



Two minutes of orthopaedics with ChatGPT: it is just the beginning; it's going to be hot, hot, hot!

Philippe Hernigou¹ · Marius M. Scarlat²

Published online: 10 July 2023
© The Author(s) under exclusive licence to SICOT aisbl 2023

What is important, what is reality, what is hallucination?

Reality

Artificial intelligence (AI) has become disruptive in industries, including healthcare. In the field of orthopaedic surgery, AI holds tremendous potential to revolutionize patient care, surgical techniques, and outcomes. With its ability to analyze vast amounts of data, detect patterns, and generate insights, AI is poised to enhance decision-making, improve surgical precision, and ultimately shape the future of orthopaedic surgery. One of the key contributions of AI in orthopaedic surgery lies in its diagnostic capabilities. AI systems can interpret medical imaging data, including X-rays, CT scans, and MRI pictures, with surprising speed and accuracy by utilizing sophisticated algorithms and machine learning. This enables early and precise detection of musculoskeletal conditions, fractures, and abnormalities, empowering orthopaedic surgeons to develop personalized treatment plans based on comprehensive and reliable information. AI assists orthopaedic surgeons in preoperative planning, enabling them to simulate and optimize surgical procedures. Through AI-powered algorithms, surgeons can access predictive models that provide valuable insights into the potential outcomes of different surgical approaches. This enhances surgical precision, reduces intraoperative complications, and minimizes the risk of postoperative complications,

thereby improving patient safety and recovery. Intraoperative guidance is another area where AI can make a significant impact. With the integration of AI technologies, surgeons can receive real-time feedback during procedures, allowing them to make informed decisions and adapt their techniques as needed. AI-driven robotic-assisted surgery has already shown promise in orthopaedics, enabling more precise implant placement, reducing surgical errors, and shortening patients' recovery times. AI algorithms can analyze vast patient data, including lab results, medical information, and treatment outcomes. By assimilating this information, AI systems can provide valuable clinical decision support to orthopaedic surgeons. AI can help anticipate patient outcomes, improve treatment strategies, and spot potential dangers or consequences using predictive analytics. This data-driven approach empowers surgeons with evidence-based insights, leading to more informed and personalized patient care. Orthopaedic surgery often involves a significant rehabilitation phase. AI-based technologies, such as wearable devices and motion-tracking systems, can monitor patients' progress and provide real-time feedback on their rehabilitation exercises. This continuous monitoring enables personalized rehabilitation programs and allows orthopaedic surgeons to remotely track patients' recovery, make adjustments as necessary, and intervene proactively if any issues arise. The application of artificial intelligence in orthopaedic surgery presents significant difficulties and moral dilemmas, as with any disruptive technology. Important considerations include data privacy, security, and the proper application of AI algorithms. Transparent validation, regulatory oversight, and ethical frameworks are imperative to ensure patient safety, protect patient confidentiality, and maintain the trust of both medical professionals and the public. Orthopaedic surgery could be transformed by artificial intelligence, which would increase patient outcomes, surgical precision, and diagnostic accuracy. The integration of AI technologies holds promise for enhanced

On May 2023, WHO declared the end of COVID-19 global health emergency, and on June 2023, PubMed search for the term "ChatGPT" yielded 674 results, with only five results from 2022.

✉ Marius M. Scarlat
mscarlat@gmail.com

¹ University Paris East, Paris, France

² Groupe ELSAN, Clinique Chirurgicale St Michel, Toulon, France

surgical planning, real-time guidance, data-driven decision support, and optimized rehabilitation. However, it is vital to balance technological advancements and ethical considerations, ensuring that AI systems are developed and implemented responsibly, with the ultimate goal of augmenting the expertise and judgment of orthopaedic surgeons.

With supplied questions or prompts, ChatGPT, an advanced language model created by OpenAI, can produce text responses that resemble a human's answer. It can deliver pertinent comments to various themes; it has been trained with a high volume of Internet material. It can comprehend and produce content in a variety of languages, making it available to a worldwide audience. An effective tool for generating original content, helping with information retrieval, giving explanations, and having conversations is ChatGPT. It has many uses, including customer service, content development, instructional support, and idea generation. It's crucial to understand that ChatGPT, like other AI models, has its limitations. It creates responses based on patterns and relationships in its training data rather than genuine understanding or reasoning, so it may occasionally provide wrong or illogical answers. However, it is susceptible to biases with biased and subjective responses. OpenAI has tried to address these limitations and improve the model's performance, but challenges remain. Overall, ChatGPT and similar AI models have demonstrated great potential in various applications, but it's important to use them responsibly and remain aware of their limitations to ensure they are used as valuable tools rather than authoritative sources.

You might be astonished to find that none of the authors wrote the two preceding paragraphs of this chapter. They were created by a chatbot that has access to an infinite amount of online data. Did you have any doubts?

“It took 15 s to ChatGPT to write Paragraph 1 as the answer to this question: Write an editorial on artificial intelligence in orthopaedic surgery.” And it took three minutes to the authors to read the text!

“Paragraph 2 was the answer in 15 s by ChatGPT to this question: what do you think about ChatGPT?”

If you ask the same questions, the answers will be similar but formulated differently!

Chatbots are software programs simulating conversations between humans, while using the AI and the natural language processing (NLP) technique. One famous example of NLP is the “third-generation generative” pre-trained transformer (GPT-3) model, which can generate text of any type. OpenAI has developed ChatGPT [1], a chatbot using the GPT-3 model. This model reached one million users within its first week of release, end of November 2022! ChatGPT has arrived at the Academic breakfast table and will probably be there to stay at Academic Diner. Conducting a PubMed search for the term “ChatGPT” on March 17, 2023, the search yielded 138

results: five from 2022 and 133 from 2023. On the 26 June, on PubMed, the search found 674 results. A similar exponential progression on PubMed was only observed for COVID-19 PubMed search between 2019 and 2020. *This is the reality.*

Importance

The World Health Organization (WHO) determined that COVID-19 “no longer constitutes a public health emergency of international concern (PHEIC).” The announcement was on May 2023, three years after WHO declared the outbreak. *This is important.*

So, what is the opinion of ChatGPT about this announce: Asking this question to ChatGPT, “On May 2023, WHO declares end of COVID-19 global health emergency: is it important?” The following answer (25 s) is obtained:

If the World Health Organization (WHO) were to declare the end of the COVID-19 global health emergency in May 2023, it would indeed be significant. Such a declaration would indicate that the WHO assesses the situation as no longer meeting the criteria for a global health emergency related to COVID-19. An official declaration of the end of the global health emergency would imply several things: Progress in Controlling the Pandemic would suggest that efforts to mitigate the spread of COVID-19, such as vaccination campaigns, public health measures, and healthcare interventions, have been successful in reducing the impact of the virus on a global scale. This would reflect positive progress in controlling the pandemic and change in the global response to COVID-19. It may shift the focus from emergency measures and crisis management towards long-term planning, recovery efforts, and strategies for preventing future outbreaks. This declaration could influence policy decisions at various levels, including national and regional governments, health organizations, and public health agencies. It could shape guidelines for travel, quarantine measures, healthcare infrastructure, and resource allocation. The declaration might have a psychological impact, bringing a sense of relief, hope, and normalcy to people living through the challenges of the pandemic. It could also impact societal behavior, including attitudes towards mask-wearing, social distancing, and other preventive measures. However, it's important to note that the significance of such a declaration would depend on the specific context, the state of the pandemic at that time, and the global consensus among health experts and authorities. It is always advisable to stay informed through reliable sources and follow guidelines from

public health organizations to ensure the safety and well-being of oneself and others.

“We can only remark the prudence of ChatGPT in its answer, a much more nuanced answer than that of the assertion of WHO!”

So, continuing with another question: “WHO declared on May 2023 end of COVID-19 global health emergency: is it true?,” the answer in 15 s is as follows:

I apologize for any confusion, but as an AI language model, my responses are based on information available up until September 2021. I don't have access to real-time data or the ability to provide updates on specific events that may have occurred after my knowledge cutoff. To find out the most accurate and up-to-date information regarding the status of the COVID-19 pandemic and any declarations made by the World Health Organization (WHO), I recommend referring to trusted news sources or official announcements from the WHO or other relevant health authorities.

Boundaries of reality: artificial intelligence hallucination

A hallucination or artificial hallucination in AI is a confident response that does not seem in concordance with its training data. For example, a hallucinating chatbot might, when asked to generate a report on the end of COVID announced by WHO, falsely discuss the announcement and at the end, recognizes that he has no information about this announcement since he has no data available after the end of 2021!

In analogy to the phenomenon of hallucination in human psychology, such experiences are referred to as “hallucinations.” One significant distinction is that although a human hallucination is typically linked to mistaken perceptions, an AI hallucination is linked to unjustified reactions or beliefs. Around 2022, the release of some large language models, including ChatGPT, contributed to the popularity of AI hallucinations. Users noted that these bots frequently appeared to “sociopathically” and pointlessly insert random falsehoods into the articles they produced.

Expanding ChatGPT knowledge from 2021 to 2023 could resolve some AI hallucination incidents. The continuously evolving nature of “AI learning” makes it challenging to update the information. Several factors contribute to hallucination, including differences in data sets and in the source used for training. Additionally, due to changes in time data, degradation can occur as in the example with COVID.

ChatGPT in orthopaedics: it is just the beginning

ChatGPT as Editor: “what is your opinion about the journal International Orthopaedics”?

As an AI language model, I don't have personal opinions or subjective evaluations. However, I can provide general information about the journal “International Orthopaedics.”

International Orthopaedics (officially known as “International Orthopaedics (SICOT)”) is a peer-reviewed medical journal that focuses on orthopaedic surgery and related disciplines. It is the official journal of the Société Internationale de Chirurgie Orthopédique et de Traumatologie (SICOT), which is an international society for orthopaedic surgeons and professionals.

The journal publishes original research articles, clinical studies, review articles, case reports, and other scholarly content related to various aspects of orthopaedic surgery. It covers topics such as musculoskeletal disorders, trauma, sports medicine, joint replacement, spine surgery, paediatric orthopaedics, and orthopaedic oncology, among others.

International Orthopaedics aims to disseminate high-quality research and provide a platform for the exchange of knowledge and advancements in the field of orthopaedics. It follows a rigorous peer-review process to ensure scientific rigor and maintains ethical standards in publishing.

As with any scientific journal, the reputation and quality of International Orthopaedics may be assessed based on factors such as the journal's impact factor, the expertise and reputation of its editorial board, the visibility and impact of published articles, and the overall recognition and citation of the journal within the orthopaedic community. It is always advisable to evaluate journals based on multiple sources and consult with peers and experts in the field for a comprehensive assessment.

ChatGPT as author: “please write a paper for the use of ChatGPT in the international orthopaedics journal”—applications, advantages, limitations, future prospects, and ethical considerations

Abstract: The advancement of artificial intelligence (AI) has revolutionized various industries, including healthcare. ChatGPT, a state-of-the-art language model developed by OpenAI, has shown promising

potential in augmenting medical professionals' clinical decision-making and improving patient care. In this paper, we explore the applications of ChatGPT in the field of orthopaedics. We discuss its potential benefits, limitations, and ethical considerations. Additionally, we provide insights into the challenges and future directions for integrating ChatGPT into orthopaedic practice.

Introduction: Diagnosing and treating orthopedic conditions often require extensive medical knowledge, complex decision-making, and effective communication between healthcare providers and patients. ChatGPT, an AI-powered conversational agent, can understand and generate human-like responses, making it a valuable tool in orthopaedic practice. This paper aims to examine the utility of ChatGPT in orthopedics and its impact on patient care.

Benefits of ChatGPT in Orthopaedics:

- **Enhanced Clinical Decision-Making:** ChatGPT can assist orthopedic practitioners by providing quick access to vast medical information, research papers, and treatment guidelines. It can help clinicians make accurate diagnoses, choose appropriate treatment options, and develop personalized care plans for patients.

- **Patient Education and Engagement:** ChatGPT can be utilized as a virtual assistant to provide patients with relevant information about their orthopaedic conditions, treatment options, and postoperative care. By answering patient queries and addressing concerns, ChatGPT enhances patient education and engagement, leading to improved treatment adherence and outcomes.

- **Efficient Triage and Appointment Scheduling:** ChatGPT can be integrated into healthcare systems to efficiently triage patients based on the severity of their orthopaedic conditions. ChatGPT can recommend appropriate appointment scheduling by assessing symptoms and historical data, reducing waiting times and optimizing resource allocation.

Limitations and Ethical Considerations.

- **Lack of Contextual Understanding:** While ChatGPT can provide responses that resemble those of a human, it may have trouble recognizing context, which could result in incorrect or lacking information. The model must be trained and improved utilizing orthopaedic-specific data to overcome this constraint.

- **Legal and Privacy Concerns:** The integration of ChatGPT in orthopedic practice raises legal and privacy concerns regarding data security, patient confidentiality, and liability. Adherence to existing regulations and implementing robust data protection protocols are crucial for maintaining patient trust.

- **Bias and Fairness:** ChatGPT's responses are influenced by the data it is trained on, potentially leading to biases in recommendations and treatment plans. Ensuring diversity and inclusivity in training data and regularly monitoring the model's outputs can mitigate this concern.

Challenges and Future Directions.

- **Integration into Clinical Workflow:** Integrating ChatGPT seamlessly into the clinical workflow is a challenge that requires careful consideration of technical implementation, user interface design, and training the model on domain-specific data.

- **Model Explainability:** ChatGPT's black-box nature limits its explainability, hindering clinicians' trust in its recommendations. Efforts should be made to develop methods that enhance interpretability and transparency, allowing clinicians to understand the model's reasoning.

- **Real-Time Learning and Continuous Improvement:** Continuous learning and improvement of ChatGPT through real-time feedback from orthopaedic practitioners can enhance its accuracy, reliability, and clinical relevance.

Conclusion: ChatGPT holds significant potential in transforming orthopedic practice by supporting clinical decision-making, improving patient education, and optimizing healthcare delivery.

ChatGPT in education: “information for resident: using a hammer and a chisel for tibial osteotomy”

Performing a tibial osteotomy requires precision and careful execution. The use of a hammer and chisel is one of the traditional techniques employed for this procedure. However, it is important to note that this response is purely informational and does not substitute proper medical training or guidance. If you are a resident or medical professional, seeking hands-on training and supervision from experienced orthopaedic surgeons before attempting any surgical procedure is essential. The steps outlined below provide a general overview of the technique involving a hammer and chisel for tibial osteotomy:

Preoperative Planning: Obtain appropriate imaging (e.g., X-rays, CT scan) to assess the patient's tibial deformity and plan the osteotomy site and desired correction. Determine the proper osteotomy technique based on the patient's specific condition, such as closing-wedge or opening-wedge osteotomy.

Patient Preparation: Ensure the patient is positioned appropriately on the operating table, providing optimal access to the operative site. Administer anaesthesia as

per the patient's needs and in consultation with the anesthesiologist.

Exposure and Approach: Make an appropriate incision over the tibia, typically along the anteromedial or anterolateral aspect, based on the planned osteotomy site. Dissect through the soft tissues to expose the tibia adequately, taking care to protect neurovascular structures.

Osteotomy Execution: Identify the planned osteotomy site based on preoperative planning and anatomical landmarks. Use a surgical marker or electrocautery to mark the osteotomy lines on the tibial surface. Choose an osteotome or chisel appropriate for the desired osteotomy width and depth. Place the osteotome perpendicular to the tibial surface, aligning it with the marked osteotomy lines. Using a mallet or hammer, gently tap the osteotome to initiate the osteotomy. Start with small, controlled taps to create a pilot hole.

Osteotomy Completion: Gradually increase the force and depth of the strikes with the hammer, progressing along the marked osteotomy lines. Continuously assess the depth and alignment of the osteotomy using fluoroscopy or other imaging modalities. A bone graft or substitute may be inserted into the gap to maintain the desired correction if performing an opening-wedge osteotomy.

Secure the osteotomy with appropriate fixation, such as plates and screws, depending on the surgeon's preference and the patient's specific requirements.

Soft Tissue Handling and Closure: Ensure proper soft tissue balancing and alignment before closing the incision. Repair and approximate the deep fascia, subcutaneous tissue, and skin layers in a standard fashion. Apply dressings, immobilize the limb, and provide postoperative care per the surgeon's instructions.

Remember, this description serves as a general outline and does not replace the need for proper training, supervision, and adherence to established surgical techniques. It is crucial to consult with experienced orthopedic surgeons and follow institutional protocols when performing any surgical procedure.

ChatGPT as prescription: “write a rehabilitation program for a patient operated with total hip arthroplasty by posterior approach”

Note: The following rehabilitation program serves as a general guideline. The specific details of a patient's rehabilitation program should be determined by their orthopaedic surgeon or physical therapist, considering individual factors such as surgical technique, patient

condition, and any accompanying medical conditions. Patients must consult their healthcare professionals for personalized guidance.

Phase I: Initial Postoperative Phase (Days 1–4)

- **Weight-bearing** as advised by the surgeon (e.g., toe-touch weight-bearing, partial weight-bearing, or weight-bearing as tolerated). Use assistive devices such as crutches, a walker, or a cane, as instructed.

- **Pain Management:** Utilize prescribed pain medications as directed. Employ ice packs for pain and swelling control, as recommended.

- **Activities of Daily Living (ADLs):** Focus on maintaining independence in ADLs such as dressing, bathing, and toileting. Utilize adaptive equipment if needed (e.g., long-handled reacher, shower chair).

- **Range of Motion (ROM) Exercises:** Perform gentle ankle pumps, quadriceps setting, and gluteal contractions to maintain muscle activation and circulation. Ankle and knee ROM exercises within pain limits.

- **Ambulation and Gait Training:** Begin with short-distance walking, assisted by a walking aid if necessary. Focus on proper gait mechanics, weight transfer, and stability during ambulation.

- **Precautions:** Adhere to hip precautions provided by the surgeon, such as avoiding hip flexion beyond a certain angle, internal rotation, or crossing legs.

Phase II: Intermediate Rehabilitation Phase (Weeks 2–6)

- **Weight-Bearing Progression:** Gradual increase in weight-bearing, as per surgeon's instructions. Gradually wean off assistive devices as gait and stability improvements.

- **Strengthening Exercises:** Initiate gentle isometric exercises for the hip muscles, including hip abductors, hip extensors, and hip flexors. Progress to resistance training with weight machines, guided by a physical therapist.

- **Range of Motion Exercises:** Perform active and passive ROM exercises for the hip joint, including flexion, extension, abduction, adduction, and external/internal rotation. Utilize stretching techniques to maintain or improve hip joint flexibility.

- **Balance and Proprioception:** Incorporate balance exercises, such as single-leg stance, tandem stance, and weight-shifting activities. Utilize unstable surfaces (e.g., balance boards) under the guidance of a therapist.

- **Cardiovascular Conditioning:** Engage in low-impact aerobic exercises, such as stationary cycling or water therapy, to improve cardiovascular fitness.

- **Education and Precautions:** Emphasize adherence to hip precautions, especially during activities that may place excessive stress on the hip joint. Educate the

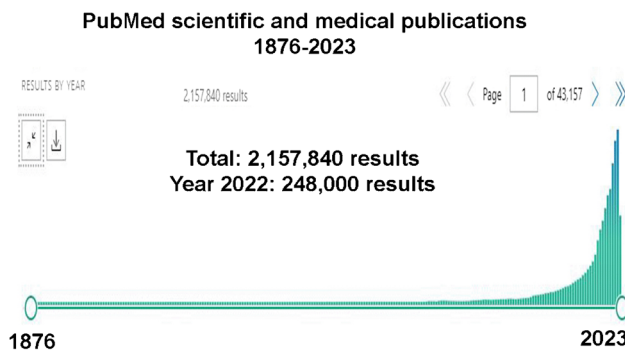


Fig. 1 Progression of publications between 1876 and 2022; if all publications represent more than 2 million, 2 million have been published in the last 20 years; and more than 500,000 during the 3 years 2020–2022 before ChatGPT

patient on proper body mechanics and techniques for preventing falls or injuries.

Phase III: Advanced Rehabilitation Phase (Weeks 6 and beyond).

- Strengthening and Conditioning: Progress resistance exercises to include more challenging movements and higher loads. Incorporate functional exercises, such as squats, step-ups, and lunges, to simulate daily activities.

- Agility and Coordination: Integrate agility drills, ladder exercises, and sport-specific movements, as appropriate. Focus on improving coordination, reaction time, and dynamic stability.

- Endurance Training: Gradually increase the duration and intensity of cardiovascular exercises to improve overall endurance and fitness.

- Return to Activities: Work with the physical therapist to gradually.

**ChatGPT as reviewer; the circle is complete!!!
“Could you review the hip rehabilitation protocol paragraph that you have written and comment on what is missing?”**

The provided hip rehabilitation protocol appears comprehensive and covers the major aspects of a typical rehabilitation program. However, there are a few areas that could be further elaborated or included:

Preoperative Education: It is essential to include preoperative education to prepare patients for rehabilitation. This education can cover expected postoperative pain levels, use of assistive devices, hip precautions, and an overview of the rehabilitation phases.

Pre-rehabilitation refers to exercises and conditioning done before surgery to optimize the patient's physical

fitness. Including pre-rehabilitation exercises, such as strengthening the hip muscles and improving range of motion, can potentially enhance postoperative recovery.

Pain Management Strategies: In addition to utilizing prescribed pain medications and ice packs, other pain management strategies like transcutaneous electrical nerve stimulation (TENS), heat therapy, or alternative pain relief techniques could be considered and included in the protocol.

Functional Training: While the protocol includes some practical exercises in the advanced phase, it would be beneficial to incorporate functional training earlier in the rehabilitation process. Functional movements mimic activities of daily living and help patients regain their functional independence more effectively.

Progression Criteria: It would be helpful to define specific criteria or milestones that indicate when a patient is ready to progress from one phase to the next. These criteria can be based on pain levels, range of motion, strength, gait quality, and functional abilities.

Return-to-Sport Guidelines: If the patient's goal is to return to sports or high-level activities, including specific guidelines for safely reintegrating into these activities would be valuable. This may involve sport-specific training, agility drills, and gradual progression based on the demands of the desired activity.

Psychological Support: Addressing the psychological aspects of rehabilitation, such as anxiety, fear of movement, and motivation, can contribute to a more successful recovery. Including strategies for addressing these factors, such as providing information, setting realistic goals, and offering psychological support, can enhance the overall rehabilitation experience.

Remember that every patient's rehabilitation program should be personalized and tailored to their specific needs and capabilities. It is crucial to consult with healthcare professionals, such as orthopedic surgeons or physical therapists, to create an individualized plan that considers the patient's unique circumstances.

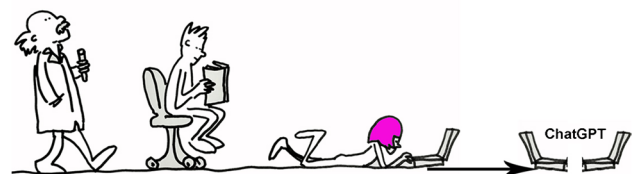


Fig. 2 Evolution of research and publication; this picture can be compared with the evolution of publications in Fig. 1

Is the next journal “The Academic ChatGPT Orthopaedic Journal (edited by ChatGPT)”?

Which part of the academic job will ChatGPT take? Editing, writing, or reviewing, or all? The system of scientific publications, i.e., all the journals disseminating new knowledge validated and growing exponentially widespread use the Internet facilitated multiplication but also paved the way for new ways of sharing knowledge. Given the number of publications (248,000) in 2022 (Fig. 1), with a rate of 20% of acceptance, more than one million papers were submitted, and with only one h of review per paper, 1 million hours were devoted to reviewing articles by reviewers.

The growth will continue exponentially by the arrival of AI and ChatGPT and other systems in the publication; it is likely that a balance will be reached when researchers will spend more time reviewing than publishing! And then, the number of reviews will be exhausted simply by lack of time. To this should also be added the proliferation of subsidy programs that require evaluators.

If it is estimated that more than 1 million hours have been devoted to the evaluation of articles, considering the average salary of researchers this is equivalent to 25 million US

dollars for the United States and China alone. The real costs are likely much higher because we do not know the number of total publications to be evaluated. It is possible that in this area within a few years CHATGPT can participate in the evaluation of articles after perhaps “having written them as in the example of rehabilitation provided in this editorial.”

Rather than viewing ChatGPT as a risk to make authors and reviewers disappear (Fig. 2), this new technology will probably have first a *therapeutic effect* by making the blank page syndrome disappear. As all medications, it should not be used as a drug. It could be used in a symbiotic manner, as robotics in operating room. With probably unlimited uses, ChatGPT will probably be a time-saving partner tool, as is now the calculator for high school students.

Reference

1. ChatGPT General FAQ. <https://help.openai.com/en/articles/6783457-chatgpt-general-faq>. Accessed 26 June 2023

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.