Neurosurgery. 2024 Mar 26. doi: 10.1227/neu.0000000000002933. Online ahead of print.

Intraoperative MRI: A Review of Applications Across Neurosurgical Specialties

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PMID: 38530004 DOI: 10.1227/neu.0000000000002933

Abstract

Intraoperative MRI (iMRI) made its debut to great fanfare in the mid-1990s. However, the enthusiasm for this technology with seemingly obvious benefits for neurosurgeons has waned. We review the benefits and utility of iMRI across the field of neurosurgery and present an overview of the evidence for iMRI for multiple neurosurgical disciplines: tumor, skull base, vascular, pediatric, functional, and spine. Publications on iMRI have steadily increased since 1996, plateauing with approximately 52 publications per year since 2011. Tumor surgery, especially glioma surgery, has the most evidence for the use of iMRI contributing more than 50% of all iMRI publications, with increased rates of gross total resection in both adults and children, providing a potential survival benefit. Across multiple neurosurgical disciplines, the ability to use a multitude of unique sequences (diffusion tract imaging, diffusion-weighted imaging, magnetic resonance angiography, blood oxygenation level-dependent) allows for specialization of imaging for various types of surgery. Generally, iMRI allows for consideration of anatomic changes and real-time feedback on surgical outcomes such as extent of resection and instrument (screw, lead, electrode) placement. However, implementation of iMRI is limited by cost and feasibility, including the need for installation, shielding, and compatible tools. Evidence for iMRI use varies greatly by specialty, with the most evidence for tumor, vascular, and pediatric neurosurgery. The benefits of real-time anatomic imaging, a lack of radiation, and evaluation of surgical outcomes are limited by the cost and difficulty of iMRI integration. Nonetheless, the ability to ensure patients are provided by a maximal yet safe treatment that specifically accounts for their own anatomy and highlights why iMRI is a valuable and underutilized tool across multiple neurosurgical subspecialties.