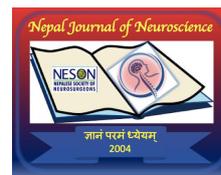


# Artificial Intelligence in Neurosurgery: Shaping the Future of Precision Neurosurgical Care

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Date of Submission: 26<sup>th</sup> February 2026Date of Acceptance: 8<sup>th</sup> March 2026Date of Publication: 15<sup>th</sup> March 2026

## Editorial

Artificial Intelligence (AI) has rapidly emerged as one of the most transformative technologies in modern medicine. In recent years, its integration into neurosurgery has begun to reshape diagnostic approaches, operative planning, and outcome prediction. The complexity of neurological diseases, coupled with the enormous volume of imaging and clinical data generated in neurosurgical practice, makes the field particularly suited for the application of AI-driven tools. As neurosurgery moves toward precision medicine, AI has the potential to significantly enhance clinical decision-making, improve patient outcomes, and optimize healthcare delivery.

Artificial intelligence broadly refers to computational systems designed to perform tasks that traditionally require human intelligence. Machine learning (ML) and deep learning—subfields of AI—enable computers to analyze large datasets, recognize patterns, and generate predictive models. These technologies are particularly valuable in neurosurgery where interpretation of neuroimaging, prediction of disease progression, and analysis of surgical outcomes often involve complex multidimensional data.<sup>1</sup>

One of the most promising areas for AI in neurosurgery is neuroimaging analysis. Modern neurosurgical practice relies heavily on imaging modalities such as CT, MRI, and functional imaging techniques. Deep learning algorithms have demonstrated high accuracy in detecting intracranial hemorrhage, brain tumors, and other neurological abnormalities on imaging studies. Automated image interpretation systems can assist clinicians in early detection of critical conditions and help prioritize urgent cases, thereby improving workflow efficiency and patient care.<sup>2</sup>

In brain tumor management, AI-based segmentation algorithms are now capable of identifying tumor boundaries and assisting in surgical planning with remarkable precision.<sup>3</sup>

Another significant application of AI lies in predictive analytics and outcome prediction. Machine learning models can analyze large clinical datasets to predict surgical risks, postoperative complications, and long-term outcomes. Such predictive models may assist neurosurgeons in counseling patients, selecting optimal treatment strategies, and improving perioperative management. Studies have demonstrated that machine learning algorithms can outperform traditional statistical methods in predicting neurosurgical outcomes.<sup>4</sup>

AI is also increasingly being integrated into robotic-assisted neurosurgery and surgical navigation systems. Robotic platforms combined with intelligent algorithms can enhance precision during delicate procedures, reduce human error, and assist surgeons in complex anatomical environments. AI-powered navigation systems may eventually integrate imaging, anatomical mapping, and real-time surgical feedback to guide surgeons with unprecedented accuracy.

Despite these advancements, several ethical and practical challenges accompany the adoption of AI in neurosurgery. Issues related to data privacy, algorithm transparency, and potential bias in training datasets remain significant concerns. Furthermore, the implementation of AI tools requires robust validation, regulatory oversight, and integration with existing clinical workflows. AI should be viewed as an adjunct rather than a replacement for clinical expertise; the neurosurgeon's judgment and experience remain central to patient care.<sup>5</sup>

For developing healthcare systems, including those in South Asia, AI also presents unique opportunities. Automated diagnostic systems and decision-support tools could help bridge gaps in specialist availability and improve access to high-quality neurosurgical care. However, successful implementation requires investment in digital infrastructure, training, and collaborative research efforts.

Artificial intelligence represents a powerful tool with the potential to transform neurosurgical practice. From advanced imaging interpretation to predictive analytics and robotic surgery, AI-driven innovations are already beginning to influence the field. Thoughtful integration of these technologies can enhance clinical decision-making, improve patient outcomes, and usher in a new era of precision neurosurgery.

Over time, marked improvements in accuracy, productivity, and workflow will likely be actualized, but whether that will be used to improve the patient-doctor relationship or facilitate its erosion remains to be seen.<sup>6</sup>

### Access this article online

Website: <https://www.nepjol.info/index.php/NJN>DOI: <https://doi.org/10.3126/njn.v23i1.91787>

### HOW TO CITE

Kafle, P. Artificial Intelligence in Neurosurgery: Shaping the Future of Precision Neurosurgical Care. *NJNS*. 2026;23(1):1-2

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ISSN: 1813-1948 (Print), 1813-1956 (Online)



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## Conclusion

Artificial intelligence is poised to become an important adjunct in modern neurosurgical practice. From improved diagnostic accuracy and advanced imaging interpretation to enhanced surgical planning and outcome prediction, AI has the potential to significantly improve patient care. While technological and ethical challenges remain, responsible integration of AI into clinical practice can support neurosurgeons in delivering more precise, efficient, and personalized treatment. Continued collaboration between clinicians, researchers, and technologists will be essential to ensure that these innovations are applied safely and effectively for the benefit of patients.

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