolution of 250 µm was achieved using a variable-density spiral readout and trajectory correction. Dictionary-based low-rank reconstruction and pattern matching was implemented for T_1 and T_2 quantification [5]. The method was validated using synthetic inner ear fluids and applied in vivo on a 3T MRI scanner in a healthy volunteer, with segmentation of cochlea, vestibulum, semicircular canals (SCC), and nerve. Relaxometry values were compared with gold-standard techniques.



Morphometry of the left (A) and right IE and T_1 (C) and T_2 (D) relaxation time maps generated with the 3D-IE-MRF sequence.

Results: IE-MRF enabled segmentation and quantitative mapping of major inner ear structures, with high agreement for cochlea, vestibulum, and nerve. However, segmentation of the SCC was incomplete due to low signal and partial volume effects. Relaxation times for synthetic fluids and in vivo subregions were consistent with prior literature, with T_2 values slightly reduced in vivo, likely due to temperature effects.

Conclusion: High-resolution 3D IE-MRF allows combined morphometric and relaxometry assessment of the inner ear and may offer new insights into challenging IE pathologies. While current limitations include signal quality in the SCC and scan duration, future improvements in coil design, acceleration techniques, and high-field imaging are expected to enhance its clinical applicability.

References: **[1]** Davis et al. Bulletin of the World Health Organization. 97(10);646 (2019). **[2]** Benson et al. Radiology. 297(2);252-265 (2020). **[3]** Layton et al. Magn Reson Med. 77(4);1544-1552 (2017). **[4]** Jiang et al. Magn Reson Med. 74(6);1621-1631 (2015). **[5]** Hamilton et al. NMR in Biomedicine. 32(2);e4041 (2019)