Purpose: To determine if biologically effective proton dose calculated using a relative biological effectiveness (RBE) model with multiple parameters may be used to explain areas of radiation induced brain necrosis indicated on follow-up imaging studies for a patient treated with postoperative intensity modulated proton radiotherapy for malignant meningioma.

Methods: In this study, treatment plan information is extracted from a clinical treatment planning system (TPS) and used to recalculate physical proton dose and linear energy transfer (LET) distributions using Monte Carlo simulations. An RBE model which accounts for tissue specific parameters, LET, biological endpoint, and dose per treatment fraction is applied on a voxel-by-voxel basis to compute a biological effective dose distribution. This dose distribution is subsequently compared to follow-up imaging studies which have indicated the presence of radiation induced necrosis in the treated region of the patient being analyzed. Corresponding areas of toxicity and dose/RBE are compared to determine the governing relationship.

Results: Areas of increased biological effective dose compared to the original dose distribution calculated by the clinical TPS are found to correspond to areas of radiation induced necrosis identified on follow-up imaging. Biologically effective dose is found to be increased over TPS dose by as much as 8% of the prescribed dose for the patient.

Conclusions: Dose distributions which account for the variable nature of proton RBE may provide insight into toxicity risk for patients treated with proton radiotherapy.