What Is the Role of AI in Orthopedic Surgery Planning?

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Abstract

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Artificial intelligence (AI) is rapidly transforming various fields of medicine, and orthopedic surgery is no exception. The integration of AI into surgical workflows, particularly in the planning stages, is revolutionizing how surgeons prepare for and execute complex procedures. By leveraging sophisticated algorithms and machine learning models, AI offers unprecedented levels of precision, personalization, and efficiency, ultimately aiming to improve patient outcomes. This article explores the pivotal role of AI in modern orthopedic surgery planning, from advanced image analysis to the development of predictive surgical models.

One of the most significant contributions of AI in orthopedic surgery is the enhancement of preoperative planning through advanced medical image analysis. Traditionally, surgeons have relied on their experience to interpret medical images such as X-rays, computed tomography (CT) scans, and magnetic resonance imaging (MRI). While effective, this process can be time-consuming and susceptible to human error. AI, particularly through the use of convolutional neural networks (CNNs), has automated and improved the accuracy of image segmentation, classification, and 3D modeling [1]. These technologies allow for the creation of highly detailed and patient-specific 3D anatomical models. For instance, AI algorithms can precisely measure vertebral rotation angles and curvature deviations in spinal deformity correction surgery, with errors reduced to within 0.5 degrees. This level of detail enables surgeons to better visualize complex anatomical structures, identify pathological regions, and develop more precise surgical strategies, significantly reducing planning time and improving physician-patient

communication [1].

Beyond image analysis, AI is being used to develop sophisticated surgical planning models that generate personalized and optimized surgical strategies. These models integrate a patient's clinical data with imaging analysis to predict postoperative outcomes and streamline orthopedic workflows. For example, the AIHIP (AI-powered preoperative planning) system for total hip arthroplasty (THA) has demonstrated superior accuracy and clinical performance compared to traditional planning methods, significantly reducing the time and manpower required to formulate a detailed surgical plan [1]. Furthermore, AI models can optimize surgical pathways, which is particularly valuable in orthopedic oncology. By integrating with robotic systems, AI can assist in planning more accurate surgical strategies and optimized pathways for bone tumor surgeries, thereby reducing procedural complexity [1]. The ability of AI to simulate different surgical scenarios and predict their outcomes allows surgeons to select the most effective and least invasive approach for each patient.

The role of AI extends beyond preoperative planning and into the operating room, providing real-time intraoperative assistance. AI-powered systems can process data from various sources, including intraoperative imaging and robotic sensors, to offer dynamic guidance and decision support to the surgeon. By integrating intraoperative imaging with preoperative 3D models, AI systems can dynamically update anatomical visualizations, offering surgeons high-resolution, real-time navigation. This is particularly beneficial in complex procedures like spinal surgery, where robotic navigation systems powered by AI have been shown to improve the accuracy of pedicle screw placement and reduce procedural time [1]. The convergence of AI with advanced robotic technologies is ushering in a new era of intraoperative precision, helping to overcome the limitations of manual procedures and improve surgical safety.

In conclusion, artificial intelligence is playing an increasingly vital role in orthopedic surgery planning, offering a wide range of benefits from enhanced visualization and personalized strategies to real-time intraoperative guidance. While challenges such as data privacy, model generalizability, and ethical considerations remain, the continued advancement of AI technologies promises to further revolutionize the field of orthopedic surgery. As AI models become more sophisticated and integrated into clinical practice, they will undoubtedly empower surgeons to deliver safer, more effective, and more personalized care to their patients.

References

[1] Han, F., Huang, X., Wang, X., Chen, Y. F., Lu, C., Li, S., Lu, L., & Zhang, D. W. (2025). Artificial Intelligence in Orthopedic Surgery: Current Applications, Challenges, and Future Directions. *MedComm*, 6(7), e70260. https://pmc.ncbi.nlm.nih.gov/articles/PMC12188104/