The Current Landscape of Clinical Predictions from Brain Tumor Imaging

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Take-Away Points

- Major Focus: To identify clinical features and tumor characteristics that can be reliably predicted from underlying brain tumor imaging.
- Key Results: This review highlights how noninvasive neuroimaging together with radiomics and artificial intelligence can reliably predict histopathologic grade, molecular biomarkers, and overall prognostication for brain tumors.
- Impact: Although many validation studies must be performed, this review details the current performance of imaging-based predictive models on brain tumor characterization and serves as a valuable resource for paving the path ahead.

While multiparametric MRI is now commonly performed for brain tumor imaging, it remains unknown if these sequences can be used to predict grading, prognostication, and molecular tumor characteristics directly. If reliable, imaging combined with machine learning approaches may reduce reliance on surgical biopsies and provide valuable, noninvasive insight into the neuro-oncologic course for patients and clinicians. Afridi et al conducted a comprehensive review of more than 40 studies to elucidate the state of the art in machine learning, radiomics, dimensionality reduction, and neural networks for brain tumor imaging.

The authors first surveyed the field for studies using multimodal imaging for grading gliomas. On inspection of several studies, deep learning–derived features appeared to be more predictive than conventional texture-based and morphologic radiomics features. Further, models trained using convolutional neural networks from scratch outperformed pretrained models for predicting high-grade gliomas. The models used metrics derived from several imaging techniques, including diffusion tensor imaging, fluorine 18–fluoroethyl-L-tyrosine (ie, ^{18}F-FET) PET, ^{18}F-dihydroxyphenylalanine (ie, DOPA) PET, and dynamic susceptibility MRI data sets. Several models achieved area under the curve values greater than 90% in classifying high-grade gliomas, and similar data sets and radiomic approaches could identify molecular biomarkers, such as IDH mutation, 1p/19q codeletion, and MGMT promotor methylation, from images alone. The authors also reviewed current research on how to differentiate pseudoprogression of gliomas from actual cancer recurrence. Last, they showcased novel applications of radiomics and machine learning models to classify different brain tumor types, even distinguishing brain metastases on the basis of their site of primary origin.

This literature review provides a landing zone for researchers across neuro-oncology to quickly assess where the field stands on predicting tumor characteristics and clinical outcomes from advanced neuroimaging and radiomics. However, much work remains to bring these models into routine clinical use, including validation on external data sets.

—Anael Rizzo and Ricky Savjani

Highlighted Article

Afridi M, Jain A, Aboian M, Payabvash S. Brain tumor imaging: applications of artificial intelligence. Semin Ultrasound CT MR 2022;43(2):153–169. doi: https://doi.org/10.1053/j.sult.2022.02.005