Radiomics in Brain Tumors
An Emerging Technique for Characterization of Tumor Environment

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KEYWORDS

• Radiomics • Radiogenomics • Big data • Brain tumors • Texture analysis

KEY POINTS

- Radiomics refers to the extraction of a large array of quantitative features from imaging that can be correlated with the demographic and genomic profile of the patient.
- Radiomic analysis has the potential to serve as a noninvasive technique for accurate characterization of tumor microenvironment.
- Incorporating simple imaging features, such as tumor location, involvement of eloquent cortex, and extent of the tumor, can improve understanding of tumor genomic profile and aid in therapy planning.

INTRODUCTION

Brain tumor is the growth of abnormal cells in the brain and ranges from noncancerous (benign) to malignant. Glioblastoma (GBM) is the most aggressive type of brain tumor, rising from glial cells, characterized by rapid growth and invasion into nearby brain tissue. GBM has an incidence of 3.19 cases per 100,000 adults per year and average age at diagnosis is 64 years.[1,2] The current line of treatment for patients with GBM involves maximal safe excision of the tumor followed by radiotherapy plus concomitant and adjuvant chemotherapy.[3,4] However, this paradigm of treatment has proven insufficient because most treatments cannot eradicate all tumor cells, explaining the high rate of progression; most patients with GBM survive approximately 12 to 15 months, and only 5% live for more than 5 years.[1,3,4] Another important factor that greatly reduces the efficacy of current therapy is the heterogeneity of gliomas.[5–7] In addition, analysis of histologic specimens highlights the intertumoral and intratumoral differences.[5,7,8] Against this background, research in the field is focused on identifying markers for patient stratification at the point of diagnosis and for follow-up.

MRI is a well-established technique for imaging evaluation of brain tumors because of its high soft tissue contrast.[9,10] Current standard of care involves acquisition of high-resolution MRI scans (<2 mm through plane resolution) that allow for tumor visualization, shape and size determination, and initial staging before surgery[10,11] (**Fig. 1**). Using more advanced imaging techniques, such

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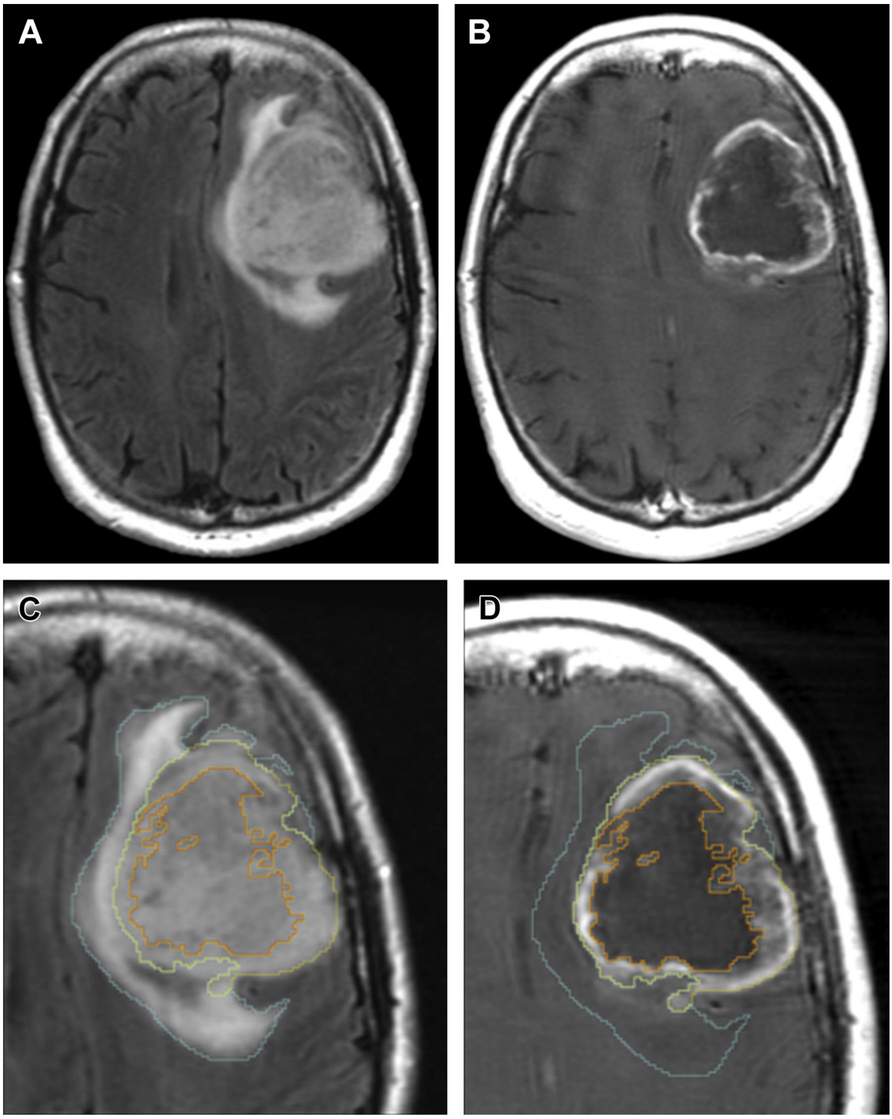

Fig. 1. Grade IV glioma on high-resolution anatomic MRI. A 60-year-old man with enhancing left frontal tumor. (*A*) Axial fluid attenuation inversion recovery MRI shows well-circumscribed intra-axial hyperintense with minimal surrounding vasogenic edema. (*B*) Axial gadolinium-enhanced T1-weighted MRI shows hypointense necrotic core with marginal enhancement. (*C*, *D*) Tumor along with the three-dimensional manual segmentation performed using 3D Slicer v. 4.3.1 (https://www.slicer.org). Edema/invasion is depicted in blue, contrast enhancement in yellow, and necrosis in red.

as diffusion weighted imaging, dynamic susceptibility contrast MRI, and magnetic resonance spectroscopy (MRS), it is now possible to probe the tumor cellularity and its vascular dynamics[12–16] (**Fig. 2**). Quantitative MRI allows for macroscopic, detailed, three-dimensional representation of the tumor and the surrounding environment without the need of invasive procedures, such as biopsy or surgery. Although, the information obtained from MRI is at the tissue/organ level and cannot substitute histologic findings, extracted quantitative parameters are believed to reflect various pathophysiologic aspects of the tissue under examination. Additionally, these parameters are suitable for statistical comparisons with clinical and genomic factors, and longitudinal analysis.

Recent findings have revealed that imaging contains complementary information with demographic and genomic data, giving rise to radiomics.[17,18] The combination of imaging features with demographic information, such as age, sex,