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Application of ChatGPT for Orthopedic Surgeries and Patient Care

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Artificial intelligence (AI) has rapidly transformed various aspects of life, and the launch of the chatbot "ChatGPT" by OpenAI in November 2022 has garnered significant attention and user appreciation. ChatGPT utilizes natural language processing based on a "generative pre-trained transfer" (GPT) model, specifically the transformer architecture, to generate human-like responses to a wide range of questions and topics. Equipped with approximately 57 billion words and 175 billion parameters from online data, ChatGPT has potential applications in medicine and orthopedics. One of its key strengths is its personalized, easy-to-understand, and adaptive response, which allows it to learn continuously through user interaction. This article discusses how AI, especially ChatGPT, presents numerous opportunities in orthopedics, ranging from preoperative planning and surgical techniques to patient education and medical support. Although ChatGPT's user-friendly responses and adaptive capabilities are laudable, its limitations, including biased responses and ethical concerns, necessitate its cautious and responsible use. Surgeons and healthcare providers should leverage the strengths of the ChatGPT while recognizing its current limitations and verifying critical information through independent research and expert opinions. As AI technology continues to evolve, ChatGPT may become a valuable tool in orthopedic education and patient care, leading to improved outcomes and efficiency in healthcare delivery. The integration of AI into orthopedics offers substantial benefits but requires careful consideration and continuous improvement.

Keywords: *ChatGPT, Orthopedics, Orthopedic surgery, Surgical planning, Patient care*

Artificial Intelligence (AI) has exponentially changed all aspects of life. The recently launched chatbot "ChatGPT" (November 2022 by the AI lab OpenAi) has attracted much attention and is highly welcomed by users.[1] This chatbot uses a natural language processing model, better known as generative pre-trained transfer (GPT). ChatGPT is a powerful language model that has been trained on a large amount of text data to generate human-like responses to a wide range of questions and topics.[2] The model is based on a transformer architecture that uses introspection mechanisms to capture long-range dependencies between words and sentences and to generate coherent and contextual responses.[2,3] This chatbot is equipped with a text-out interface. This model was trained using approximately 57 billion words and 175 billion parameters from the online data. However, these figures varied depending on the version of the model. For example, the original GPT-3 model has 175 billion parameters, whereas the smaller GPT-2 model has 1.5 billion parameters.[4] Consequently, it can respond to a wide range of domains, including medicine and healthcare.[5] One of the key strengths of ChatGPT is its ability to generate highly relevant and informative responses by drawing on a large amount of knowledge and language patterns from the training data. Thus, it can be used to explore various services ranging from patient ser-

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vices and medical support to education and healthcare.[6)]

In the field of orthopedics, AI has tremendous potential to revolutionize patient care. By analyzing big data, preplanning, and designing surgical techniques, AI will greatly assist orthopedic surgeons. Additionally, ChatGPT's ability to detect patterns and provide insights will enhance decision-making and improve surgical precision.[7)] One of the notable features of ChatGPT is its personalized and easy-to-understand responses, delivered efficiently within seconds.[5)] It continuously learns from user interactions, becoming increasingly adaptive and responsive over time.[2,4)] Based on a deep learning algorithm called Transformer Architecture, ChatGPT has gained popularity in natural language processing tasks such as text generation, translation, and question answering since its introduction in 2017 by Vaswani et al.[8)] The Transformer architecture utilizes self-regarding mechanisms to weigh the importance of different parts of the input text when generating an output. This consideration of broad dependencies between words and phrases ensures coherent and contextually relevant responses.[2,9)] As mentioned earlier, ChatGPT is trained using a large textual dataset that refines the model parameters through a process called unsupervised learning.[10)] This process is important for training the machine to predict word order without explicit supervision or feedback from a human teacher/interpreter/expert.[10,11)] This model can be used to generate responses to a variety of questions and topics by providing an initial prompt or context and allowing the model to generate a response based on the learned knowledge of language and patterns in the training data.[11)] As a sophisticated and powerful deep learning architecture, ChatGPT can proficiently handle various natural language questions and tasks, generating high-quality responses.[12)]

AI has revolutionized the medical field to support medical diagnosis, treatment, and drug discovery. In orthopedics, deep learning has improved musculoskeletal diagnosis and surgical procedures, while natural language processing has simplified communication between physicians and patients.[13,14)] ChatGPT shows promise in assisting orthopedic surgeons, patients, and students, providing relevant information about orthopedic topics and acting as an informative tool for students.[7,15-17)] With continual improvements in algorithms and datasets, ChatGPT may serve as a virtual assistant for orthopedic surgeons.[18)] Despite its advantages, ChatGPT has limitations and ethical concerns. Biased or inaccurate responses may arise due to biases and limitations in the training data.[13)] Additionally, using ChatGPT for tasks like medical diagnosis or legal advice raises ethical concerns regarding accountability and responsibility.[8,19-21)]

ChatGPT IN ORTHOPEDIC

ChatGPT is a cutting-edge technology with the potential to revolutionize healthcare providers' interactions with medical information. Unlike many AI-based tools in healthcare that rely on peer-reviewed information, research, case studies, clinical pathways, and statistical analyses for unbiased and accurate results, the ChatGPT generates responses based on recorded patterns and associations. Its access to vast Internet information may lead to less detailed or accurate responses compared with those from qualified medical professionals/experts. Consequently, ChatGPT responses should be regarded as general information and not as a substitute for expert medical advice or diagnosis.[12,19,21)]

Fig. 1 shows some widely acclaimed applications of the ChatGPT. This study aimed to explore the potential of healthcare providers, particularly in orthopedic care. One of its key benefits is its ability to provide access to vast amounts of medical information rapidly. According to ChatGPT, healthcare providers dealing with orthopedic surgeries and care can quickly obtain information on patient care topics, including symptoms, treatments, and medication dosages, which can deepen their knowledge and understanding of complex medical concepts.[20-22)] Despite these advantages, concerns have been raised about ChatGPT's biased responses. To address this, the Journal of the Medical Association published guidelines for authors on the appropriate use of ChatGPT in manuscript preparation.[23)]

AI can aid in fast and accurate diagnosis for complex surgeries, such as spinal fusion, complex spinal recon-

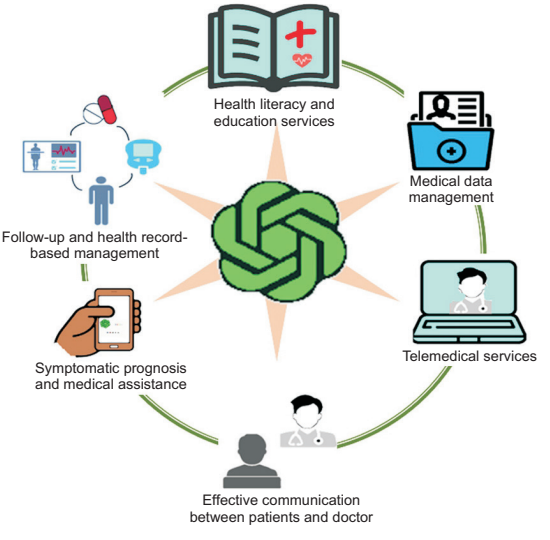

Fig. 1. Application of ChatGPT in healthcare services and allied industry.

struction, total joint replacement, anterior cruciate ligament surgery, and shoulder replacement.[24] ChatGPT can help in personalized preoperative planning and precise implementation. During surgery, ChatGPT functions as a virtual assistant, providing real-time surgical navigation information and facilitating data recording for convenient postoperative use.[21,25] Postoperatively, both surgeons and patients can use the ChatGPT to design personalized rehabilitation programs.[15,26] Currently, ChatGPT is a valuable tool for obtaining surface-level information on various topics. This assists orthopedic surgeons in diagnosing and analyzing reports efficiently within a short period. Furthermore, ChatGPT assists surgeons in constructing personalized treatments and preoperative planning with accuracy and safety.[7] To evaluate the above, we prepared a set of hypothetical questions and evaluated their responses (Supplementary Material 1, including responses to general queries and detailed description of the situation).

As AI algorithms gain insightful knowledge of designed implants and surgical techniques, ChatGPT can aid in planning and optimizing surgical procedures and in reducing postoperative risks and complications. This technology serves as a crucial partner for orthopedic surgeons, contributing significantly to the planning and optimization of surgical procedures. Therefore, it can play a pivotal role in reducing postoperative risks and complications, ultimately enhancing surgical precision, patient safety, and overall recovery. This real-time assistance enhances surgical accuracy, patient safety, and recovery.[7] Furthermore, ChatGPT extends its reach to the realm of patient education and engagement, offering a more straightforward and patient-centered approach.[27] The diagnostic capacity of ChatGPT is continually evolving and holds great promise for orthopedic surgeons and radiologists. Its capabilities extend to aid in the diagnosis of patient symptoms and interpretation of complex medical imaging. When combined with other AI tools, ChatGPT plays a pivotal role in radiology reports by effectively translating intricate medical jargon into simplified versions that improve communication between healthcare providers and patients. The seamless integration of AI technology is a challenge in the field of orthopedic surgery. It is still evolving but holds promise for orthopedic surgeons and radiologists, aiding in diagnosing patient symptoms and interpreting medical images. Combined with other AI, ChatGPT's use in radiology reports and translation into simplified versions improves communication with patients.[12,20,22,28] To further elucidate the potential of ChatGPT in the context of orthopedic surgery, let us delve into the specific applications and benefits it offers to this specialized medical field.

PATIENT COMMUNICATION

Patient counseling is a challenging task for orthopedic surgeons; however, ChatGPT can play a vital role by simplifying explanations and overcoming language barriers for patients globally. This chatbot has the potential to revolutionize the way orthopedic surgeons handle medical information and communicate with their patients.[29] By using ChatGPT, doctors can get an idea of the questions they can ask patients to ensure they fully understand the treatment.[30] Moreover, ChatGPT can be used to support medical education, acting as a virtual assistant for medical students, answering their questions, and providing personalized feedback to enhance their learning experience.[12,20,22,28] ChatGPT can facilitate effective communication between surgeons and patients. It can generate plain-language explanations of surgical procedures, expected outcomes, and potential risks, helping patients make informed decisions and alleviating anxiety before surgery. In orthopedic surgery, effective patient communication is paramount to ensure that individuals fully comprehend the surgical process, expected results, and associated risks.[26] ChatGPT serves as a valuable bridge between orthopedic surgeons and patients. It excels at generating clear and concise explanations of complex surgical procedures using plain language that patients can readily understand. It not only outlines the steps involved in the surgery but also delves into the expected outcomes, recovery process, and potential risks, thus empowering patients with comprehensive information.[18] By equipping patients with this knowledge, ChatGPT plays a vital role in facilitating informed decision-making, as patients can weigh the benefits and risks more confidently. Furthermore, the empathetic and reassuring nature of ChatGPT interactions can help alleviate patient anxiety, foster trust, and strengthen doctor-patient relationships.[28] Overall, in orthopedic surgery, ChatGPT enhances patient communication, ensuring that individuals are well-informed, emotionally supported, and actively engaged in their own healthcare journey.

ChatGPT's analysis of a patient's medical history and imaging studies could generate treatment recommendations based on established clinical guidelines and expert opinions, assisting orthopedic surgeons in decision-making.[12,20,22] A study by Liu et al.[30] was conducted to determine the feasibility of utilizing AI in the recognition of tibial plateau fractures, and the results demonstrated that AI was able to identify the same number of fractures as orthopedic specialists. This finding affirmed the potential of AI as a reliable tool in both diagnosis and treatment.[28,31]

VIRTUAL SURGICAL SIMULATION

ChatGPT can generate 3-dimensional (3D) models or simulations of orthopedic surgeries. Surgeons can interact with these virtual models to plan and practice surgical procedures, improve precision, and reduce the risk of errors during surgery. Virtual Surgical Simulation represents a groundbreaking advancement in orthopedic surgery facilitated by ChatGPT. With the capability to generate intricate 3D models or simulations of orthopedic procedures, this technology enables surgeons to delve into meticulous planning and practice before entering the operating room.[20] These virtual models provide an immersive and highly detailed representation of patient anatomy, enabling surgeons to explore different angles, approaches, and surgical techniques. This not only fosters a deeper understanding of the patient's unique anatomy but also allows for the rehearsal of complex procedures, refining the surgeon's skill set and enhancing precision. Importantly, virtual surgical simulations substantially reduce the risk of errors during surgery. Surgeons can identify potential challenges and complications in a risk-free environment, ultimately leading to safer and more successful orthopedic surgeries.[28] This transformative use of ChatGPT in orthopedics exemplifies how AI-driven technologies are revolutionizing surgical practices and improving patient outcomes.

INTRAOPERATIVE GUIDANCE

ChatGPT can provide real-time guidance and decision support to surgeons during orthopedic procedures. Processing data from surgical instruments and patient vitals can offer suggestions and alerts to ensure that the surgery proceeds smoothly and safely. Intraoperative guidance is a crucial aspect of orthopedic surgery, and ChatGPT plays a pivotal role in enhancing this facet of surgical practice.[18] During orthopedic procedures, ChatGPT can act as a virtual surgical assistant by processing real-time data from various sources including surgical instruments and patient vital signs. This sophisticated AI system can continuously monitor the surgical environment and assist surgeons by providing immediate insight and recommendations. For instance, it can analyze data from surgical instruments to ensure that incisions and bone cuts are made with precision, helping to maintain the integrity of the surrounding tissues.[28] Simultaneously, ChatGPT can monitor patient vital signs, detect anomalies or deviations from the norm, and promptly alert the surgical team to potential complications. By offering these suggestions and alerts, ChatGPT contributes to the overall safety and success of surgery, reduces the likelihood of errors, and enhances the surgeon's ability to focus on the intricacies of the procedure. Ultimately, this real-time guidance empowers orthopedic surgeons to navigate complex surgical scenarios with greater confidence, thereby ensuring optimal patient outcomes.

IMAGE RECOGNITION

In the operating room, ChatGPT can analyze live imaging data, such as fluoroscopy or intraoperative computed tomography (CT) scans.[19] It can assist in identifying anatomical structures, guiding instrument placement, and ensuring accurate alignment during joint replacement surgeries. The image recognition capabilities of ChatGPT hold immense promise for orthopedic surgery. Within the operating room, this advanced AI system can seamlessly analyze real-time imaging data, including fluoroscopy and intraoperative CT scans, with exceptional precision and speed.[22] This functionality plays a pivotal role in several critical aspects of orthopedic surgery, particularly during procedures such as joint replacement. This aids in the placement of surgical instruments by offering real-time feedback and ensuring that they are positioned with optimal accuracy. Furthermore, the ability of AI to verify and maintain alignment throughout the procedure is of paramount importance, as it helps prevent complications and ensures the successful outcome of complex surgeries.[22,28,32] In essence, ChatGPT's image recognition capabilities in orthopedic surgery are game-changers that enhance surgical precision, reduce risks, and ultimately benefit patient well-being.

SURGICAL WORKFLOW PLANNING

ChatGPT can assist in planning the surgical workflow by suggesting the sequence of steps, instruments, and implants required for a specific procedure. This can help optimize the surgical plan for efficiency and patient safety.[7,15] In orthopedic surgery, ChatGPT plays a crucial role in surgical workflow planning by offering comprehensive and highly valuable support to surgeons.[16] In complex procedures, the meticulous orchestration of each step is paramount. ChatGPT excels in this aspect by not only suggesting the sequence of surgical steps but also recommending the specific instruments and implants required for a particular procedure. By drawing from a vast database of medical knowledge and previous surgical experience, ChatGPT can provide surgeons with tailored and optimized surgical plans.[15,17] This includes identifying

the optimal incision sites, detailing the order of bone cuts or joint manipulations, and suggesting the most suitable types and sizes of implants. This level of precision and planning not only enhances the overall efficiency of the surgical process but also significantly contributes to patient safety.[27,30,33] Surgeons can rely on ChatGPT to reduce the margin of error, minimize the risk of complications, and ensure that the procedure is conducted with the utmost accuracy and care, ultimately leading to improved surgical outcomes and patient well-being.

PROCEDURAL CHECKLISTS

ChatGPT can generate procedural checklists tailored to specific surgeries. Surgeons can use these checklists to ensure that critical steps are not missed during complex orthopedic procedures, reducing the likelihood of complications. In orthopedic surgery, the integration of procedural checklists generated by ChatGPT presents a transformative approach to enhance surgical precision and patient safety.[7,15,22,32] These meticulously tailored checklists serve as invaluable tools for orthopedic surgeons by meticulously outlining the intricate steps and considerations required for specific surgical procedures. In the high-stakes environment of orthopedic surgery, where precision is paramount, these checklists act as a safeguard against oversight.[29,34] By promoting adherence to established best practices and safety protocols, ChatGPT's procedural checklists not only enhance surgical outcomes but also provide a standardized framework for continuous improvement in orthopedic surgery, ultimately benefitting both surgeons and their patients.

MINIMALLY INVASIVE SURGERY

For minimally invasive orthopedic procedures, ChatGPT can assist in instrument navigation and placement, optimizing the use of smaller incisions and reducing tissue damage. Minimally invasive surgery (MIS) represents a significant advancement in orthopedic surgery, and ChatGPT plays a crucial role in optimizing this approach. The primary goal of MIS is to achieve surgical precision while minimizing trauma to the surrounding tissues.[13,33] ChatGPT contributes to this objective by assisting with instrument navigation and placement. By analyzing real-time data from imaging tools, such as fluoroscopy or intraoperative CT scans, ChatGPT helps orthopedic surgeons accurately position instruments and implants through smaller incisions. Precise guidance is paramount in procedures such as arthroscopy and endoscopic spine surgery, where the visualization of internal structures is limited. As ChatGPT aids surgeons in maintaining optimal alignment and placement, it reduces the risk of unintended tissue damage and complications, resulting in shorter recovery times and reduced postoperative pain.[20,27,29] The integration of AI-driven navigation systems, such as ChatGPT, into MIS exemplifies the synergy between technology and surgical expertise, leading to safer, more efficient, and patient-friendly orthopedic interventions.

ERROR PREVENTION

ChatGPT can assist in error prevention by alerting surgeons to potential mistakes or deviations from the planned procedure. It can serve as a virtual assistant to ensure that surgical steps are accurately executed.[7] In orthopedic surgery, error prevention is paramount to patient safety and positive surgical outcomes. ChatGPT plays a vital role by functioning as a vigilant virtual assistant within the operating theater.[11] ChatGPT promptly alerts the surgical team if any deviation or anomaly is detected. For instance, it can cause inconsistencies in implant placement, deviations from the intended incision site, or unexpected anatomical variations. This real-time feedback serves as a crucial safety net, helping avert potential errors and ensure that each step of the surgery aligns precisely with the established plan.[13,29] By enhancing surgical precision and minimizing the risk of procedural mistakes, ChatGPT significantly contributes to the overall safety and success of orthopedic surgeries, ultimately benefiting patients by reducing the likelihood of complications and optimizing postoperative recovery.

COLLABORATIVE SURGERY

In scenarios involving remote or collaborative surgeries, ChatGPT can facilitate communication and information exchange between the operating surgeon and remote experts, thereby enhancing overall surgical experience and outcome. Collaborative surgery in the field of orthopedics has evolved significantly with the integration of ChatGPT. In complex cases or scenarios involving remote surgical experts, ChatGPT plays a pivotal role in enhancing communication and information exchange.[28] During such procedures, ChatGPT serves as a seamless bridge between the operating surgeon and remote specialists. It facilitates real-time discussions, enabling the surgical team to share critical insights, exchange medical images, and engage in virtual consultation. This collaborative aspect ensures that all stakeholders are on the same page regarding the surgi-

cal plan and patient condition.[20,28,33] The ChatGPT's ability to provide instant access to medical literature and reference materials ensures that any unforeseen challenges or decisions that arise during the procedure can be addressed promptly and based on the latest evidence-based practices. Ultimately, this collaborative synergy leads to enriched surgical experience, harnessing the collective knowledge and expertise of multiple specialists, and significantly contributes to optimizing surgical outcomes for orthopedic patients, even in geographically dispersed settings.

ChatGPT can also provide patients with information about their medical condition, treatment, rehabilitation strategies, and expected recovery period, thus benefiting them and bridging the communication gap with surgeons.[7] AI can assist in postoperative care and recovery monitoring, as well as identify early complications and provide timely patient details about secondary interventions.[6,28,32,35] In the academic sphere, ChatGPT has shown potential in revolutionizing healthcare, providing accurate and easily understandable information on orthopedic topics. It can create interactive quizzes and educational tools for students, reinforcing learning and providing immediate feedback on their progress.[33] As ChatGPT continues to improve, it may become a virtual assistant for arthroplasty doctors, magnifying the therapeutic effects of joint replacement by providing rehabilitative guidelines and enhancing patient satisfaction.[34] This AI-driven technology holds great promise for the future of orthopedics, facilitating better patient care, surgical planning, and medical education.[36]

LIMITATIONS OF ChatGPT

The launch of ChatGPT has attracted significant attention in various fields, with professionals discussing its potential impacts and controversies. In the healthcare sector, previous studies have explored the application of ChatGPT, but its potential in orthopedic research remains unclear. Despite the potential benefits of improving communication between orthopedic surgeons and patients, ChatGPT has limitations that must be addressed for safe and effective use in orthopedic surgery. One critical limitation is the accuracy and reliability of the generated information, because ChatGPT may not always grasp the context or correctly interpret complex medical data, leading to misleading or incorrect responses. The lack of transparency in response generation also raises concerns about the trust between healthcare providers and patients. Moreover, ChatGPT's limited ability to understand language nuances and emotional states could result in miscommunication and misunderstandings. These limitations call for active education among surgeons to leverage AI effectively in healthcare.[30,36]

Although ChatGPT can be employed in various orthopedic healthcare and research and development applications to improve the effectiveness and efficiency of information delivery, it fails when dealing with complex medical conditions. Thus, its use in healthcare orthopedics remains questionable until it is adequately trained to handle such cases.

To evaluate the efficacy of ChatGPT, complex surgical situations were posed and the responses were scrutinized for ambiguity. While ChatGPT provides clear and detailed summaries for certain surgical treatments, it may only present the basics for others.[5] An important limitation is the accuracy and reliability of the information generated by ChatGPT. Although ChatGPT can generate human-like speech, it is not always possible to understand the context of a particular situation or to correctly interpret complex medical information. Therefore, the information generated by ChatGPT may be misleading or incorrect.[4,37] This could lead to misunderstanding or misinterpretation of the surgical procedures, techniques, and outcomes. There is also a lack of transparency regarding how ChatGPT generates responses. The complex algorithms used by ChatGPT are difficult to understand, which makes it difficult to assess the quality and accuracy of the generated information. This lack of transparency can lead to mistrust between healthcare providers and patients. ChatGPT also has a limited ability to understand language nuances.[3,38] Therefore, surgeons have to be active and educated about the latest advancements in AI to maintain the integrity of AI in healthcare and ensure that it is developing in a way that benefits both patients and medical professionals.[3,22,29]

We asked about complex surgical situations to evaluate the efficacy of ChatGPT, and the responses were regenerated to check for ambiguity (Supplementary Material 1). For instance, total hip arthroplasty neglects to address potential risks and complications associated with the surgery, such as damage to nearby organs or anesthesia-related concerns. ChatGPT does not address any issues that could arise, such as damage that will occur to nearby organs during surgery, blood loss, or the risk of anesthesia.[17] This shows that sometimes the ChatGPT responses were very superficial and changed with regenerated answers for the same questions. The cost comparison also had significantly changed values, which can create a trust deficit between the patients and healthcare providers. These superficial responses could lead to trust issues between patients

and healthcare providers. Furthermore, the inability of ChatGPT to detect sarcasm, irony, or patients' emotional states hinders effective communication. Additionally, the inability of ChatGPT to perform physical examinations or interpret diagnostic images limits its role in the surgical environment. Language used in medicine is often technical and can be influenced by cultural and social factors. If the data used to train ChatGPT are biased, they could lead to biased or inaccurate responses.[29,30] Another potential limitation is the inability of ChatGPT to capture the subtleties and nuances of individual patient cases. Arthroscopy is a highly specialized field, and individual patient cases can vary significantly in terms of complexity and surgical approaches.[39] Although ChatGPT can provide general guidance and recommendations, it cannot always capture the unique aspects of individual patient cases. ChatGPT is limited by the lack of physical presence in the surgical environment as it cannot physically manipulate or adjust implants or surgical instruments.[28]

In a previous study, ChatGPT failed to achieve the required threshold to pass the written part of the Fellowship of the Royal College of Surgeons examinations in Trauma and Orthopedics. ChatGPT was unable to implement higher-order judgments or employ multi-logical reasoning in clinical scenarios involving complex patient-specific factors. To date, ChatGPT lacks the capacity to generate in-depth responses, and its knowledge is limited compared to that of orthopedic students.[40] However, improvements in large language models may have a significant impact on improving overall healthcare in the near future.[29,40] ChatGPT has been observed to help experts with their fundamental knowledge or assist them, but the present iteration of ChatGPT is still in its infancy for the healthcare industry; thus, it is unable to resolve complex or multi-logical concerns. Moreover, specialized orthopedic details and expertise are still necessary, making ChatGPT a supplementary tool rather than a comprehensive solution for orthopedic education.[28,40] There is still room for improvement in patient education regarding orthopedic surgery. Perhaps, it would be helpful if ChatGPT offered more information on surgical consent or on aftercare for patients.[27]

As previously mentioned, ChatGPT may be a valuable asset to radiologists; for example, it may provide assistance with orthopedic medical imaging. However, in the present state, ChatGPT cannot be used as a diagnostic tool because the information generated by it on the subject is limited, as observed in a recent study where ChatGPT was unable to accurately answer patients' frequently asked questions during their radiologist visits. Furthermore, most answers consisted of errors and surface-level information. Perhaps the biggest limitation was that the references provided were inaccurate and could not be cross-referenced. Only a minority of the provided references contained information applicable to the query.[41] Similarly, in another study, ChatGPT failed to provide relevant references on the topic of thumb arthritis. The generated references were inaccurate, indicating that ChatGPT cannot generate high-level evidence references.[42] These studies challenged the validity of ChatGPT because it generates factually incorrect information that appears to be fabricated owing to its limited training dataset. Currently, ChatGPT suffers from artificial hallucinations, suggesting it may create false reports in the medical field inadvertently causing more harm than good.[43]

ChatGPT presents both opportunities and challenges in orthopedics. Although it has the potential to enhance communication and patient education, its limitations in terms of accuracy, transparency, and response generation must be addressed. Surgeons and healthcare providers need to be well-informed about AI advancements to make prudent use of ChatGPT in the healthcare landscape. Continuous improvements in AI technology may pave the way for ChatGPT to become a valuable tool in orthopedic education and patient care.[29,44]

DISCUSSION

Considering the potential risks and limitations, the media hype surrounding ChatGPT may not benefit users (i.e., patients or health professionals). To exploit this potential, a thorough understanding of their limitations is crucial. Notably, the model lacks knowledge of developments/research after June 2021, as OpenAI explicitly states.[38,45] Furthermore, the lack of citations for the information provided by the chatbot makes it difficult for users to verify the sources, potentially leading to biased representations that influence the responses. However, as the chatbot underwent updates and further training, it yielded improved results. Some articles suggest its utility in providing advice and recommendations based on medical history, symptoms, and clinical data, ultimately aiding healthcare providers in making more accurate diagnoses and informed treatment decisions.[38,45]

ChatGPT has the potential to be a valuable tool in orthopedics, particularly in preoperative planning, intraoperative management, and postoperative rehabilitation. AI's ability to provide fast and reliable diagnostic data can significantly reduce the time required for treatment planning and design. Consequently, orthopedic surgeons

can work more efficiently on complex tasks, leading to enhanced precision and efficacy. However, ChatGPT's responses were limited by the word limit, which may restrict its use in medical research. Careful consideration must be given to the dataset used to train ChatGPT, its ability to interpret technical language, and its ethical and legal implications. Therefore, ChatGPT should be used in conjunction with other medical tools and resources to ensure the best possible surgical outcomes for patients.[17,46] ChatGPT holds promise for orthopedic applications. During preoperative planning, orthopedic surgeons can use ChatGPT to explain complex medical terms to patients in a concise and simpler manner, promoting better patient understanding. Similarly, patients can utilize ChatGPT to comprehend their condition and prescribed treatment regimens.[21,25] Intraoperatively, ChatGPT can function as a virtual assistant for surgeons, providing real-time surgical navigation information and facilitating data recording for convenient postoperative use.[26] Postoperatively, both surgeons and patients can use ChatGPT to design detailed rehabilitation programs tailored to individual patient needs.[15] Currently, ChatGPT is a valuable tool for obtaining surface-level information on various topics. While it provides simple explanations that can be understood by laypersons, its limitations lie in complex tasks that require multi-logical reasoning. However, with improvements in its dataset, ChatGPT can become more effective for medical professionals and patients. It describes scientific data in ordinary language, making it easier for patients to understand medical terms. Nonetheless, it lacks the expert opinions necessary for in-depth orthopedic research, limiting its impact on orthopedic surgeons.[17]

It is important to recognize that ChatGPT is a language model based on patterns and associations learned from a vast corpus of text. Although it is designed to provide helpful suggestions and recommendations, it occasionally provides incorrect or misleading information. The accuracy of ChatGPT responses depends on various factors, including the quality and relevance of the user input and the accuracy of the data used to train the model. Therefore, users should exercise caution and complement ChatGPT outputs with expert opinions and verified data. Therefore, it is important for users to critically evaluate the information provided by ChatGPT and verify its accuracy through independent research and verification from reputable sources. It is also important to note that ChatGPT cannot replace professional/expert medical advice/prescriptions.[12,19,20] Scientific validation of the information provided by ChatGPT requires a systematic and thorough approach to assess its accuracy, reliability, and credibility. The following steps can be taken to scientifically validate ChatGPT information. (1) Identifying the source of information. It is important to identify the source of information provided by ChatGPT. This will help to assess the credibility and reliability of the information. (2) Check the accuracy of information by comparing it with other reputable sources. The accuracy of this information was verified through independent research and analysis. (3) Check for bias: determine whether there is any bias in the information provided by ChatGPT. This may include bias in the data used to train the model, bias in the language or terminology used by ChatGPT, or any other bias that may affect the accuracy of the information. (4) Evaluate the evidence: determine whether there is sufficient evidence to support the information provided by ChatGPT. This may include an assessment of the quality and significance, authenticity, and consistency of the evidence. (5) Consultation with experts: opinions of experts in the field to verify the information provided by ChatGPT. This will help to ensure that the information is accurate and reliable.

It is important to note that ChatGPT responses cannot replace human expertise and judgment, at least at this stage. Although ChatGPT can provide helpful recommendations and guidance, the surgical team must ultimately rely on their knowledge, wisdom, experience, and judgment to make the best decisions for their patients. By following these steps, users can ensure that the information provided by ChatGPT is accurate and reliable.[47,48]

CONCLUSION

ChatGPT is valuable but not a replacement for trained medical professionals, especially in orthopedic surgery. Exercise caution and consultation with a qualified surgeon or physician for personalized medical advice and treatment. AI integration in medical decision-making should consider legal and ethical considerations such as privacy, patient confidentiality, and liability for potential errors. Surgery involves human qualities such as empathy and emotional intelligence, which cannot be fully replaced by AI technology. Further training and data refinement specific to orthopedic surgery are needed to enhance the applicability of ChatGPT in this medical specialty.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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SUPPLEMENTARY MATERIAL

Supplementary material is available in the electronic version of this paper at the CiOS website, www.ecios.org

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