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Early and late structural brain changes after radiation therapy: an MRI study in glioma patients

Erika Joselyn Ludeña Maza [1], Juliana Fernandes Pavoni [1 2], Renata Ferranti Leoni [3]

Affiliations

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Abstract

Purpose: Given the increasing survival rate of patients with brain tumors, it is relevant to investigate the relationship between radiation dose and the severity of lesions in healthy tissue. This study evaluated the effects of radiotherapy (RT) on healthy brain tissue in glioma patients using quantitative magnetic resonance imaging (MRI) to identify radiation-sensitive brain regions and support personalized RT strategies.

Methods: A retrospective analysis included 75 MRIs from 25 patients (Group A) and 39 MRIs from 13 patients (Group B). All underwent postoperative RT with doses ranging from 25 to 60 Gy. MRIs were collected multiple times: before RT, up to 8 months post-RT (Group A), and between 9 and 16 months post-RT (Group B). A linear mixed-effects model identified predictors of volume reduction, cortical thinning, and increased apparent diffusion coefficient (ADC) after RT.

Results: Significant ADC increases were observed in the hemisphere ipsilateral to the tumor site after RT, in the cuneus, inferior parietal, paracentral, pericalcarine, parahippocampal, precuneus, and superior parietal cortices. When controlling for the confounding factors (sex, age, tumor type, scanner, imaging interval, total dose, and regional dose), ADC changes correlated with dose in contralateral middle temporal, par opercularis, and lingual gyri.

Conclusions: Brain volume reduction, cortical thinning, and, mainly, ADC increase were observed in healthy brain regions, indicating potential treatment sequelae. These findings emphasize the importance of developing neuroprotective strategies for radiation-sensitive brain regions and individualized treatment approaches to mitigate cognitive and functional impacts, enhancing patient care and quality of life.

Keywords: Brain volume; Cortical thickness; Diffusion; Glioma; Linear mixed-effect model; Magnetic resonance imaging.