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EDITORIAL

Artificial Intelligence in Orthopedics: The Promise, The Challenges, and The Path Forward

Bibek Banskota
Editor-in-chief

INTRODUCTION

The use of artificial intelligence (AI) is gaining traction in orthopedic education and research, offering novel surgical training and scientific advancement approaches.[1-3] As the global AI healthcare market grows at 47.6% annually, certain fundamental questions on readiness have to be faced.[4] While AI technology offers unprecedented opportunities to address healthcare inequities, successful deployment requires comprehensive policy frameworks, robust infrastructure, and systematic capacity building. The central premise remains: "AI should augment, not replace, clinical expertise". This editorial explores the opportunities and challenges in mainstreaming AI in healthcare in Nepal.

THE PROMISE

1. Diagnostic Capabilities

AI's most immediate impact lies in diagnostic precision. Computer vision algorithms can process medical images (radiographs, CT, MRI) at scale—classifying fractures, segmenting anatomy, or measuring joint alignments—with accuracy rivaling experienced experts'.[1,3,7,8] For Nepal's context, this capability addresses critical specialist shortages across various specialties.

Modern deep learning systems have shown the potential to detect subtle fractures, early osteoarthritis, bone tumors, and spinal abnormalities. In scenarios where specialist radiologists are unavailable, AI could provide immediate expert-level image interpretation. The potential ability of AI to standardize diagnostic quality across geographic barriers offers unprecedented potential for healthcare equity.

The transformative implications of AI where vertebral compression fractures could be identified instantly, osteosarcomas flagged for urgent referral, complex trauma cases appropriately triaged, and so forth, without requiring specialist availability, opens the prospect of a new era of 'fast-track' diagnosis and referral.

2. Enhanced Surgical Training and Planning

Virtual reality (VR) and augmented reality (AR) surgical simulators, often coupled with AI analytics, let trainees practice complex procedures (e.g., arthroscopy, trauma management, joint replacement) in immersive, risk-free settings.[1,2,7] This can prove to be invaluable to address limited training opportunities where case volumes and supervision may be constrained.

AI-powered surgical planning creates detailed 3D anatomical models from standard imaging, enabling surgeons to visualize complex cases before operation. Machine learning algorithms applied to virtual reality surgical tasks can accurately distinguish novice from expert techniques and provide automated feedback on safety, efficiency, and precision.[1,7] This objective assessment has the potential to overcome traditional apprenticeship model limitations.

Cumulatively, AI's surgical planning and training opportunities could help reduce operative times, minimize complications, and improve outcomes through better preparation.

AI also has the ability to enhance and expedite research by virtue of it's ability to scan huge datasets and literature, though the question of plagiarism, accuracy, and originality, is still a subject of debate.

3. Predictive Analytics

Studies have shown that artificial neural networks accurately predict postoperative length of stay, discharge disposition, and functional recovery in joint arthroplasty.[3,10] AI systems can be utilized to identify patients at high risk for complications, enabling proactive interventions. By analyzing thousands of similar cases, algorithms predict which patients will benefit most from specific treatments, optimizing resource allocation.

4. Telemedicine

In a resource-limited environment with difficult geography, telemedicine seems to be a necessity rather than a luxury! AI-enhanced platforms can provide real-time diagnostic support, enabling local healthcare workers to access specialist expertise remotely.[5,6,9] Mobile applications with AI diagnostic capabilities have the potential to transform rural healthcare delivery.

THE CHALLENGES

1. Policy Development Progress and Healthcare Implementation Gaps

In August 2025, Nepal took a significant step forward by approving its **National AI Policy, 2025**, establishing institutional, legal, and regulatory frameworks for AI governance while ensuring its ethical, transparent, and inclusive use across all sectors.[12] The policy focuses on developing human resources with the necessary skills to work with AI in promoting innovation, research, and development.[12] The policy includes several healthcare-relevant provisions: it emphasizes skill development from school to university levels, encourages AI use in public service delivery including health, and establishes risk management strategies to address AI-related threats.[12] An **AI Regulation Council** chaired by the communications minister and a **National AI Centre** under the

communication ministry will manage AI developments.[12]

However, significant implementation challenges remain for healthcare applications. While the policy provides overarching frameworks, clear definitions are required to address the issues of healthcare-specific guidelines for AI system validation, clinical liability determination, and patient data protection.[4,11]

2. Infrastructure Barriers: A Digital Reality

Nepal's current digital infrastructure presents fundamental implementation barriers. Technical challenges such as network overload, frequent power cuts, lack of electricity, and internet instability directly impact AI system reliability.[5,6] AI diagnostic systems require consistent power, reliable connectivity, and high-resolution image transfer. Current infrastructure limitations could result in system failures during critical diagnostic moments. Moreover, real-time cloud-based applications may not function optimally without substantial upgrades in bandwidth and reliability.

3. Data Infrastructure Deficit

Nepal lacks uniform standardized electronic health records (EHRs) essential for AI training and validation.[4,6,11] Without comprehensive local datasets, AI models trained on international populations have the risk of underperforming in our clinical contexts. Local validation requires significant investments in data collection and management capacity.

4. Human Capital and Training Challenges

Most AI studies in orthopaedics remain limited to simulation-based settings, with insufficient evidence on clinical skill transfer.[1,7] This limitation is magnified in settings (such as ours) where current medical education curriculums provide negligible AI exposure. Majority of healthcare providers are still unprepared for AI-enhanced practice. Beyond technical skills, clinicians must understand the use as well as limitations of AI, and maintain clinical judgment alongside automated recommendations.[2,4]

THE PATH FORWARD

1. Building on National AI Policy Framework

Nepal's **National AI Policy, 2025** provides a strong foundation for healthcare AI governance.[12] However, orthopaedic implementation requires healthcare-specific adaptations:

- Clinical validation protocols for AI diagnostic systems
- Liability frameworks for AI-assisted medical decisions
- Patient consent procedures for AI use in care
- Integration standards with existing health information systems

2. Infrastructure Investment Strategy

Investment should prioritize healthcare facility connectivity, reliable power, and local data centers to reduce dependence on international cloud systems.[5,6,9] Development of comprehensive EHR systems and interoperability frameworks are critical to ensure uniformity and smooth function of AI systems.

3. Strategic Public-Private Partnerships

Healthcare institutions, technology companies, and international organizations, must collaborate on pilot projects—such as AI fracture detection in emergency settings, osteoarthritis screening in primary care etc. to define the role of AI in specific pathologies.[4,9] The results of such projects can inform the way forward for wider dissemination and application.

4. Education and Capacity Building

AI adoption requires both computational resources and skilled professionals.[4] Medical curriculums should integrate AI literacy while safeguarding the integrity of clinical reasoning. Hybrid human–AI training models and standardized evaluation metrics have the potential to maximize the clinical benefits without compromising on patient safety.[1,2,7]

CONCLUSION

AI holds considerable promise to improve and advance orthopaedic education, research, and care delivery. However, its integration must be guided by rigorous validation, ethical safeguards, and multi-stakeholder collaboration. Integration of AI systems into current practice depends on our collective willingness to address policy gaps, invest in infrastructure, and prioritize human capacity building. The opportunity is substantial, but the window is limited. As the global race for AI supremacy gains momentum, we must also act timely and decisively to avoid being left behind, and more importantly to lose precious opportunities to benefit our trainees and our patients.

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