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DO ROBOTIC AND AI TECHNOLOGIES IMPROVE OUTCOMES IN ORTHOPAEDIC SURGERY OR RAISE COSTS AND LEARNING CURVES?

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Abstract

Robotic and AI technologies are making waves in orthopaedic surgery by enhancing precision in procedures like total knee arthroplasty (TKA), total hip arthroplasty (THA), and spinal surgeries. While these advancements offer improved implant alignment and diagnostics, concerns linger regarding their high costs, steep learning curves for surgeons, and limited long-term evidence surrounding their cost-effectiveness.

Keywords: Robotics; Artificial Intelligence; Orthopaedic; Arthroplasty.

Editorial

The landscape of orthopaedic surgery is rapidly evolving with robotic-assisted systems (RAS) and artificial intelligence (AI). These technologies promise greater precision, improved outcomes in total knee arthroplasty (TKA), total hip arthroplasty (THA), and spine surgeries, as well as data-driven personalization of care. Yet, critical questions remain: do these innovations genuinely improve patient outcomes, or do they primarily add costs and learning burdens for surgeons?

Benefits and Potential

Proponents highlight that robotic platforms enhance surgical accuracy, lower malalignment rates, and may reduce revision surgeries. RA-TKA and RA-THA demonstrate improved implant positioning and recovery profiles, while spine surgery reports up to 95% accuracy in pedicle screw placement.[1–3] AI further complements this by predicting complications, optimizing preoperative planning, and reducing diagnostic errors, thereby advancing patient-centred care.[4-6]

Challenges and Limitations

Despite these advances, steep learning curves and increased operative times remain significant hurdles, with 15–30 cases often required for proficiency in RA-TKA.[7-11] Costs also weigh heavily: robotic lumbar fusion can be up to 30% more expensive than minimally invasive methods, while cost-effectiveness analyses often show negligible outcome differences compared with navigation techniques.[12–16] Furthermore, AI integration faces barriers of data quality, algorithmic bias, and validation gaps.[17–19] Environmental concerns and high consumable use add to the debate.

The Wider Team and Patient Role

Anesthesiologists play a critical part in ensuring patient safety during RAS procedures, where bulky equipment and fixed positioning increase risks.[20] Patient expectations also influence adoption, though outcomes sometimes fall short of perceived superiority, underscoring the importance of transparent education.[21]

Looking Forward

Future integration may hinge on hybrid approaches, combining AI's predictive power with robotic precision, while thoughtful implementation is vital to avoid creating costly distractions.[22–25] While RAS can help reduce surgical waiting lists in high-volume systems by accelerating recovery and freeing beds, their role in global orthopaedics must be assessed carefully.[26]

Conclusion and Relevance to LMICs

Robotics and AI represent a transformative shift in orthopaedic surgery, with potential to enhance accuracy, safety, and personalization. Yet, steep costs, extended training, and limited long-term evidence challenge their universal adoption. Equitable integration requires robust multi-centre trials to clarify cost-effectiveness, ethical oversight of AI algorithms, and strategies to minimize healthcare disparities. For low- and middle-income countries such as Iraq, the promise of improved outcomes must be weighed against strained health budgets, workforce training needs, and limited infrastructure. Thoughtful prioritization—emphasizing affordable, scalable, and context-appropriate innovations—will be essential to ensure these technologies serve patients equitably rather than widening global surgical gaps.

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