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# Artificial intelligence in orthopaedics

## WHAT LEVEL OF EVIDENCE DOES IT REPRESENT AND HOW IS IT VALIDATED?

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Artificial intelligence (AI) refers to the development of computer systems that can perform tasks that typically require human intelligence. These tasks include understanding language, recognizing images, learning from experience, making decisions, and solving problems. The term 'artificial intelligence' was coined in 1956 during a conference at Dartmouth College, New Hampshire, USA.[1] The conference brought together a group of scientists and researchers who were interested in exploring the idea of creating machines that could exhibit intelligent behaviour. John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon were among the prominent figures who organized the conference and popularized the term 'artificial intelligence'.[1] AI has various subfields that have emerged within the discipline, including machine learning, natural language processing (NLP), computer vision, robotics, and more. AI technologies are now being applied in various industries and domains, such as healthcare, finance, transportation, and entertainment, among others, which has revolutionized the way society works. AI aims to create machines that can perceive their environment, understand and learn from it, reason and make decisions, and interact with humans in a natural and intelligent manner.

AI systems are designed to mimic or simulate human cognitive functions, such as problem-solving, pattern recognition, learning, and decision-making. They achieve this through various techniques, including:

1. Machine learning, which involves training algorithms on large datasets to recognize patterns and make predictions or decisions without being explicitly programmed. This can be separated into two groups of supervised learning or unsupervised learning. It enables systems to learn from data, identify trends, and improve the performance of the algorithm over time.

2. Natural language processing (NLP), which enables machines to understand, interpret, and generate human language. It involves tasks such as speech recognition, language understanding, sentiment analysis, and machine translation, allowing AI systems to interact with humans in a more natural and intuitive way.

3. Computer vision, which involves enabling machines to understand and interpret visual information from images or videos. It includes tasks such as object detection, image classification, facial recognition, and scene understanding. Computer vision algorithms enable AI systems to analyze and make sense of visual data.

4. Robotics, which combines AI with physical systems to create intelligent machines that can interact with and manipulate their environment. AI-powered robots can perform tasks autonomously or with human guidance, enabling applications in areas such as healthcare, manufacturing, and logistics.

The goal of AI is to develop systems that can exhibit intelligent behaviour, adapt to new situations, learn from experience, and improve their performance over time. AI technologies have numerous real-world applications across various industries, including healthcare, finance, transportation, entertainment, and more. AI has the potential to greatly impact the field of orthopaedics in several ways.

## Diagnostic assistance

AI can aid orthopaedic specialists in accurate and efficient diagnosis. Machine learning

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algorithms can analyze medical imaging to detect and classify various orthopaedic conditions, including fractures, tumours, and joint abnormalities.[2,3] AI algorithms can assist in identifying subtle patterns or anomalies that might be missed by human observers, leading to earlier detection and treatment.

## Surgical planning and assistance

AI can assist orthopaedic surgeons in surgical planning by providing valuable insights and recommendations.[4] By analyzing patient data, such as medical images and patient records, AI algorithms could assist in preoperative planning, optimizing implant selection, and predicting surgical outcomes. During surgery, AI-powered robotic systems can provide real-time guidance, enhancing the precision and accuracy of surgical procedures.

## Rehabilitation and recovery

AI can play a role in orthopaedic rehabilitation by developing personalized treatment plans.[5] By analyzing patient data, AI algorithms can assess factors such as range of motion, muscle strength, and gait analysis to create tailored rehabilitation programmes. AI-powered wearable devices can monitor patient progress and provide real-time feedback, helping patients adhere to their rehabilitation plans and facilitating quicker recovery.

## Data analysis and research

AI can assist in analyzing large volumes of orthopaedic data, including patient records, clinical trials, and research articles. By applying NLP and data mining techniques, AI can identify patterns and correlations within the data, leading to improved understanding of orthopaedic conditions, better treatment strategies, and the development of innovative therapies. These may have advantages over traditional risk models using regression analysis when analyzing large datasets.[6,7]

## Predictive analytics

AI can leverage predictive analytics to forecast patient outcomes and identify potential complications.[8] By analyzing patient data and historical records, AI algorithms can identify risk factors and predict the likelihood of postoperative complications, such as infections or implant failures. This can enable proactive intervention and personalized patient care.

## Patient communication

Freely available AI dialogue platforms can be used to facilitate optimization of patient education materials and convert them to the appropriate reading age with retention of the accuracy of content.[9] Interestingly, there is also the potential to expand the AI application to optimize the reading level to documents used for patient consent and postoperative instructions.

AI holds great promise in orthopaedics, but it may be no substitute to human expertise. There are limitations and these should be acknowledged when interpreting the AI data.[10] There are also publishing implications with language models having the ability to create research manuscripts that are challenging to identify. This has led to the editors of several of the leading orthopaedic journals stating that AI applications cannot be listed as an author, but a description of how AI was used should be stated in the methods section of the manuscript in addition to an acknowledgement of its use.[11] An area that seems to be deficient in the literature is where AI research is placed in the traditional evidence-based medicine model; what level of evidence is it and how is the validity of the outputs assessed? There are, however, limitations with traditional evidence-based medicine and some of these may be addressed with AI using large data sets.[12] The surgeon may also feel a little uneasy in trusting the results from an AI platform when the workings may not be clear. Furthermore, how does AI cope with missing data, outliers, and other variables that typically influence and skew the outputs from traditionally accepted regression models? It does, however, serve as a powerful tool to augment the capabilities of orthopaedic specialists, leading to improved diagnostics, treatment planning, and patient care.

When asking ChatGPT[13] to "to make a rhyme that highlights the benefits of AI in orthopaedics", the response was:

*In the world of orthopaedics, AI takes flight, bringing benefits that shine so bright. With precision and insight, it aids the way, enhancing patient care day by day.*

*AI's diagnostic prowess, a remarkable feat, analyzing images with speed, accuracy so sweet. Fractures and ailments it swiftly detects, empowering doctors, their skills it perfects.*

*Surgical planning, a realm it excels, AI's guidance, the surgeon compels. From implant selection to strategies refined, precise procedures, outcomes redefined.*

*Rehabilitation, a journey it aids, personalized plans, AI creates. Monitoring progress, providing feedback, accelerating recovery, getting patients on track.*

*Data analysis, a treasure trove revealed, unveiling insights that were once concealed. Research advances with AI's keen eye, expanding knowledge, reaching new highs.*

*Predictive analytics, a visionary guide, identifying risks, potential troubles it cannot hide. Pre-emptive measures, proactive care, AI's foresight, ensuring patients fare.*

*In orthopaedics, AI takes its stance, improving lives with its intelligent dance. A partner to experts, a valuable ally, embracing the future, where innovation will fly.*

It is clear from this that AI rather smugly considers itself to be a great asset to orthopaedics. However, in 2016 Professor Stephen Hawking declared AI to be "either the best, or the worst thing, ever to happen to humanity"[14] and similar anxieties have been raised by Geoffrey Hinton (dubbed the "godfather of AI" due to his work in the field) and Sam Altman, CEO of OpenAI (the developer of ChatGPT). It is therefore an innovation for us to embrace, but with caution.

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