A Machine Learning Model with Radiomics for Predicting Local Control Outcomes for Melanoma Brain Metastases Treated with Stereotactic Radiosurgery

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Objectives: Radiomics has the potential to revolutionize clinical decision making in the management of melanoma brain metastases (MBM) treated with stereotactic radiosurgery (SRS). Radiomic features extracted from baseline magnetic resonance (MR) imaging could be integrated into patient and treatment parameters to predict long term outcomes in order to tailor multimodal treatment strategies, permit individualized surveillance imaging frequency and facilitate early changes to therapy following SRS. This study aimed to assess the predictive accuracy of a baseline-MRI radiomics model in MBM patients to predict local failure following SRS.

Methods: Patients receiving single-fraction Cobalt-based SRS for MBM at a single Australian institution were analysed. Predictive patient and treatment characteristics, including the type and timing of systemic therapy were collected. Progression of disease (PD) outcomes were defined either histologically or according to clinicoradiologic criteria as per RANO-BM. 108 radiomic features were extracted from T1-weighted Gadolinium contrast-enhanced MPRAGE MRI sequences using in-house software developed in MATLAB. Highly dependent radiomic features were selected using an analysis of variance (ANOVA). Four models; logistic regression, random forest, SVC, and decision tree models were generated to predict local progression as a binary classifier. A multivariate model was additionally developed, integrating radiomic features with baseline lesion volume, immunotherapy use and SRS dose. The models' accuracy and precision score were computed to assess the power of the model to predict progression of disease.

Results: 101 MBM patients were treated with SRS. The median duration of follow-up was 29.2 months (IQR 19.7-39.8). Median dosage was 20Gy (IQR 18-20). The median volume and diameter of the lesion at baseline were 0.24cc (IQR 0.06-1.02) and 7.7mm (IQR 4.8-12.2), respectively. 53% of patients were BRAF mutants, and 65% of those patients had failed BRAF inhibitors prior to SRS. 34.4% of patients took BRAF inhibitors concurrently (48 hours), and 77.0% received immunotherapy concurrently (4 weeks pre to 4 weeks post-SRS). 349 MBM lesions were included in the radiomics model. The local control rate was 87.1% with a median time to progression of 8.7 months. Utilizing baseline imaging alone, all four models were able to predict long term PD following SRS with an average 85% prediction accuracy and an 86% precision score. Homogeneity, Correlation, Joint Entropy, Cluster Prominence,

and Difference Entropy were the prominent features among all the extracted features and have the potential to predict PD.

Conclusion(s): A baseline-MRI radiomics model in MBM patients can predict local failure following SRS to a high degree of accuracy. Additional integration of radiomics models utilizing multiparametric imaging combined with patient and treatment characteristics will optimize the use of radiomic tools into the clinic.