

Meningioma WHO Grade Prediction via a Novel Artificial Intelligence Algorithm Combining Preoperative MRI and Intraoperative Spectroscopy

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Introduction

The extent of meningioma resection influences the rate of tumor recurrence and, in higher-grade lesions, overall survival. Surgical aggressiveness depends on presumed disease severity, which can be difficult to assess until postoperative tissue analysis. Our group has developed 1) a non-destructive laser endogenous fluorescence spectroscopy device (“TumorID”) to predict pathology prior to resection in real-time, and 2) a preoperative WHO grade prediction algorithm based on MRI-derived topological features of the tumor. We demonstrate a first-of-its kind fusion of these two novel data streams for potentially improved prediction of meningioma grade prior to tissue resection.

Methods

Two patients undergoing resection of a suspected meningioma were included in this preliminary analysis. The TumorID was used to scan intraoperative, in vivo tissue of each patient and a machine learning model previously trained on in vivo meningiomas predicted the WHO grade. Additionally, we implemented a pipeline that extracts custom features to describe a tumor’s shape and topology to predict the WHO grade from preoperative MRIs, which our group has previously described. Both outputs were combined in order to create a new prediction of each patient’s WHO grade. Due to limited data, training a fusion layer to combine both models was not possible, so instead a logistic regression model with pre-determined weights and thresholds (set at 0.5) was implemented.

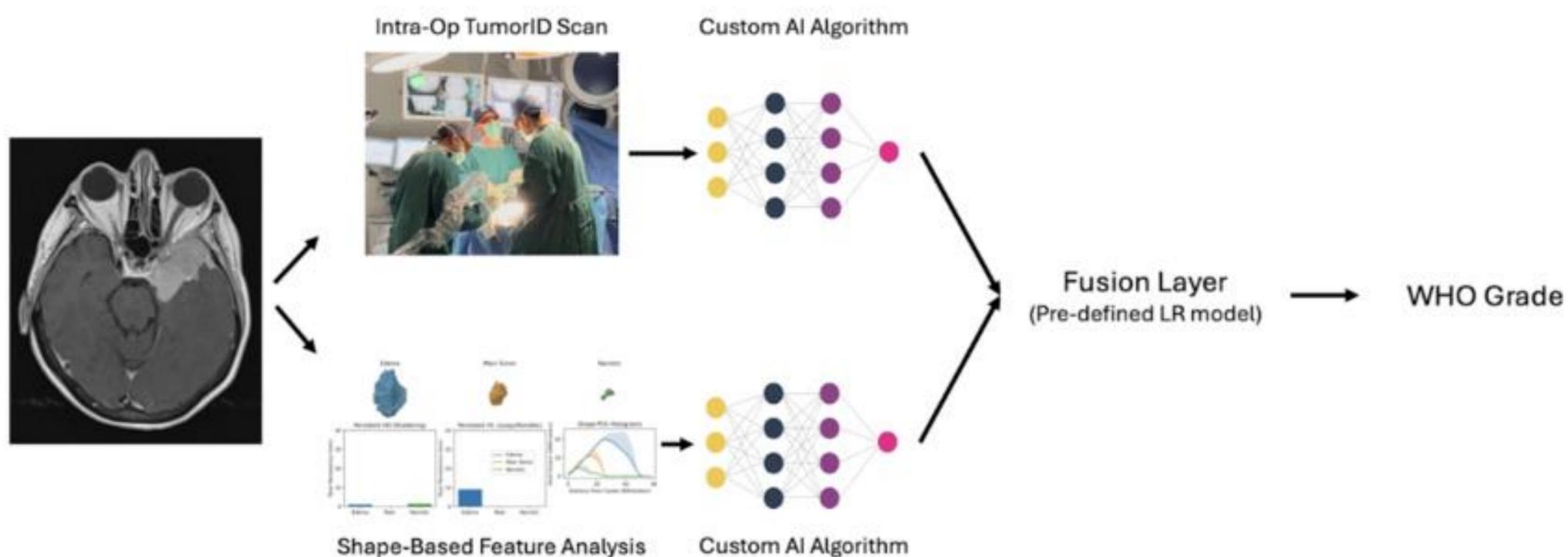


Figure 1: Preoperative MRI is integrated with intraoperative TumorID fluorescence spectroscopy and quantitative shape-based radiomic feature analysis. Each modality is processed through a custom artificial intelligence algorithm to generate modality-specific predictive outputs. These outputs are combined in a predefined logistic regression–based fusion layer, producing a final prediction of WHO tumor grade. This framework enables synergistic integration of structural imaging, intraoperative optical signatures, and morphometric features to improve grading accuracy.

Results

One patient had a final diagnosis of WHO grade 1 meningioma, and the other was grade 2. The combined TumorID and topology model correctly predicted each patient’s WHO grade, including when one modality predicted incorrectly.

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Conclusions

This proof-of-concept study demonstrates the successful implementation of a fusion model combining endogenous fluorescence data intraoperatively and preoperative MRI topology features to predict meningioma WHO grade prior to tissue resection. This study provides the basis for a larger scale investigation in more patients and centers. Future studies should investigate other pathologies and genetic markers.