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Indian Journal of Medical Sciences

Viewpoint

Uses, benefits and future of artificial intelligence (AI) in orthopedics

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ABSTRACT

The use of artificial intelligence (AI) technology in healthcare is estimated to grow at 47.6%/year. AI applications in orthopedics are used for diagnostics, predictive models, medical image analysis, and risk prediction. This review aims to provide an understanding of AI applications used in orthopedics, their benefits, future applications, and challenges to be overcome.

Keywords: Orthopedics, Artificial intelligence, Machine learning, Natural language processing, Deep learning, Future of AI in Healthcare

INTRODUCTION

The use of artificial intelligence (AI) in healthcare has become increasingly popular due to its ability to improve health outcomes while reducing the cost of care. AI in the healthcare market is projected to grow from USD 14.6 billion in 2023 to USD 102.7 billion by 2028 at a compound annual growth rate of 47.6%.[1] Big data solutions that can effectively process large and complex healthcare data from multiple sources such as medical devices, electronic medical records, claims and billing records, prescriptions, and wearable devices have been a major driver for innovative healthcare AI solutions.

At present, the use of AI applications in orthopedics ranges from machine learning (ML) algorithms that can grade osteoarthritis by analyzing radiographs to augmented reality-based medical training systems that will improve implant orientation in hip replacements.

In this review, we provide an overview of AI applications in orthopedics, AI techniques used, their benefits, future AI applications, and the challenges that need to be overcome to realize their potential.

IMPORTANCE OF MEDICAL DATA IN AI APPLICATIONS

The average hospital produces approximately 137 terabytes of data per day or 50 petabytes of data every year and this data has been growing by 47%/year.[2] The accuracy and usability of AI applications to produce desired results are heavily dependent on the data available for the various AI techniques. For example, the recent AI sensation ChatGPT application was trained using 300 billion words and 175 billion parameters from web pages, books and other online resources.[3] Data need to be cleaned to eliminate incomplete, incorrect, duplicate, and improperly formatted data before it can be standardized and used in AI applications. In general, the larger the data available for AI applications, the better the results.

Data can be categorized as structured and unstructured data. Structured medical data would include patient demographics, vitals, laboratory results, and prescriptions, while unstructured data would include clinical notes, discharge summaries and radiology images. Medical data are largely unstructured with medical imaging data making up 80% of all clinical data.[2]

AI TECHNIQUES USED IN ORTHOPEDIC AI APPLICATIONS

AI is an umbrella term that includes several techniques such as ML, natural language processing (NLP), and deep learning (DL). Most orthopedic AI applications use multiple AI techniques in their solution.

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Received: 07 October 2023 **Accepted:** 01 January 2024 **EPub Ahead of Print:** 17 February 2024 **Published:** 06 July 2024 **DOI:** 10.25259/IJMS_205_2023

Machine learning (ML)

ML uses algorithms to identify patterns in data and to make predictions. In supervised ML, algorithms are trained using a training data set to produce a predefined outcome. For example, in one application, six supervised ML algorithms accurately predicted the length of stay for lumbar fusion surgery patients.[4]

Unsupervised ML algorithms are used to find patterns and group patients based on the symptoms, radiographs, and other medical data. For example, an unsupervised ML algorithm was used to predict quality of life at 3 and 12 months after a total knee arthroplasty (TKA).[5] Based on demographics, comorbidities and pain scores, this algorithm clustered patients into 5 unique patient clusters with predictable quality-of-life scores. Such algorithms can be used to provide personalized patient care.

Natural language processing (NLP)

NLP applications like ChatGPT are used to facilitate human and machine communication. Since chart notes, diagnosis or treatment recommendations, discharge summaries, etc., are unstructured data, NLP techniques are used to extract useful health information from this unstructured data. For example, rule-based NLP algorithms were able to automatically extract knee arthroplasty specific data elements from operative notes with over 98% accuracy.[6] Such AI applications provide an alternative to expensive manual chart review.

Deep learning (DL)

DL techniques use many layers of complex algorithms that mimic the neural networks of a human brain through artificial neural networks (ANNs). Imaging analysis and computer vision applications mostly use convolutional neural networks (CNNs). For example, a CNN algorithm had 98% accuracy in identifying hip fractures on X-rays.[7]

BENEFITS OF USING AI APPLICATIONS IN ORTHOPEDICS

AI applications provide significant benefits in every aspect of orthopedic practice. AI applications have shown to improve accuracy and reduce time for diagnosis. For example, a DL algorithm was able to differentiate 9 knee arthroplasty implants from four different manufactures with 99% accuracy.[8] This application would reduce the time and cost involved in the accurate identification of implant manufacture and model for reoperation for patients who have undergone TKA, unicompartmental knee arthroplasty, and distal femoral replacement.

AI algorithms have been effectively used to combine various clinical and physiological indicators for risk prediction. For example, eight algorithms were developed to predict osteoporosis and classify individuals from their clinical data as healthy, osteopenia and osteoporosis. These eight algorithms were 75–93% accurate in predicting osteoporosis in patients.[9] Such AI applications can be used to develop personalized risk prevention strategies and to identify patients who will benefit from early intervention.

AI applications have been shown to have high accuracy in predicting post-operative complications. For example, from a large patient dataset, an ANN algorithm was able to accurately identify risk factors of developing complications after posterior lumbar fusion.[10] These types of predictive analytics algorithms can help clinical decisions through personalized suggestions.

FUTURE AI APPLICATIONS IN ORTHOPEDICS

AI applications of the future will offer an efficient and personalized treatment plan that will be tailored to the specific needs of orthopedic patients. Future AI applications in orthopedics will include:

AI-assisted surgery

AI-powered surgical robots will help surgeons perform complex procedures with high-level precision and accuracy. AI applications trained on millions of surgical videos might have the ability to provide additional oversight during surgery and will also be able to perform repetitive tasks like closing a port site and tying a suture.

Implants developed using AI

AI applications can help develop personalized implants based on a patient's anatomy and physiology. This would improve the fit and functions of the implants and reduce complications.

AI-based remote patient monitoring

These remote monitoring systems can track patient progress and predict potential problems early on. This would reduce the number of hospital visits and improve continuity of care.

AI-guided pain management

AI could be used to develop personalized pain management plans that are based on patient's need and their response to treatment. This can help patients manage their pain better and improve their quality of life.

AI applications of the future have the potential to improve health outcomes, assist clinicians in providing personalized, high-quality care, and reduce the cost of care.

CHALLENGES

There are several challenges that need to be addressed to enable the widespread adoption of AI applications in orthopedics. Some of the challenges include:

Data quality and accessibility

AI applications require large amounts of high-quality data for training and validation. Obtaining diverse and well-annotated orthopedic data can be a challenge since data formats are different for every data source. Standardizing a diverse set of data is expensive and requires a significant amount of manual work.

Regulatory compliance

Implementing AI solutions in orthopedics requires adherence to a complex set of regulations and privacy laws.

Liability and legal

AI applications can lead a physician to make a decision that can result in a bad outcome. In such cases, determining the liability can be complex and needs to be addressed carefully.

Clinical validation

To ensure the safety and efficacy of AI applications, they must undergo rigorous validation which would be time-consuming and expensive.

Addressing these challenges will require collaboration between AI researchers, healthcare professionals, regulatory bodies, and policymakers.

CONCLUSION

AI applications will continue to revolutionize orthopedics by improving diagnostics, predicting outcomes, assisting with surgery, and personalizing treatments. Addressing the challenges effectively will ensure precise and efficient care to orthopedic patients.

Ethical approval

Institutional Review Board approval is not required.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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How to cite this article: Nathan L, Muthusamy V. Uses, benefits and future of artificial intelligence (AI) in orthopedics. Indian J Med Sci. 2024;76:95-7. doi: 10.25259/IJMS_205_2023