Redefining MRI:
From Image to Insight

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Beyond Diagnosis: Translating Oncologic MRI into Immersive Surgical Simulation

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Oncologic MRI should do more than identify and classify a tumor; it should help the surgeon decide how to approach, navigate, and resect it. This lecture presents a framework for converting multiparametric MRI from two-dimensional images into an immersive, patient-specific surgical environment. Structural MRI, tractography, perfusion, vascular anatomy, and functional information can be spatially integrated to visualize the tumor, eloquent networks, critical vessels, and the intended operative corridor.

The framework builds on our research in photographic three-dimensional neuroanatomy, virtual dissection, and multiuser virtual-reality education. Our work integrating photogrammetric brain models into VR, followed by comparison of cadaveric photogrammetric and Visible Korean–derived segmented models, highlights two complementary requirements for simulation: tissue realism and structural clarity. Photogrammetric models preserve texture and operative context, whereas segmented models support labeling and selective visualization. Together, these principles provide an architecture for patient-specific oncologic simulation, allowing surgeons to interrogate the tumor–brain interface, compare craniotomy and trajectory options, rehearse alternative extents of resection, and communicate strategy and risk in a shared virtual space. Our glioblastoma studies of extent of resection and recurrence patterns further emphasize that imaging should guide not only tumor localization, but also the spatial and oncologic boundaries of surgery.

Future platforms will combine automated segmentation, quantitative imaging biomarkers, longitudinal MRI, molecular data, and intraoperative updates into continuously refined digital models. Key barriers include segmentation uncertainty, registration error, brain shift, workflow burden, interoperability, and insufficient evidence of improved patient outcomes. Immersive simulation should therefore be viewed not as a visualization endpoint, but as a translational interface connecting oncologic imaging, surgical decision-making, education, and precision neuro-oncology.

Keywords: *Oncologic MRI, Virtual reality, Surgical simulation, Glioblastoma, Three-dimensional modeling, Precision neuro-oncology*