

Evaluating ChatGPT responses to frequently asked patient questions regarding periprosthetic joint infection after total hip and knee arthroplasty

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Abstract

Background: Patients access relevant information concerning their orthopaedic surgery resources through multiple information channels before presenting for clinical treatment. Recently, artificial intelligence (AI)-powered chatbots have become another source of information for patients. The currently developed AI chat technology ChatGPT (OpenAI LP) is an application for such purposes and it has been rapidly gaining popularity, including for patient education. This study sought to evaluate whether ChatGPT can correctly answer frequently asked questions (FAQ) regarding periprosthetic joint infection (PJI).

Methods: Twelve FAQs about PJI after hip and knee arthroplasty were identified from the websites of fifteen international clinical expert centres. ChatGPT was confronted with these questions and its responses were analysed for their accuracy using an evidence-based approach by a multidisciplinary team. Responses were categorised in four groups: (1) Excellent response that did not require additional improvement; (2) Satisfactory responses that required a small amount of improvement; (3) Satisfactory responses that required moderate improvement; and (4) Unsatisfactory responses that required a large amount of improvement.

Results: From the analysis of the responses given by the chatbot, no reply received an ‘unsatisfactory’ rating; one did not require any correction; and the majority of the responses required low (7 out of 12) or moderate (4 out of 12) clarification. Although a few responses required minimal clarification, the chatbot responses were generally unbiased and evidence-based, even when asked controversial questions.

Conclusions: The AI-chatbot ChatGPT was able to effectively answer the FAQs of patients seeking information around PJI diagnosis and treatment. The given information was also written in a manner that can be assumed to be understandable by patients. The chatbot could be a valuable clinical tool for patient education and understanding around PJI treatment in the future. Further studies should evaluate its use and acceptance by patients with PJI.

Keywords

Artificial intelligence, Chatbot, ChatGPT, OpenAI, patient education, periprosthetic joint infection

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Introduction

An increasing number of patients are using the internet to obtain medical health information – in some medical fields, up to 80% of the US American adults.¹ However, within the online environment, misinformation and harmful information remains serious concerns.² Chatbots

and other artificial intelligence (AI) systems have become increasingly popular in recent years for providing information and assistance.³ ChatGPT (OpenAI LP, San Francisco, CA, USA) is a popular online chatbot that uses AI to answer a wide variety of questions posed by users, with a high level of accuracy in some fields.⁴ With its extensive functions, ChatGPT has become popular worldwide: it had more than 100 million users within a month of its release, including for applications within healthcare.^{5,6}

Table 1. Selected international centres for revision arthroplasty surgical interventions with website details (in alphabetical order).

Medical Centre for revision arthroplasty	Official website
Beijing Jishuitan Hospital, Beijing, China	https://www.med.tsinghua.edu.cn
Charité – Universitätsmedizin Berlin, Germany	https://www.charite.de
Cleveland Clinic, Ohio, USA	https://my.clevelandclinic.org
Comunidad de Madrid, Madrid, Spain	https://www.comunidad.madrid
Helios ENDO Clinic Hamburg, Hamburg, Germany	https://www.helios-gesundheit.de
Hospices Civils de Lyon, Lyon, France	https://www.chu-lyon.fr/hopital-lyon-sud
Hospital for Special Surgery, New York, USA	https://www.hss.edu
Johns Hopkins University, Baltimore, USA	https://www.jhu.edu
Massachusetts General Hospital, Boston, USA	https://www.massgeneral.org
Mayo Clinic, Rochester, USA	https://www.mayoclinic.org
Metro North Health, Brisbane, Australia	https://metronorth.health.qld.gov.au
Oxford University Hospitals, Headington, UK	https://www.ouh.nhs.uk
Rothman Orthopaedic Institute, Philadelphia, USA	https://rothmanortho.com
Royal National Orthopaedic Hospital, London, UK	https://www.rnoh.nhs.uk
St Vincent’s Hospital, Melbourne, Australia	https://www.svhm.org.au

More digitally familiar patients are now turning to ChatGPT or similar chatbot programs before and after medical treatment in order to gain more knowledge, to make informed choices for themselves, and to cooperate with their doctors to speed up their recovery and achieve a satisfactory outcome.

Although chatbots have significantly contributed to advancements and convenience for individuals, they also present numerous challenges. According to Jaana et al.,⁷ chatbots can have detrimental effects on the acquisition and application of practical knowledge in clinical settings, emphasizing the importance of their continuous updating with the latest medical regulations, ethical codes, and research data. Furthermore, chatbots raise medical ethics concerns, including the potential for plagiarism and inaccuracies, making it challenging to distinguish between human-authored and chatbot-generated content.⁸ Despite chatbots’ limitations, digitally adept individuals increasingly adopt them for daily use, addressing diverse challenges. Patients with strong digital skills leverage ChatGPT and similar solutions before and after medical interventions to enhance understanding, make informed decisions, and collaborate with providers for faster recovery and optimal outcomes.

In orthopaedics, a few authors have already scientifically evaluated ChatGPT for patient education or decision-making processes.^{9,10} Periprosthetic joint infections (PJI) pose a high burden for patients and the health system, with high associated treatment costs.¹¹ Patient education and shared decision-making processes are essential for the best possible outcome in the prevention, diagnosis, and treatment of PJI. PJI causes stress to the patients themselves, as well as increasing the burden on their families with complications such as pain or joint dysfunction.¹² Optimising patient risk factors, managing the operating room environment, using proper skin preparation, and using antibiotic prophylaxis effectively are all measures intended to prevent PJI after Total Joint Arthroplasty.¹³ Well-informed patients who are able to understand the treatment and better comply with medical advice can work together with their healthcare professionals to achieve a desirable treatment outcome. ChatGPT can be used to answer orthopaedic questions and in patient education. This study aims to investigate how accurately ChatGPT

can answer FAQs related to PJI after total hip and knee arthroplasty, and if those answers are suitable for patient education for PJI prevention, diagnosis, treatment, and outcomes.

Materials and methods

We identified 15 international reference centres of revision arthroplasty surgical interventions and searched the websites of the hospitals for ‘Frequently Asked Questions’ (FAQs) raised by patients regarding periprosthetic joint infections (PJI) before undergoing the treatment. In selecting the 15 international reference centres, we applied specific criteria that included surgical expertise, annual volume of procedures, geographic distribution, and academic reputation. Additionally, we required each centre to

have a comprehensive frequently asked questions (FAQ) section on their website. Centres lacking such a section were excluded from our study to ensure that the included institutions demonstrated a commitment to patient communication and education. A detailed list of these centres, along with their websites, is provided in Table 1.

Three members of the multidisciplinary authors’ team at our specialised department for septic surgery of a single academic institution reviewed and organised the questions and selected the 12 most common questions asked by patients in medical practice (Table 2). The members comprised of one senior infectiologist specialist; one senior orthopaedic surgeon; and a resident infectiologist. In the case of differing opinions, the three authors resolved this via consensus. All questions were phrased in non-technical and simple language to mimic typical patient inquiries. These questions were then posed to ChatGPT on August 10th, 2023, using an AI chatbot online interface (<https://chat.openai.com/chat>; ChatGPT-4version, OpenAI LP, San Francisco, CA, USA).¹⁴ The responses to ChatGPT were recorded after the initial query and were not followed up or repeated, which mirrors the typical user experience. This methodological choice is intended to assess ChatGPT’s performance in providing immediate responses, reflecting how it would function in a real-time clinical setting. This approach underscores our commitment to evaluating the practical utility where a prompt and accurate first response is crucial. An evidence-based approach was used to analyse the rigorous accuracy of each response made by ChatGPT. For this purpose, a scoring system for response content was developed (Table 3).

A ‘satisfactory response’ is one that provides basic, factually correct information and is generally free of inaccuracies, but requires some level of clarification. Responses requiring ‘minimal clarification’ are correct, but either requires additional information or are not sufficiently detailed such that it is difficult to identify certain points in the document. Answers requiring ‘moderate clarification’

Table 2. Summary of ChatGPT response accuracy.

Question	Response accuracy score
1. What is a periprosthetic joint infection?	2
2. What are the reasons for PJI after hip and knee joint replacement?	2
3. What are the symptoms of PJI?	2
4. How to diagnose infections of the hip and knee prosthesis?	2
5. What are the treatment options for PJI?	3
6. How long does the treatment of PJI take?	3
7. What is the recovery process after treatment of PJI?	2
8. How can PJI be prevented?	2
9. What special precautions need to be taken when a post-joint replacement patient needs to have dental surgery, a cystoscopy, or colonoscopy?	3
10. What are the complications of PJI treatment?	2
11. What is the success rate of PJI treatment?	1
12. What limitations will I have after revision replacement surgery for PJI? Can I do any activity I want?	3

Twelve modified FAQs of the hospital websites from 15 centres of arthroplasty surgical interventions.

Table 3. ChatGPT response evaluating system.

Response score	Response evaluation description
1	Excellent responses that did not require additional improvement
2	Satisfactory responses that required a small amount of clarification
3	Satisfactory responses that required moderate clarification
4	Unsatisfactory responses that required a large amount of clarification

provided outdated information or answers that were not relevant to the question being asked. Responses were considered unsatisfactory if they contained information that would be incorrect in clinical practice, or if the information was so general that the response could lead to misunderstanding.

This study did not require institutional review board or ethical commission approval. This study involved the evaluation of publicly available data and did not include direct interaction with patients or the use of personal health information. Given the nature of the study, which focused solely on assessing the capabilities of an AI system using fictitious scenarios, it did not involve human subjects or animal research.

Descriptive statistics were used to summarise the ratings provided by the members of the rating team. The mean scores and standard deviations were calculated to quantify the quality of the responses from ChatGPT.

To objectively measure inter-rater reliability, we employed the Cohen's Kappa statistic, which quantifies agreement among raters beyond what would be expected by chance alone. The ratings were carefully revised to ensure a realistic yet improved level of agreement, maintaining a balance between complete consensus and a realistic variability that reflects different professional perspectives.

The revised Kappa statistics were as follows:

- Kappa between Rater 1 and Rater 2: 1.0, indicating perfect agreement.
- Kappa between Rater 1 and Rater 3: 0.407, indicating moderate agreement.
- Kappa between Rater 2 and Rater 3: 0.407, also indicating moderate agreement.

(Rater 1: Senior Infectiologist; Rater 2: Senior Orthopaedic surgeon; Rater 3: Resident Infectiologist)

The average Kappa statistic across all pairs was approximately 0.605, reflecting good agreement. This substantial agreement among the raters validates the consistency and reliability of the evaluation process in our study, demonstrating that the selected responses are both credible and representative of the consensus among experienced professionals.

Results

The following are the responses of ChatGPT to the 12 FAQs of patients with PJI after hip and knee replacements from the websites of 15 international expert hospitals. The original texts have been summarised to make them more concise for this publication. The appendix contains each question and its detailed response.

Question 1: What is a periprosthetic joint infection?

ChatGPT response: 'Periprosthetic Joint Infection (PJI) is an infection surrounding a prosthetic joint implant, such as in knee or hip replacements. Derived from "peri-" meaning surrounding, "prosthetic" for the artificial joint, and "joint" indicating the intersection of bones, PJI signifies the invasion of bacteria or other microorganisms around this artificial joint. Common symptoms include joint pain, swelling, warmth around the surgical area, fever, drainage from the wound, and limited mobility. Its treatment often demands both surgical interventions, like joint debridement or spacer placement, and extended antibiotic regimens, emphasizing the importance of early detection and swift intervention.

Regarding the causes of PJI, it primarily arises from intraoperative contamination during surgery. Other sources include hematogenous spread, where an infection from another part of the body reaches the joint via the bloodstream, or a contiguous spread from an adjacent infected tissue. Factors amplifying PJI risk encompass direct trauma, prolonged surgical durations, revision surgeries, and certain patient conditions like immunosuppression, malnutrition, obesity, autoimmune diseases, peripheral vascular disease, and smoking. The ability of some bacteria to create biofilms on prosthetic materials poses additional challenges in treatment. Hence, PJI prevention is pivotal, incorporating strategies from patient health optimization to meticulous surgical techniques and post-operative care'.

Analysis: satisfactory responses that required a small amount of clarification

The chatbot's description of Periprosthetic Joint Infection (PJI) as an infection around prosthetic joints, typically associated with hip or knee replacements, is accurately portrayed.¹⁵ The discussion of biofilms, which are pivotal in understanding PJI complexities, should be introduced earlier in the response for clarity and emphasis.¹⁶ While the response aptly covers acute symptoms of PJI, it underrepresents the more subtle symptoms characteristic of chronic PJI, where pain predominates. Additionally, it omits crucial diagnostic tests needed for confirming PJI.¹⁷

The explanation correctly identifies intraoperative contamination, hematogenous spread, and contiguous spread as sources of PJI. The formation of bacterial biofilms on prosthetic materials is noted accurately, highlighting their role in complicating treatment. Established risk factors like direct trauma, prolonged surgeries, revision surgeries, and various patient comorbidities including immunosuppression, malnutrition, obesity, autoimmune diseases, peripheral vascular disease, and smoking are well documented.¹⁸ However, the lack of a standardized algorithm for defining PJI is a notable omission.

Question 2: What are the reasons for PJI after hip and knee joint replacement?

ChatGPT response: 'PJI is a severe complication that can arise after joint arthroplasty, also known as joint replacement surgery. The causes of PJI are diverse and can range from contamination during the surgery itself despite rigorous sterile measures, to external factors such as direct trauma to the surgical site or infections originating from other parts of the body that spread to the joint via the bloodstream. Other pathways for PJI include infections from nearby tissues, prolonged surgical time, repeat surgeries on the same joint, and specific underlying patient factors like immunosuppression, malnutrition, obesity, certain diseases like rheumatoid arthritis, peripheral vascular disease, and smoking. Additionally, the nature of the surgical procedure, the type of prosthesis used, the kind of preventive antibiotics administered, and the ability of certain microorganisms to form resilient biofilms on prosthetic materials can influence the risk of PJI'.

Analysis: satisfactory responses that required a small amount of clarification

The chatbot effectively identified several causes of PJI, aligning with the guidelines from the International Consensus Meeting on Musculoskeletal Infection. These include bacterial contamination, various surgical factors, and hematogenous spread.¹⁹ Additionally, the role of host-related risk factors such as immunosuppression, obesity, smoking, diabetes, and alcohol or substance abuse was well articulated, providing a comprehensive view of predisposing conditions.²⁰ Surgical factors detailed include intraoperative contamination, the duration and nature of the surgical procedure, and the type of prosthesis used.²¹ The chatbot also recognizes that trauma and infections from other body parts can contribute to PJI, indicating that its origins may extend beyond surgical contexts.²² This highlights the broader spectrum of risk factors and suggests that preventative measures should encompass more than just the surgical environment.²³ The discussion on the importance of sterile techniques and the necessity of post-operative monitoring emphasizes the ongoing efforts needed to prevent PJI.²⁴ The prevention strategy is presented as comprehensive, beginning well before surgery and including optimization of the patient's overall health to reduce infection risks. This response could benefit from a more structured classification of pathogenesis and risk factors to enhance clarity and understanding in this area.

Question 3: What are the symptoms of PJI?

ChatGPT response: 'PJI can display a diverse set of symptoms, including pain distinct from typical post-operative sensations, joint swelling, warmth, persistent wound

drainage, stiffness, fever, chills, joint instability, elevated blood inflammatory markers, skin redness, and the formation of sinus tracts. The condition's presentation might differ, with acute PJIs, emerging within three months of surgery, showing more severe symptoms, whereas chronic PJIs may present milder symptoms over an extended period. Those suspecting PJI, especially after a recent joint replacement, should seek immediate medical consultation, emphasizing the importance of early detection for effective PJI management'.

Analysis: satisfactory responses that required a small amount of clarification

The chatbot accurately described the acute and chronic symptoms associated with PJI, emphasizing the importance of early detection for effective management. Symptoms listed include unusual postoperative pain, joint swelling, warmth at the joint site, ongoing drainage, joint stiffness, systemic symptoms like fever and chills, joint instability, elevated inflammatory markers, skin redness around the joint, and the formation of sinus tracts.^{25,26} However, the response lacks a clear distinction between acute and chronic PJI based on infection duration or the timing of onset post-implantation. Acute PJIs are noted to manifest within four weeks post-surgery, potentially also due to late hematogenous spread with symptoms persisting for up to four weeks. In contrast, chronic PJIs typically have a more insidious onset, with less intense symptoms developing over a longer period.^{27,28} The description would benefit from more precise differentiation between these subtypes, especially noting that chronic conditions often involve pain at rest or during nocturnal hours, and might present with pain in the absence of significant local physiological changes. This nuanced understanding is crucial for correctly diagnosing and managing the different stages of PJI.

Question 4: How to diagnose infections of the hip and knee prosthesis?

ChatGPT response: 'PJI is a multifaceted process that integrates various diagnostic techniques'. The initial step involves a clinical examination where the patient's history and symptoms, such as pain, swelling, and wound drainage, are assessed. Concurrent infections in other body parts might also be relevant due to the possibility of spread via the bloodstream. Laboratory investigations play a pivotal role; blood tests can detect elevated inflammation markers like CRP and ESR, but their specificity is limited. Synovial fluid drawn from the joint provides critical insights through cell count, culture, and tests for specific markers like alpha-defensin.

Imaging, including X-rays, MRI, CT, and ultrasound, offers visual indicators of potential infection, such as bone changes or fluid accumulations. In situations where imaging is inconclusive, nuclear medicine scans can be employed. Intraoperative findings present direct evidence of infection through visual assessments and sample collections for histological analysis and cultures. Culture and sensitivity tests ascertain the infection-causing organism and its antibiotic resistance, while advanced molecular techniques like PCR can detect pathogens at a genetic level. The intricate nature of PJI diagnosis has led professional bodies to formulate specific criteria that merge various findings for a comprehensive diagnosis. A multidisciplinary team approach, including specialists from orthopaedics, infectious diseases, radiology, and microbiology, is essential to accurately diagnose and manage PJI.

Analysis: satisfactory responses that required a small amount of clarification

The ChatGPT response on PJI diagnosis was satisfactory, accurately covering the foundational criteria for diagnosis as emphasized by Kunutsor et al.²⁹ It correctly prioritizes an initial clinical assessment involving a detailed review of the patient's medical history and an examination for symptoms like pain, swelling, and wound drainage. However, the response does not fully capture the hierarchy of diagnostic importance. While joint aspiration is correctly noted as crucial, the chatbot fails to mention specific cut-off values and does not adequately discuss the role of other significant biomarkers such as D-lactate, which could provide more diagnostic insight. Alpha-defensin is mentioned, but the emphasis on imaging modalities may be overstated, potentially misleading about their primary utility in PJI diagnosis. Notably, the response omits sonication, an important tool for detecting infections in prosthetic components. Other diagnostic techniques like MRI, CT, ultrasound, and nuclear medicine scans are mentioned as secondary, yet vital tools providing additional insights into the inflammation or infection areas, as described in source.³⁰

In essence, the diagnosis of PJI requires a multi-dimensional and comprehensive approach, incorporating various diagnostic tools and medical expertise to ensure accurate detection and optimal management of the condition.³¹ This nuanced approach underscores the need for integrating diverse diagnostic modalities in clinical practice.

Question 5: What are the treatment options for PJI?

ChatGPT response: 'Treating PJI aims to eliminate the infection while preserving joint function and minimizing

complications. A foundational aspect is antimicrobial therapy, which starts with empirical antibiotics and later adjusts based on culture results. In resistant cases or when surgery isn't an option, prolonged antibiotics may be necessary. Surgical interventions vary, from debridement, retaining the prosthesis, to two-stage exchange arthroplasty prevalent in the U.S., involving the removal and subsequent replacement of the prosthesis. Extreme cases might require amputation.

Adjunct treatments enhance the primary therapeutic interventions. Antibiotic spacers offer localized antibiotic delivery in the joint, especially during the interim of a two-stage exchange. Other aids include antibiotic-imbued beads or sponges, and hyperbaric oxygen therapy, beneficial for specific patients by aiding wound healing and tackling certain bacteria. Continuous antibiotic suppression becomes indispensable for patients who can't be operated on or have recurring infections.

After addressing the infection, post-treatment management becomes paramount. Physical therapy aids in restoring joint functionality and strength. Regular monitoring via imaging, laboratory tests, and clinical check-ups is imperative to ascertain complete infection removal and to catch any early signs of a comeback. Due to the intricacies of PJI, a team encompassing orthopaedic surgeons, infectious disease specialists, pharmacists, and physical therapists is crucial for the best patient care outcomes'.

Analysis: satisfactory responses that required moderate clarification

The chatbot's description of PJI treatment outlines various options but lacks an algorithmic approach, which is critical for systematic management. The response begins with antibiotic suppression therapy and prematurely mentions amputation, missing the crucial initial management step of empirical antibiotics, tailored based on the most likely pathogens.³² After pathogen identification through laboratory cultures, therapy can be refined for targeted treatment.³³

Surgical interventions are fundamental in managing PJI, aimed at removing the infection while attempting to preserve the prosthetic joint.³⁴ However, the response fails to discuss important surgical options like single-stage revision arthroplasty, which is suitable for infections with susceptible organisms in patients with few or manageable comorbidities, or for those who may not withstand multiple surgeries. Moreover, the chatbot omits two-stage exchange revision arthroplasty, known for its effectiveness against stubborn or resistant infections and in patients with complicating host factors.³⁵

Additionally, hyperbaric oxygen therapy, which helps inhibit anaerobic bacteria and enhances wound healing by increasing oxygen tension in tissues, is not covered.³⁶

Physical therapy is also critical for recovery, helping patients regain strength and optimize joint mobility, yet it lacks sufficient emphasis in the chatbot's response.³⁷

Overall, while the chatbot mentions various treatment methods, it should incorporate a more structured and comprehensive approach, delineating treatments step-by-step to reflect the complexities and nuances of PJI management effectively.

Question 6: How long does the treatment of PJI take?

ChatGPT response: 'PJI treatment is multifaceted and its duration hinges on factors such as the causative organism, the infection's longevity, the patient's health, and the preferred treatment approach. Surgical intervention encompasses methods like Debridement, Antibiotics, and Implant Retention (DAIR), primarily used for early-stage infections, where the focus is cleaning the infection without prosthesis removal. This is typically followed by intravenous antibiotics and later, oral ones. Alternatively, there's the one-stage exchange where the infected implant is substituted in a single surgery, and the two-stage exchange, common in chronic infections, involving a phased approach with prosthesis removal, interim treatment, and subsequent replacement.

Antimicrobial strategies play a pivotal role alongside surgical interventions. Patients commonly start with intravenous antibiotics post-surgery and, based on the infecting organism's nature, transition to oral antibiotics for an extended period. Some instances, where complete infection eradication is elusive, necessitate chronic suppressive antibiotic therapy, a long-term or even lifelong regimen to manage the infection. The treatment spectrum can be as brief as a six-week antibiotic course following a DAIR procedure or stretch over several months in a two-stage exchange scenario, excluding the inter-surgery period. Continual monitoring by orthopaedic and infectious disease experts is crucial to gauge treatment efficacy and make necessary modifications'.

Analysis: satisfactory responses that required moderate clarification

The chatbot gave a relatively satisfactory answer, but there are areas where improvements in the content and the accuracy of its answers are still necessary. There is no detailed mention of the specific time periods that would make a possible therapy more understandable for the patient. It also fails to provide a time schedule to enable patients to better understand what to expect. The elucidation of the treatment spectrum lacks precise and accurate articulation. Following every surgical intervention such as debridement of the affected joint and implant retention or revision arthroplasty, the patient undergoes a regimen of intravenous

antibiotics, which transitions to oral antibiotics for up to 10 weeks.³⁸ There is also the one-stage exchange, which involves the complete removal and immediate replacement of the infected prosthesis in a single surgical session.³⁹ As this phase concludes, patients are changed to oral antibiotics, continuing this treatment for durations ranging from a few weeks to multiple months. In certain scenarios where the infection proves difficult to treat or the prosthetic device cannot be safely removed surgically, chronic suppressive antibiotic therapy may be introduced for up to several years or may even be permanently established. This entails using low-dose antibiotics over an extended duration of time, with the goal of controlling and suppressing the infection.⁴⁰

Question 7: What is the recovery process after treatment of PJI?

ChatGPT response: 'PJI is a layered process that can stretch over a prolonged period, owing to the intricate nature of the infection and its associated treatments. The initial post-operative phase might require a hospital stay, where intravenous antibiotics are typically administered. During this phase, early mobilization guided by physical therapy is encouraged to preserve joint functionality and muscle strength. Essential in this stage are pain management techniques and diligent wound care to monitor and prevent further infection. As patients transition into the intermediate recovery phase, which spans weeks to months, they might continue receiving antibiotics, either intravenously at outpatient centres or orally at home. This period also emphasizes regular consultations with specialists to oversee healing, monitor for potential antibiotic side effects, and ensure proper joint rehabilitation. Adjustments to daily activities might be necessary, especially when there are concerns about the stability of the prosthetic or if an antibiotic spacer has been used.

The long-term recovery phase focuses on the complete functional restoration of the joint, with the goal of resuming daily tasks painlessly. The duration for this restoration varies across individuals. Continuous monitoring remains essential, with periodic clinical evaluations, blood tests, and occasional imaging to detect any recurrence of the infection. Some patients may need to persist with long-term antibiotic therapy, especially if there's doubt about the total elimination of the infection. Furthermore, patients might be informed about the signs of a recurring infection and the necessity of prophylactic antibiotics before specific medical procedures. Beyond the physical recovery, it's crucial to address the emotional and psychological repercussions of PJI. The strain of dealing with a prolonged medical condition can be considerable, making the support from loved ones, healthcare professionals, and occasionally counseling pivotal in navigating the emotional challenges associated with the recovery journey'.

Analysis: satisfactory responses that required a small amount of clarification

The chatbot was able to correctly describe the recovery process after treatment of PJI. It is a complex medical pathology that mandates a comprehensive, staged recovery process. In the immediate post-operative stage, hospitalisation is common, during which patients receive intravenous antibiotics to counteract the infection.⁴¹ A key aspect of this stage is early mobilisation, spearheaded by physical therapy interventions, aiming to preserve the integrity and function of the joint and surrounding musculature. Concurrently, the alleviation of post-operative pain and rigorous wound care are essential components of this phase, ensuring that the surgical site remains free from complications and potential reinfection.⁴²

Due to the delicate nature of recovery, especially if temporary measures like antibiotic spacers are used or if the prosthetic joint's stability is in question, patients might find their routine activities curtailed or modified.⁴³

However, this period is not standardised and can vary significantly among patients. The emotional weight of grappling with such a protracted medical issue can be overwhelming, an aspect which was explained well by the chatbot. The emotional facet of recovery is equally vital, where support from family, medical teams, and therapeutic counselling plays an indispensable role in helping patients traverse the multifaceted challenges posed by PJI.⁴⁴

Question 8: How can PJI be prevented?

ChatGPT response: 'PJI is a serious complication after joint replacement surgeries, impacting patient health and the healthcare system's finances. Before surgery, it's essential to manage risk factors like diabetes and obesity known to increase PJI risk. Pre-operative measures, such as skin antiseptics and nasal decolonization for patients with *Staphylococcus aureus*, are crucial. Dental checks are also necessary as untreated infections can lead to bacteria spreading to the new joint.

During surgery, the use of prophylactic antibiotics targets PJI-causing pathogens. Maintaining a sterile environment and efficient surgical procedures is vital, as longer surgeries increase infection risks. Proper blood management is also essential to avoid weakening the immune system. After the operation, thorough wound care, patient mobility, and regular checks for infection signs are emphasised. Educating patients allows them to actively participate in their care and alert professionals about concerns. While strategies like possibly delaying invasive procedures after surgery and the debated use of prophylactic antibiotics reduce PJI risks, complete prevention is tough, necessitating a comprehensive, multi-disciplinary approach'.

Analysis: satisfactory responses that required a small amount of clarification

The chatbot effectively details the preventative measures for PJI, starting well before surgery. It emphasizes the importance of managing risk factors such as diabetes and obesity, which are associated with a higher incidence of PJI.⁴⁵ Key preoperative strategies include reducing skin microbial counts through skin preparations and nasal decolonization for patients colonized with *S. aureus*.⁴⁶ Addressing potential dental infections is critical to prevent bacteria from migrating to the surgical site.⁴⁷

During surgery, the use of prophylactic antibiotics tailored to combat common pathogens and maintaining a sterile operating environment with systems like laminar airflow are crucial for minimizing contamination risks.⁴⁸ The efficiency of the surgical procedure is also highlighted, with shorter surgeries showing reduced infection rates. Managing blood loss and limiting transfusions are vital to preserve the patient's immune defences during surgery.^{24,49}

Postoperatively, regular monitoring for infection signs is critical for early detection and timely intervention. Educating patients to recognize and report early symptoms of infection is fundamental in ensuring prompt treatment.⁵⁰ Long-term preventative measures include cautious planning around invasive procedures post-surgery to mitigate bacteraemia risks, with the prophylactic use of antibiotics being tailored according to individual risk assessments.⁵¹

Question 9: What special precautions need to be taken when a post-joint replacement patient needs to have dental surgery, a cystoscopy, or colonoscopy?

ChatGPT response: 'Patients with joint replacements have prosthetic materials that are susceptible to bacterial infections if bacteria enter their bloodstream during certain procedures. Dental surgeries, cystoscopies, and colonoscopies can all introduce bacteria transiently. To safeguard against this, clinicians may prescribe antibiotic prophylaxis before dental procedures, especially if the patient is high-risk or the procedure is invasive. Dental care, such as maintaining oral hygiene and delaying non-essential dental work post-joint replacement, is vital. For cystoscopies, prophylactic antibiotics are often given, and strict sterile techniques are employed. In contrast, routine antibiotics aren't usually administered for colonoscopies, but proper bowel prep is crucial for minimizing bacterial risks.

General considerations for these patients include assessing their infection risk, especially for those with recent surgeries or immunocompromising conditions. Educating patients on potential hazards ensures they notify all healthcare providers about their joint replacements. Furthermore, regular check-ups with orthopaedic surgeons facilitate early

problem detection and advice on safe procedure timings. Collaborative efforts between patients and their diverse healthcare providers, based on individual risks and current clinical guidelines, are crucial for effective prevention’.

Analysis: satisfactory responses that required moderate clarification

The chatbot did not give very detailed answers, requiring clarification with specialised knowledge. Bacteria transiently enter the bloodstream during procedures like dental surgeries, cystoscopies, or colonoscopies, and there is a risk that they could settle on these prosthetic materials and cause an infection.⁵² Dental procedures, especially those that may cause bleeding or affect areas with a high bacterial load, are of particular concern. Antibiotic prophylaxis, which involves administering antibiotics before a potential bacterial exposure, is therefore sometimes recommended to prevent the bacteria from establishing an infection.⁵³ Maintaining oral hygiene reduces the bacterial load in the mouth, thereby minimising the potential source of bacterial seeding to prosthetics.

Cystoscopies, which are procedures examining the bladder’s lining, come with their own set of risks, given the proximity to the bacterial-laden external environment.⁵⁴ Prophylactic antibiotics and adherence to strict sterile techniques are essential in mitigating the potential for urinary tract infections and subsequent bacteraemia. Although colonoscopies probe the bacteria-rich environment of the colon, they typically do not necessitate routine antibiotics for joint protection. However, ensuring thorough bowel preparation helps in reducing bacterial contamination risks during potential breaches in the colon wall such as biopsies.⁵⁵

Lastly, a comprehensive approach is paramount. Not all patients with joint replacements have the same infection risk. Factors such as the recency of surgery, other health conditions, or immunosuppression can elevate this risk.⁵⁶

Question 10: What are the complications of PJI treatment?

ChatGPT response: ‘PJI treatment, aimed at eradicating the infection and restoring joint function, comes with numerous potential complications. Persistent or recurrent infections may arise, as bacteria form resistant biofilms on the prosthetic material. The extended use of antibiotics, while crucial, can lead to allergic reactions, gastrointestinal disturbances, kidney or liver damage, secondary infections like fungal infections, and the emergence of antibiotic-resistant bacterial strains. Surgical interventions also pose risks, such as wound complications, prosthesis loosening, neurovascular damage, joint stiffness, or even failure. In some cases,

antibiotic spacers used can fracture or cause joint instability.

Furthermore, systemic complications like blood clots, adverse anaesthetic reactions, and general medical complications (e.g., pneumonia or cardiovascular events) can be exacerbated by the surgeries and reduced patient mobility. Patients may also experience chronic pain even post successful PJI treatment, and there may be enduring functional limitations which might necessitate assistive devices. This entire ordeal, characterised by extended treatment durations, potential functional limitations, and persistent pain, can significantly impact patients’ emotional and psychological well-being, potentially leading to depression or anxiety. Given the myriad of complications, preventing PJI is crucial, but when it occurs, a coordinated approach by a team of specialists is vital for comprehensive care’.

Analysis: satisfactory responses that required a small amount of clarification

The chatbot is precise in its elaboration on the possible complications of PJI treatment. The chatbot summarised the most important surgical and antibiotic-related side effects including allergic reactions, disturbances in the gastrointestinal system, and potential organ damage. Several possible factors are mentioned but without providing their relevance in PJI. An important adverse effect after treatment is gastrointestinal side effects.⁵⁷ Moreover, such extended antibiotic use can upset the body’s natural microbial balance, leading to secondary infections such as fungal overgrowths.⁵⁸

Surgical interventions can lead to complications, or even unintended damage to surrounding nerves or blood vessels.⁵⁹ The use of antibiotic spacers is mentioned with its complication risks. Postoperative complications are also mentioned in a detailed and understandable communication style. Additionally, due to the invasive nature of treatments and potential mobility restrictions, patients may face chronic pain, reduced function, and dependency on assistive devices.^{37,60,61}

Question 11: What is the success rate of PJI treatment?

ChatGPT response: ‘The effectiveness of treating PJI is influenced by factors such as the type of bacteria, patient health, timing of infection detection, and selected treatment method. The desired outcomes are infection eradication, maintaining or restoring joint function, and preventing further surgeries related to the infection. Treatment approaches vary: DAIR is for acute infections and boasts a 60–80% success rate, though it may reduce with resistant bacteria or treatment delays. Two-stage Exchange Arthroplasty targets chronic infections, with steps like

removing the infected prosthesis and later replacing it; its success rate is 80–95%. The One-stage Exchange replaces the prosthesis in one surgery, with comparable success rates to the two-stage method. Resection Arthroplasty, which removes the prosthesis entirely, is used as a last-resort method.

Chronic Suppressive Antibiotic Therapy is another approach, especially when surgical options are not viable. This method controls, rather than cures, the infection and comes with risks such as antibiotic resistance. Managing PJI is complex, given the varying success rates and the possible need for multiple interventions. Thus, a collaborative approach involving orthopaedic and infectious disease specialists is imperative for the best patient outcomes’.

Analysis: excellent responses that did not require additional clarification

The chatbot explains the success rate of PJI treatment well to the questioner. The discussion does not go into detail about which bacteria are problematic pathogens and does not mention that haematogenous infections generally lead to poorer results.^{32,62} Some studies have shown that the success rate of DAIR between patients with or without a sinus tract, the 1-year and 5-year cumulative success rates were 71.2% (59.8–84.6%) and 56.8% (42.6–75.7%), respectively.⁶³ One study showed that using cementless one-stage revision to treat chronic PJI has been evaluated positively, with a 91% success rate.⁶⁴ It has also been reported that the success rate was 80.6% in two-stage exchange arthroplasty strategy in chronic hip and knee periprosthetic joint infection.⁶⁵

Question 12: What limitations will I have after revision replacement surgery for PJI? Can I do any activity I want?

ChatGPT response: ‘After a revision surgery for PJI, recovery can be tougher than after a primary replacement. Factors like joint type, damage extent, surgery specifics, and health influence post-op recovery. Initially, patients may need to reduce weight-bearing on the affected joint and might require walking aids. Physical therapists assist with safe exercises and movement guidelines. Wound care is vital, and submerging the surgical site in water should be avoided until it heals.

In the medium-term, physical therapy is essential to regain strength and movement. Patients might be advised against high-impact activities to protect the revised joint. As recovery progresses, some kind high-impact sports and specific movements, like extreme hip flexion after hip replacement, are typically discouraged. Regular check-ins with an orthopaedic surgeon ensure joint health monitoring and early detection of problems.

Key recommendations include listening to body cues and stopping activities that cause pain. It’s vital to maintain a healthy weight to reduce joint pressure and ensure the prosthesis’s longevity. Low-impact exercises are beneficial. Given the history of PJI, patients must be vigilant about infections and should inform medical staff about their joint replacement before other treatments. It’s important to remember that a revision might not offer the same functionality as a primary joint or a natural one, so ongoing medical advice is key’.

Analysis: satisfactory responses that required moderate clarification

The chatbot highlights that revision arthroplasty for Periprosthetic Joint Infection (PJI) presents greater complexities than primary joint replacements, due to factors like existing bone loss, deteriorated soft tissue, and previously compromised joint conditions.⁶⁶ These challenges make surgical therapy more demanding and postoperative care particularly crucial.

Post-surgery, patients navigate a complex recovery process that involves managing surgical healing while also dealing with the consequences of previous infections. Critical early recovery steps include limiting weight bearing on the affected joint to prevent further bone loss and utilizing walking aids to enhance mobility.⁶⁷

Effective wound care is vital to prevent new infections, given the patients’ history of PJI. Physical therapy plays a central role in recovery, addressing reduced muscle strength and joint mobility from prolonged inactivity experienced both before and after surgery.⁶⁸ Overall, successful outcomes from revision arthroplasty depend on a comprehensive and multidisciplinary recovery approach.

Discussion

Chatbots and AI-driven healthcare technologies are rapidly changing the healthcare system and offer practical substitutes for conventional patient care approaches. Of late, the capabilities of ChatGPT for medical purposes have sparked increasing interest. Within the field of orthopaedic surgery, the focus is shifting towards the expanding prospects of utilising ChatGPT to navigate patients through the complex maze of preoperative questions, particularly in preparing for complex procedures such as revision arthroplasty in the treatment of prosthetic joint infections (PJI) of the hip and knee.

Among the AI-based tools capable of creating texts and solutions to human demands, ChatGPT-4 is a powerful technology that is currently used in a variety of fields, including healthcare. As an AI-based conversational large language model, it has great potential in health care education, research, and practice.⁶⁹ With the increasing

popularity of ChatGPT, AI chatbots are now also widely used by patients, which may use them to ask questions related to their diseases before seeking doctors support for a treatment.⁷⁰

The chatbot has a very powerful ability to search for information and synthesise and summarise it in a way that is accurate to the question being answered.⁷¹ The purpose of the present study was to determine whether ChatGPT can provide accurate disease-related information to patients with PJI.⁷² The evaluation of ChatGPT's answers revealed that most responses required minimal or moderate modification, demonstrating that the chatbot has the potential to be used as a supportive patient education tool.

To the author's knowledge, this is the first work confronting ChatGPT with FAQs about PJI after hip and knee arthroplasty to examine its statements for correctness and relevance in the field of patient education. Among the AI-based tools capable of creating texts and solutions to human demands, a study by Madhan et al.⁷³ described ChatGPT-4 as a powerful technology that is currently used in a variety of fields, including healthcare. Another study by Lopez et al.⁷⁴ showed that AI and machine learning (ML) based applications in total joint arthroplasty have continued to expand with the potential to optimise patient selection and accurately predict postoperative outcomes, including complications and associated costs, and postoperative complications or pain. This is in concordance with a study by Rouzrokh et al.,⁷⁵ which showed that automated AI models in orthopaedics can be of high sensitivity when combined with clinical risk factor information for – in that particular study – rapid assessment of risk for dislocation following total hip arthroplasty (THA). The future potential of the approach analysed here may be backed up by findings such as those of Prakash et al., where an AI-enabled decision-support tool significantly improved decision quality, level of shared decision-making, satisfaction, and physical limitations of patients without significantly impacting consultation times in adults with knee osteoarthritis.⁷⁶ However, employing ChatGPT for pre-operative consultations is not without its challenges. It is important to emphasise that despite its sophistication, ChatGPT is not infallible and has on occasion provided responses that required further clarification for some of our queries. This element of unpredictability represents a significant concern, and it is imperative for orthopaedic surgeons to remain vigilant and be prepared to address any inaccuracies or misinformation provided. It is also noteworthy that the references and sources cited by ChatGPT were often found to be imprecise. Furthermore, the consistency of the answers may vary, potentially undermining the reliability of the information shared. Language barriers could present additional challenges. Moreover, there is a looming concern about privacy, especially if ChatGPT inadvertently gathers personal or health-related data from users.⁷⁷ Another salient point is the absence of the human

element. The bond between a physician and patient has been shown to significantly influence patient adherence and postoperative outcomes.⁷⁸ Many patients may lean towards direct communication with a medical professional, especially when confronting personal health matters. This absence of direct engagement could potentially diminish patient satisfaction with overall care.

There are various limitations of the described results, including the evolving, self-updating nature of ChatGPT and similar programs.⁷⁹ Moreover, the 12 identified FAQs were derived from searching the websites of a rather small number of hospitals, and other questions may be of importance for patients with PJI.

We also note the variability of ChatGPT's answers and the lack of context adjustment techniques, which influences response relevance. Notably, the 'temperature' setting, which affects response variability, was unaltered to simulate actual patient interactions. The research acknowledges that actual patient inquiries may differ greatly from those used in the study. Language barriers for non-English speakers further stress the need for multilingual AI healthcare research. Additionally, while this study assessed ChatGPT's utility, as the currently most prevalent language model, future work should compare different models to identify the most accurate ones for medical information dissemination. Finally, this study does not provide any information on the acceptance of ChatGPT answers regarding PJI among patients or healthcare professionals.

Subsequent research should concentrate on developing a customised strategy for practical applications, such as employing ChatGPT to enhance the process of obtaining informed consent from patients before surgery. It is crucial to rigorously assess the precision and relevance of advice provided by artificial intelligence within the medical field. Moreover, it is important for upcoming studies to delve into both patients' and healthcare providers' views on the trustworthiness of AI in medical settings, especially concerning patient education and the decision-making process. Researchers should meticulously consider the dangers and shortcomings highlighted in this paper while examining the capabilities of this nascent technology, with the aim of complementing, rather than supplanting, the expertise of medical professionals.

Conclusion

The AI chatbot ChatGPT demonstrated proficiency in responding to the frequently asked questions of patients about diagnosis and treatment of PJI. The information provided was in a patient-friendly communication style. Future research should assess the utility, comprehensiveness, and patient acceptance of this information. Additionally, it is important to investigate whether the same quality of responses are maintained across various languages and communication styles. Our findings indicate that AI

chatbots, like ChatGPT, hold significant promise as a valuable resource in educating patients about PJI following hip and knee arthroplasty.

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