Diffusion Tensor Imaging for Predicting Cochlear Implant Outcomes: A Novel Application of Noninvasive Microstructural Analysis

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OBJECTIVE: Cochlear implants (CIs) are the standard for treating profound sensorineural hearing loss, yet postoperative speech perception outcomes remain highly variable. This study hypothesized that the microstructural integrity of subcortical auditory tracts—measured via diffusion tensor imaging (DTI), an MRI technique—can differentiate between hearing and deaf cohorts and serve as a significant predictor of CI success. METHODS: DTI data from 12 normal-hearing controls and 17 CI candidates were preprocessed through an automated pipeline. Probabilistic tractography reconstructed three central auditory tracts: the trapezoid body, lateral lemniscus (LL), and brachium of the inferior colliculus (BI), along which three microstructural DTI metrics were extracted and integrated into ordinary least squares multilinear regression (MLR) models to predict postoperative CNC and AzBio speech scores. RESULTS: CI candidates exhibited significantly higher mean diffusivity (MD) and radial diffusivity (RD) within the LL and BI compared to controls, indicating neural degradation, while fractional anisotropy (FA) was not significantly different. The MLR models demonstrated high predictive accuracy, accounting for 96.8% of the variance in AzBio scores (adj. R-squared = 0.968) and 98.5% in CNC scores (adj. R-squared = 0.985). CONCLUSION: Preoperative diffusivity metrics of auditory tracts are a quantifiable indicator of auditory pathway microstructural health directly influencing speech recovery. While these results validate DTI as a promising clinical tool for outcome prediction, the current predictive model is limited by a small longitudinal cohort (n = 5). A larger sample size is required to confirm MLR coefficients and ensure generalizability among all CI candidates.

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