Editorial
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The Rise of Artificial Intelligence: Implications in Orthopedic Surgery

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Learning Point of the Article:

This article describes artificial intelligence and its subfields, its current applications in orthopaedics, the limitations, and the future prospects.

Abstract

Artificial intelligence (AI) is slowly making its way into all domains and medicine is no exception. AI is already proving to be a promising tool in the health-care field. With respect to orthopedics, AI is already under use in diagnostics as in fracture and tumor detection, predictive algorithms to predict the mortality risk and duration of hospital stay or complications such as implant loosening and in real-time assessment of post-operative rehabilitation. AI could also be of use in surgical training, utilizing technologies such as virtual reality and augmented reality. However, clinicians should also be aware of the limitations of AI as validation is necessary to avoid errors. This article aims to provide a description of AI and its subfields, its current applications in orthopedics, the limitations, and its future prospects.

Keywords: AI, artificial intelligence, orthopedics.

Introduction

Artificial intelligence (AI) is a broad term given to the technology that replicates human intellect with the help of a computer [1]. AI is now increasingly being used in a wide variety of fields, including medicine. The correct definition for AI is the application of complex algorithms to produce useful results, without the requirement for human cognitive intelligence [2]. AI has evolved rapidly in recent years and is finding its way into almost all domains of society. From flight autopilot, social media tools, fraud detection, and the widely popular chat GPT by open AI, AI is slowly becoming an integral and unavoidable part of modern society.

With the availability of continuously expanding digital patient data, it creates an exponentially growing digital medical database that is virtually impossible for humans to comprehend together. However, AI can rapidly analyze and make sense of such huge data and make inferences or conclusions [3]. Further, AI can become better over time with successive exposure to more data and provide more accurate results like the human brain which can increase comprehension upon sequential and repetitive exposure to information [3].

Though AI is still in its infancy stage, it could still have various applications in orthopedic surgery and open new frontiers to treatment with the help of the latest technology. Orthopedics is a branch which is already known for its application of the latest technologies in creating innovations in patient care such as robotic-assisted surgeries. The purpose of this article is to provide a narrative into the understanding of AI and its subfields, its applications in orthopedic surgery, its limitations, and the future prospects.

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Machine Learning

Machine learning is a part of AI where it can "learn and adapt" based on algorithms and the data provided. This may be of 2 types – supervised machine learning and unsupervised machine learning. In supervised machine learning, humans correct the mistakes that AI has made and thus it can be improved over time. For example, to detect fractures, AI is first provided with X-rays of normal bone which are labeled normal by humans, and then provided with thousands of X-rays of a broken bone, which are labeled as broken. This method involves correct labeling of the data by humans to create the algorithm that dictates the AI to decide if the bone is broken or not.

In unsupervised machine learning, unlabeled data are provided to the AI which then groups together similar sets. Like in the previous example, AI is provided with thousands of X-rays, including that of normal and broken bones that are not labeled, and the computer then ascertains what normal looks like and then groups the X-rays into normal and abnormal ones based on an algorithm [4]. This process is repeated thousands of times (called epoch) to fine-tune the algorithm and to improve the accuracy before it can be validated and used on unknown data.

Deep Learning and Neural Networks

Deep learning is a more advanced type of machine learning, which has multiple complex layers of algorithms forming an artificial neural network. This is similar to the neuronal networks seen in the brain. When normal machine learning has millions of parameters, deep learning can have billions of parameters with variable degrees of complexity. Like machine learning, deep learning also currently requires human supervision to rectify the mistakes and improve its accuracy. However, developments are being made to develop deep learning algorithms that can function without the need for any human intervention. It can obtain desired results even from unlabeled and unstructured input data. In orthopedics, deep learning is currently being developed in AI-assisted image analysis using a technology called convolutional neuronal networks [5].

Natural Language Processing

Natural language processing is described as the comprehension of language by a computer. In medicine, it refers to AI being able to scan medical records, operative notes, and radiographic records and making sense of the gathered information. It has already proven useful in the detection of periprosthetic joint infections in patients treated for peri-prosthetic fractures using the musculoskeletal infection society criteria [6] applied to detect the presence of terms such as sinus tract, purulence, or growth of microorganisms from the available patient data [7].

Image Recognition

Fracture recognition from radiographs has been a considerable part of AI research in orthopedics in the past years. Various studies have shown that AI was effective in detecting fractures from radiographs with an accuracy of up to 98%, performing equal to or sometimes even better than humans [8, 9]. AI was found to be promisingly effective in detecting even difficult fractures such as fracture of the scaphoid from plain radiographs, at par with human specialists [9]. However, these systems need to be validated before clinical use. Internal validation within an institution is often effective, whereas when it is used in another institution, which may have different labeling systems or radiation dosages, the algorithm may become ineffective. Furthermore, if an institution changes its imaging protocols, the algorithm may become invalid [10].

AI has been shown to be effective also in the detection of bone tumors. One study has shown that AI algorithm was able to detect proximal femur tumors better than human specialists [11]. This could be more useful in difficult diagnoses such as some primary bone and soft-tissue tumors that may not be very evident in plan X-rays.

AI has also been proven to be helpful in detecting soft-tissue injuries around the knee. A study by Xie et al. has shown that magnetic resonance imaging scans augmented with AI were able to detect meniscal defects combined with tibial plateau fractures with an accuracy of 95 % and the features were very consistent with intraoperative findings [12].

AI is also found to be effective in making accurate measurements from radiographs as in cases of congenital hip dysplasia and evaluation of bone mineral density from radiographs [13]. Although not currently in use, AI could also be effective in pre-operative planning and decision-making in hip and knee arthroplasties. Studies have also reported that in revision arthroplasty, the AI algorithm was able to identify the prosthesis used from a plain X-ray, within milliseconds and also suggest required extraction equipment [14]. This is very helpful in reducing operating time, blood loss, and bone loss. AI was also effective in the early detection of implant loosening from plain radiographs and outperformed human counterparts in the same [15]. All these could help in decreasing complication rates and also redistributing time to improve patient care.

Predictive Algorithm

AI algorithm has also been shown to be effective in performing predictive algorithms. Studies have shown that AI models were able to predict the mortality risk and duration of hospital stay in patients undergoing elective arthroplasty [10]. AI machine learning could also analyze the bone texture and clinical risk factors of patients and predict the incidence of osteoarthritis up to a decade in advance [16]. These could theoretically be used as a risk stratification tool and to give early interventions wherever necessary. A deep learning algorithm developed by Kim et al. was able to predict the morbidity and mortality risk in patients undergoing spinal fusion better than the traditionally used scoring systems [17].

Surgical Training

AI has also made its way into improving surgical training. AI can gather large amounts of data and provide meaningful and personalized results. AI systems such as the virtual operative assistant may be integrated with virtual reality and augmented reality (AR). This could revolutionize surgical training and help increase patient safety during surgical training. A working example of this was done by Siemionow et al. who developed a machine learning AI system that overlays a 3D image of the spine onto cadavers using AR and helping the surgeon in accurate placement of metal probes into lumbar vertebrae [18].

AI can also help in post-operative rehabilitation. This was already tested on patients undergoing rehabilitation after a total knee arthroplasty. Machine learning algorithms can constantly track the patient's rehabilitation progress and ensure the expected milestones are met on time, and if not met, can alert health-care professionals to make necessary modifications [19].

AI has been found to be effective in predicting complications following surgery and predicting the need for revision surgery in the future. Rouzrokh et al. used a deep learning algorithm that was trained on over 90,000 post-operative X-rays and used it to predict the risk of implant dislocation after hip arthroplasty with high accuracy [20]. These may help in identifying the patients at high risk of complications and taking any pre-emptive interventions with the help of AI.

With all the advantages, AI also has its own limitations. The high capital costs are one reason for AI not being used widespread currently. However, this may be only a short-term problem once the cost-benefit analysis is explored. With AI handling large data sets, the breach in patient confidentiality is a major cause of ethical concern. Any AI model should undergo a process of rigorous validation before being used in clinical practice. Any errors in the AI algorithm could lead to serious complications and have a tremendous impact on patient safety. Hence, at least for now, AI could be used only as an adjunct in the decision-making process and not as a substitute. Doctors should always be aware of the limitations of AI and make calculated judgments.

AI has a huge potential to drastically improve patient care, reduce complications, and reduce the workload of health-care professionals. AI could be the beginning of precision medicine, being able to predict the development of diseases, treatment outcomes, and interventions to prevent complications personalized, and tailored to the patient, even up to the genome level.

Clinical Message

AI has a huge potential to drastically improve healthcare, with various applications in diagnosis, treatment, predicting complications, suggesting solutions and teaching. However, at least in its current stage, due to its various limitations, AI can only be used as an adjunct and not as a substitute.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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