ABSTRACT

IEEE Trans Biomed Eng. 2022 Apr 29;PP. doi: 10.1109/TBME.2022.3171287. Online ahead of print.

Electromechanical Characterization of Human Brain Tissues: A Potential Biomarker for Tumor Delineation.

Bs A, B A, R S H, V V, Mahadevan A, Pandya HJ.

OBJECTIVE: Objective: Accurate identification of surgical margins in brain tumors is of significant prognostic importance. Despite the availability of methods such as 5-ALA and image guidance, recognizing tumor boundary is highly subjective, dependant on recognizing subtle changes in tissue characteristics including texture and color to aid distinction.

METHOD: Design and development of a semi-automated system integrated with MEMS-based electromechanical sensors to enable an objective and reliable method of distinguishing tumors from normal brain tissue. Simultaneous electrical impedance and viscoelastic characterization of three types of freshly excised gliomas (glioblastoma (GBM), astrocytoma (AST), and oligodendroglioma (OLI)) (N=8 each) and seventeen different normal brain regions (N=6 each) obtained postmortem.

RESULTS: The electrical impedance of gliomas (46256) was found to be significantly lower than corresponding normal (1267515) regions at 100kHz (p=7.46e-11). The difference in the impedance between individual tumor types and corresponding normal regions was also statistically significant (p=1e-8), suggesting accurate tumor delineation. There were distinct differences in the viscoelastic relaxation responses of high-grade and low-grade gliomas. White matter regions demonstrated higher impedance and faster stress relaxation compared to grey matter regions as a characteristic of their structural composition.

CONCLUSION: We demonstrate that simultaneous electromechanical characterization of brain tumors and normal brain tissues can be an effective biomarker for tumor delineation, grading, and studying heterogeneity between the brain regions.

SIGNIFICANCE: The observations suggest the potential use of the technology in a clinical setting to achieve gross total resection and improve treatment outcomes by helping surgeons perform real-time risk evaluation during surgery.

DOI: 10.1109/TBME.2022.3171287
PMID: 35486560