



Article Artificial Intelligence Language Model Performance for Rapid Intraoperative Queries in Plastic Surgery: ChatGPT and the Deep Inferior Epigastric Perforator Flap

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Abstract: Background: The integration of artificial intelligence in healthcare has led to the development of large language models that can address various medical queries, including intraoperatively. This study investigates the potential of ChatGPT in addressing intraoperative questions during the deep inferior epigastric perforator flap procedure. Methods: A series of six intraoperative questions specific to the DIEP flap procedure, derived from real-world clinical scenarios, were proposed to ChatGPT. A panel of four experienced board-certified plastic surgeons evaluated ChatGPT's performance in providing accurate, relevant, and comprehensible responses. Results: The Likert scale demonstrated to be medically accurate, systematic in presentation, and logical when providing alternative solutions. The mean readability score of the Flesch Reading Ease Score was 28.7 (\pm 0.8), the Flesch–Kincaid Grade Level was 12.4 (\pm 0.5), and the Coleman–Liau Index was 14.5 (\pm 0.5). Suitabilitywise, the DISCERN score of ChatGPT was 48 (±2.5) indicating suitable and comprehensible language for experts. Conclusions: Generative AI tools such as ChatGPT can serve as a supplementary tool for surgeons to offer valuable insights and foster intraoperative problem-solving abilities. However, it lacks consideration of individual patient factors and surgical nuances. Nevertheless, further refinement of its training data and rigorous scrutiny under experts to ensure the accuracy and up-to-date nature of the information holds the potential for it to be utilized in the surgical field.

Keywords: ChatGPT; artificial intelligence; large language model; DIEP; intraoperative; plastic surgery

1. Introduction

The integration of artificial intelligence (AI) and machine learning (ML) technologies into the medical field has brought about remarkable advancements, particularly in the domain of clinical decision support systems [1–4]. Among these advances, large language models (LLMs) represent a cutting-edge application of AI in the realm of natural language processing. These models have garnered significant interest for their potential to augment healthcare processes, facilitate real-time communication, and provide valuable insights to healthcare professionals [3,5–7]. Notably, LLMs, such as Generative Pre-trained Transformer (GPT) models, demonstrate capabilities in understanding and generating human-like text, thereby facilitating real-time communication and providing valuable insights to healthcare professionals [5–7]. By training LLMs on extensive clinical data and medical literature, it becomes possible to develop AI systems that can support surgeons with intraoperative queries and difficulties.



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The deep inferior epigastric perforator (DIEP) flap is the gold standard reconstructive option for women undergoing autologous breast cancer reconstruction [8]. It is a complex and intricate microsurgical operation involving the transfer of subcutaneous tissue and blood vessels from the abdominal region to the chest wall to reconstruct the breast mound. The procedure requires a high level of precision and technical skill, thus making it imperative for the operating surgeon to have comprehensive knowledge. The success of the DIEP flap procedure hinges on meticulous planning and execution, given its complexity and microsurgical nature. Intraoperative decision making is a critical aspect of the DIEP flap procedure, as it involves various considerations such as flap design, perforator selection, and microvascular anastomosis [9]. Advancements of innovative LLMs like ChatGPT present a promising solution to this challenge. By leveraging its ability to comprehend and generate context-specific information, ChatGPT can offer instantaneous responses to intraoperative queries. This capability is particularly valuable in scenarios where the operating surgeon needs quick access to scientific knowledge to make informed decisions. The model's potential to bridge the gap between theoretical knowledge, as found in guidelines and research articles, and real-time surgical applications can significantly enhance the efficiency and precision of the DIEP flap procedure.

ChatGPT is an advanced natural language processing model that has demonstrated remarkable success in generating human-like responses across various domains including plastic surgery [1–10]. By harnessing the power of ML, ChatGPT can provide accurate, concise, and relevant information in a conversational manner. The integration of ChatGPT into the intraoperative environment may serve as an invaluable resource for plastic surgeons, potentially enhancing surgical outcomes and patient care. In the context of complex surgical procedures like the DIEP flap, ChatGPT's capabilities could be harnessed to provide real-time, evidence-based answers to surgical queries. This includes offering insights on anatomical variations, suggesting procedural modifications based on patient-specific factors, and providing quick references to the latest research and clinical guidelines [1-4]. Such a tool could be pivotal in decision-making processes during surgery, potentially enhancing surgical outcomes and patient care. Moreover, ChatGPT's ability to learn and adapt over time through continuous training and updates means that it can stay current with the latest medical advances and surgical techniques. This feature is particularly crucial in fields like plastic surgery where new techniques and research findings emerge regularly [3–7]. The utilization of ChatGPT in the operating room could also facilitate a more collaborative approach, allowing surgical teams to access shared knowledge bases and reduce the cognitive load on the operating surgeon, ultimately contributing to improved patient safety and care quality.

In this case study, we evaluate the performance of ChatGPT in addressing intraoperative queries related to the DIEP flap procedure. We assess the LLM's ability to provide accurate, relevant, and timely information, as well as its overall utility in a clinical setting. By examining the role of ChatGPT in addressing intraoperative queries in plastic surgery, this study seeks to contribute to the growing body of research on AI and ML in healthcare and explore the potential for LLM to enhance surgical decision-making and patient outcomes.

2. Materials and Methods

Aim: In this study, we aim to investigate the potential of artificial intelligence language models to provide safe and up-to-date medical information to plastic surgeons. For this purpose, we employed (ChatGPT-4, San Franciso, CA, USA), the most popular LLM currently accessible to the public. We evaluated its capacity, effectiveness, and accuracy in designing, implementing, and assessing the information provided for intraoperative DIEP complications. The questions (Figures 1–6) were derived by a panel of expert plastic surgeons from real world scenarios according to the Delphi study [11].

Hi ChatGPT, I am an experienced Plastic Surgeon, I am currently dissecting out a deep inferior epigastric perforator flap for breast reconstruction. I am unable to locate any perforators of sufficient calibre for the arterial anastomosis. How should I proceed?

I'm not a medical professional, but I can provide some general information that might help you. If you are having difficulty locating perforators of sufficient caliber during a deep inferior epigastric perforator (DIEP) flap procedure for breast reconstruction, you may consider the following options. Always consult with colleagues or expert sources in case of any uncertainty.

- Intraoperative imaging: Utilize intraoperative imaging techniques, such as Doppler ultrasound or handheld indocyanine green (ICG) angiography, to help identify and map the perforators more accurately.
- Extend dissection: You could consider extending your dissection to identify more perforators that might have been missed initially. However, keep in mind that this could increase the risk of complications and damage to the tissue.
- 3. Superficial inferior epigastric artery (SIEA) flap: If you are unable to identify suitable perforators for the DIEP flap, consider an alternative like the SIEA flap, which uses the superficial inferior epigastric artery and vein. Keep in mind that not all patients have suitable SIEA vessels, and the dissection is slightly different from the DIEP flap.
- 4. Muscle-sparing transverse rectus abdominis myocutaneous (ms-TRAM) flap: If the DIEP flap is not feasible, you may also consider the ms-TRAM flap, which preserves more rectus muscle compared to the traditional TRAM flap. This option, however, may be associated with a higher risk of abdominal wall complications.
- 5. Alternative flaps: If neither the DIEP nor the other options mentioned above are feasible, you may need to consider alternative flaps for breast reconstruction, such as the latissimus dorsi flap, the gluteal flap, or the thoracodorsal artery perforator (TDAP) flap. Discuss these options with your patient and your surgical team.

Remember that this information is not a substitute for professional medical advice, and it's essential to consult with colleagues, mentors, or expert sources when dealing with complex surgical situations.

Figure 1. Prompt 1 regarding operator unable to locate suitable perforators.

Hi ChatGPT, I am an experienced plastic surgeon, I have damaged the perforating vessels during deep inferior epigastric perforator flap dissection that has compromised flap perfusion and viability. What do you recommend I do?

🛞 🛛 As an Al language model, I am not a medical professional, but I can provide some general 👘 🗘 🖓 suggestions for you to consider if you've damaged perforating vessels during a deep inferior epigastric perforator (DIEP) flap dissection, and the flap perfusion and viability have been compromised. Please consult with your colleagues or seek expert advice as needed. 1. Meticulous hemostasis: Control bleeding by applying direct pressure or using hemostatic agents 2. Evaluate flap perfusion: Assess the flap's blood supply using techniques like handheld Doppler or indocyanine green (ICG) angiography to determine the extent of compromised perfusion 3. Repair the damaged vessels: If possible, repair the damaged vessels using microsurgery techniques. 4. Re-evaluate perfusion: After the repair, re-evaluate the flap perfusion and viability to ensure adequate blood supply. 5. Consider alternate flaps: If the damage is extensive and the perfusion remains severely compromised even after repair, you might need to consider using an alternate flap, such as a superficial inferior epigastric artery (SIEA) flap, a muscle-sparing TRAM flap, or a latissimus dorsi flap. 6. Postoperative monitoring: Closely monitor the flap postoperatively to ensure proper healing and perfusion. Look for signs of flap failure, such as color changes, temperature changes, and capillary refill time. 7. Collaborate with colleagues: In complex cases, it may be beneficial to consult with colleagues or seek advice from other experienced plastic surgeons to determine the best course of action. Remember that these suggestions are general and may not apply to your specific case Please discuss your situation with your colleagues and any other medical professionals involved in your patient's care to determine the best course of action.

Figure 2. Prompt 2 regarding compromised flap perfusion and viability.

Hi ChatGPT, I am an experienced plastic surgeon, currently performing deep inferior epigastric perforator flap dissection, there was no internal mammary vein present as a recipient vessel for microsurgical anastomosis. What do you recommend I do and what should I look for intraoperatively?

 I am not a surgeon, but I can try to provide some general suggestions based on my knowledge. If you encounter a situation where the internal mammary vein is not present or suitable for microsurgical anastomosis in a deep inferior epigastric perforator (DIEP) flap procedure, you could consider alternative recipient vessels. Here are a few options:

- Thoracodorsal vessels: The thoracodorsal artery and vein could be suitable alternatives for anastomosis. They are located in the axillary region and are typically utilized in the latissimus dorsi flap. The dissection should be done carefully to avoid injuring the vessels
- Lateral thoracic vessels: As another option, you could explore the lateral thoracic artery and vein, which are found along the lateral chest wall. They may be more difficult to locate and dissect, so proceed cautiously.
- Serratus branch vessels: In some cases, the serratus branch of the thoracodorsal vessels
 can be used. This would require a more extensive dissection, but it could provide a viable
 option if other recipient vessels are not available.
- 4. Contralateral internal mammary vessels: If the other side's internal mammary vessels are suitable, you could perform a "cross-chest" anastomosis, connecting the flap vessels to the contralateral internal mammary vessels. This approach has the potential for increased complications and should be considered carefully.
- 5. Superficial inferior epigastric artery (SIEA) flap: If the superficial inferior epigastric artery and vein are of adequate size, you could consider using an SIEA flap instead of a DIEP flap. The SIEA flap has a more straightforward dissection, but is limited by the caliber and availability of the superficial inferior epigastric vessels.

It is essential to discuss your options and the potential risks with your surgical team, and tailor your approach to the individual patient's anatomy and specific needs. Always consult with colleagues and refer to the latest clinical guidelines and research when making decisions during surgery.

Figure 3. Prompt 3 regarding absence of internal mammary vein for microsurgical anastomosis.

Hi ChatGPT, I am an experienced plastic surgeon, currently performing deep inferior epigastric perforator flap dissection, and there is significant intraoperative bleeding around the anastomosis. What do you recommend I do?

I am not a medical professional, but I can try to offer some general suggestions based on the information you've provided. However, it is essential that you consult with your surgical team and follow established protocols for managing intraoperative bleeding in your specific situation.

If you're encountering significant bleeding during a deep inferior epigastric perforator (DIEP) flap dissection, some general steps you could consider include:

- Applying direct pressure: Use a sterile gauze or surgical sponge to apply direct pressure on the bleeding site, which may help with temporary hemostasis.
- Identifying the source of bleeding: Carefully inspect the surgical field to identify the precise location of the bleeding. It could be from a perforating vessel, the deep inferior epigastric artery or vein, or surrounding tissues.
- Controlling the bleeding: Once the source of bleeding has been identified, you can attempt to control it using various methods such as electrocautery, suture ligation, or hemostatic agents (e.g., Surgicel, Floseal, or GelFoam).
- Ensuring proper visualization: Adequate visualization of the surgical field is crucial to control bleeding effectively. Use suction devices to clear the field and retractors to provide optimal exposure.
- Reassessing the anastomosis: After achieving hemostasis, reassess the anastomosis to ensure it is still intact and functioning correctly. Repair or revise the anastomosis if necessary.
- Monitoring the patient's vitals: Continuously monitor the patient's vital signs, such as blood pressure, heart rate, and oxygen saturation, to ensure their stability during the procedure.
- Consider involving additional surgical expertise: If you are unable to control the bleeding or if the patient's condition deteriorates, consult with colleagues or other experts who may be able to provide additional guidance.

Remember, it is essential to consult with your surgical team and follow established protocols in your specific situation. The information provided here is only for general knowledge purposes and should not be considered medical advice.



Hi ChatGPT, I am an experienced plastic surgeon, currently performing deep inferior epigastric perforator flap dissection, I noted that there is a clot formation in the arterial anastomosis. What do you recommend I do?

As an AI language model, I am not a medical professional, but I can provide some general G suggestions for you to consider if you're experiencing clot formation in the arterial anastomosis during a deep inferior epigastric perforator (DIEP) flap dissection. Please consult with your colleagues or seek expert advice as needed.

- 1. Stop the bleeding: Achieve hemostasis around the anastomotic site by applying direct pressure, using electrocautery, or employing hemostatic agents as appropriate.
- 2. Remove the clot: Carefully remove the clot from the anastomotic site, taking care not to damage the vessels further.
- 3. Evaluate the arterial anastomosis: Inspect the anastomosis to determine if there are any technical issues, such as a suture line problem or a kinked vessel, that might have contributed to clot formation.
- 4. Revise the anastomosis: If necessary, revise the anastomotic site, ensuring proper alignment and tension-free approximation of the vessels.
- 5. Irrigate with heparinized saline: Flush the anastomotic site with heparinized saline to minimize the risk of clot formation and to promote blood flow
- 6. Assess blood flow: Confirm adequate blood flow in the anastomosis and flap using techniques such as handheld Doppler, indocyanine green (ICG) angiography, or direct observation of the flap's color and capillary refill.
- 7. Use medical management: Consider using anticoagulants or antiplatelet agents as appropriate, in consultation with the patient's medical team, to reduce the risk of further clot formation.
- 8. Postoperative monitoring: Closely monitor the flap postoperatively to ensure proper healing and perfusion. Look for signs of flap failure, such as color changes, temperature changes, and capillary refill time
- 9. Collaborate with colleagues: In complex cases or if you have concerns, it may be beneficial to consult with colleagues or seek advice from other experienced plastic surgeons

Remember that these suggestions are general and may not apply to your specific case. Please discuss your situation with your colleagues and any other medical professionals involved in your patient's care to determine the best course of action.

Figure 5. Prompt 5 regarding clot formation in arterial anastomosis.

- Hi ChatGPT, I am an experienced Plastic Surgeon, I have just completed my anastomosis for the deep inferior epigastric perforator flap, with anastomosis of the deep inferior epigastric artery to the internal mammary artery. I'm concerned my flap is now showing signs of venous congestion intraoperatively. What should I do next?

I'm not a surgeon, but I can try to provide some general advice based on the information I've been trained on. If you suspect venous congestion in a deep inferior epigastric perforator (DIEP) flap intraoperatively, it's crucial to act quickly to address the issue and minimize the risk of flap loss. Here are some steps you can consider

- 1. Reassess the anastomosis: Check the venous anastomosis for any technical issues, such as twisting, kinking, or compression, and ensure there is no clot formation. If you find any problem, you might need to revise the anastomosis.
- 2. Verify flap inset and positioning: Ensure the flap is inset correctly without tension or compression on the pedicle or anastomotic site.
- 3. Examine the donor site: Check the donor site and flap pedicle for any compressive dressing, hematoma, or seroma that might be contributing to venous congestion.
- 4. Additional venous anastomosis: If the primary venous anastomosis is patent and there is still venous congestion, you could consider performing a secondary venous anastomosis using a vein graft or an adjacent vein to improve venous outflow.
- 5. Optimize hemodynamics: Communicate with your anesthesiologist to ensure the patient's blood pressure, fluid balance, and other hemodynamic parameters are
- optimized to promote flap perfusion. 6. Leech therapy: As a last resort, you could consider using leech therapy to temporarily
- relieve venous congestion, but this should be done cautiously due to the risk of infection and significant blood loss.
- 7. Close monitoring: If the congestion does not resolve immediately but shows signs of improvement, you might decide to closely monitor the flap in the immediate postoperative period, as some degree of congestion could resolve spontaneously.

Remember that it's crucial to address venous congestion as soon as possible to minimize the risk of flap failure. Consult with your surgical team and consider the patient's individual circumstances when making decisions. If you're unsure about how to proceed, seek advice from colleagues with experience in microsurgery and flap procedures.

Figure 6. Prompt 6 regarding intraoperative venous congestion.

Study Design: A series of six intraoperative questions specific to the DIEP flap procedure were prompted to ChatGPT-4. A panel of four experienced board-certified plastic surgeons (RJR, DHS, RC, and WMR) with extensive breast surgery experience (over 65 years cumulatively) evaluated ChatGPT's performance in conjunction in providing accurate, relevant, and comprehensible responses using a qualitative Likert scale ranging from 1 to 5. If any differences in the Likert scale arose, these were discussed until consensus was achieved. The readability of ChatGPT responses was assessed using the Flesch Reading Ease Score (range 0–100, a higher score indicating easier readability), Flesch-Kincaid Grade Level and Coleman-Liau Index (both have no theoretical upper limits, lower scores indicate simpler texts), whilst the DISCERN score (range 16–80, higher scores mean greater quality) was used to evaluate the suitability of the response in conveying information.

Inclusion and Exclusion Criteria: ChatGPT-4 operates on a probabilistic algorithm, utilizing random sampling to generate diverse responses, potentially yielding different answers to identical questions. Therefore, only the first response was included, and the 'regenerate response' feature was not employed. Care was taken to ensure grammatical and syntactical correctness in each question, with all queries entered on the same day using a single ChatGPT Plus account with access to ChatGPT-4. Institutional ethics was not required for evaluating publicly available AI LLM.

3. Results

The qualitative analysis of the Likert scale of ChatGPT-4 can be seen in Table 1. The authors found that ChatGPT consistently provided accurate, albeit somewhat superficial, responses that corresponded to the knowledge level of a plastic surgery trainee. While ChatGPT did not offer any insights beyond what an expert plastic surgeon would already be aware of, its contributions could prove valuable for trainees. Its potential in serving as an educational tool and a medium for surgical simulation exercises is noteworthy.

Table 1. Qualitative evaluation of ChatGPT-4's responses using the Likert scale.

Criteria			ChatGPT		
	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
The large language model provides accurate answers to questions.				х	
The large language model is reliable when generating factual and relevant information.				х	
The large language model is proficient at understanding complex questions and providing appropriate answers.				х	
The large language model provides comprehensive information when answering questions.		х			
The large language model generates content that covers all relevant aspects of a subject.			х		
The large language model can provide in-depth information on a wide range of topics.		х			
The large language model is a valuable source of general knowledge.				х	
The large language model can provide useful insights and perspectives on complex surgical topics.			х		
The large language model is a valuable resource for addressing intricate queries pertaining to complex plastic surgery procedures during operations.		х			

The mean readability score of the Flesch Reading Ease Score was 28.7 (\pm 0.8) indicating a moderate readability. This score suggests that the material may be complex and more difficult to read, typically suitable for university graduates. The Flesch–Kincaid Grade Level of 12.4 (\pm 0.5) suggests that the content is most likely comprehensible for individuals with approximately 12.4 years of formal education, corresponding to a high school level education with some university-level experience. The Coleman–Liau Index of 14.5 (\pm 0.5) implies that the content generated by ChatGPT is most suitable for individuals who have completed university-level education. Suitability-wise, the DISCERN score of ChatGPT was 48 (\pm 2.5), indicating that the information generated by ChatGPT is of good quality, reliable, and suitable for experts in the field, suggesting that it can be used as a valuable resource for healthcare professionals. However, it might be less accessible or harder to understand for those without a professional background in the topic, seen in Table 2. Overall, these scores suggest that the language and content generated by ChatGPT are suitable and comprehensible for experts in the field and for individuals with a certain level of formal education, which, in this case, leans towards the higher end of the educational spectrum.

			Suitability		
	Prompts	Flesch Reading Ease Score	Flesch–Kincaid Grade Level	The Coleman–Liau Index	DISCERN Score
ChatGPT	Unable to locate perforators	27.8	12.3	14	45
	Damaged perforators	29.6	12.4	14	47
	No internal mammary vein	28.9	13.1	15	44
	Bleeding around anastomosis	29.7	12.5	15	47
	Clot formation in anastomosis	27.6	12.6	15	50
	Venous congestion	28.7	1.7	14	43
	Mean (s.d.)	28.7 (±0.9)	12.4 (±0.5)	14.50 (0.6)	46 (±2.5)

Table 2. Readability and reliability of ChatGPT-4 responses.

4. Discussion

The DIEP flap is a complex, lengthy surgical procedure requiring meticulous dissection and microsurgery. Although routinely employed as a method of breast reconstruction, variations in anatomy and the proximity to major vessels during the flap inset can present a real risk of intraoperative complications, even to the experienced surgeon. As with all surgical procedures, the preoperative planning phase is integral to the overall success of the operation. Identification of optimal abdominal perforators through preoperative imaging has improved outcomes by reducing flap harvest time as well as the overall operation [12].

The application of technology is now being used to enhance intra-operative procedures, with the use of virtual and augmented holographic reality to improve perforator localization and identification [13]. The integration of AI and ML systems could further support surgical decision-making as various intraoperative challenges arise, including lack of sufficient caliber perforators, compromised flap perfusion, flap congestion, and issues with anastomosis [14].

In this study, ChatGPT demonstrated a high degree of accuracy in responding to intraoperative queries, showcasing its capability to interpret, synthesize, and quickly respond to complex medical information. By leveraging its extensive training data and advanced natural language processing techniques, ChatGPT was able to generate contextually appropriate and medically accurate responses to various questions related to the DIEP flap. For example, ChatGPT recognized the SIEA as a viable alternative option within the anatomical territory of the DIEP flap dissection [15]. ChatGPT also offered suitable alternative recipient vessels in the absence of the internal mammary vein for microsurgical anastomosis. The options provided were valid and accurate, such as the thoracodorsal vessels, serratus branch, or lateral thoracic vessels [16,17]. This ability to access and process large amounts of medical data has the potential to reduce the cognitive load on surgeons and trainees. Provision of accurate and up-to-date information in real time could prove beneficial during times of acute operative stress where cognition can be impaired. Furthermore, ChatGPT demonstrated an understanding of critical issues that must be addressed promptly to ensure patient safety and the success of the procedure. For example, when questioned about intraoperative bleeding, it formulated a focused and systematic approach to apply direct pressure, identify the source of bleeding, and employ appropriate techniques such as electrocautery, suture ligation, or hemostatic agents. It emphasized basic surgical principles of broadening the field of visualization. It also provided logic to reassess the anastomosis, ensuring preservation of the flap, and recommendations of postoperative monitoring of the patient's vital signs.

This form of logic was also applied when challenged with questions regarding arterial or venous flap compromise. A systematic approach of evaluating the cause was proposed, followed by relevant treatment options, both local and systemic. The structured response is certain to prompt critical thinking in an experienced clinician and highlights the predominant role of ChatGPT as an adjunct, not simply a replacement for learned knowledge. ChatGPT's ability to engage in logical and systematic problem-solving extends beyond mere algorithmic responses. It demonstrates a sophisticated understanding of surgical principles, integrating scientific knowledge with clinical acumen. While emphasizing its role as an adjunct to human expertise, the model showcases potential contributions to surgical decision-making processes, particularly in the dynamic and nuanced realm of plastic and reconstructive surgery. The emphasized role of ChatGPT as an adjunct rather than a replacement for learned knowledge aligns with the scientific consensus on the collaborative nature of artificial intelligence in healthcare. Studies highlight the potential synergy between AI systems and human expertise, recognizing that AI can enhance decision making by providing rapid access to relevant scientific information and facilitating critical thinking in experienced clinicians. In the evolving field of plastic and reconstructive surgery, where precision and adaptability are paramount, ChatGPT's contributions to surgical decision-making processes underscore its potential to advance patient care by integrating scientific knowledge into the dynamic and nuanced challenges of the specialty.

However, it is essential to note that the ChatGPT system is not without limitations, and in certain instances we found the responses lacking in detail. During postoperative monitoring, for example, ChatGPT advised close monitoring of the flap for healing and perfusion; however, it did not define what parameters of temperature, color, and capillary refill time changes would be concerning for flap failure [18,19]. In other circumstances, the chatbot provided responses that were not contextually relevant or specific to the DIEP flap procedure. For example, interrogation of flap perfusion via Doppler or indocyanine green is not routinely performed intraoperatively [20]. This highlights the need for further refinement and customization of AI-driven chatbots for application in specialized medical fields.

Moreover, the dependence on textual input for communication presents an inherent challenge in an intraoperative setting, where the surgeon's hands may be occupied. In this instance the technology does not prove to be an advantageous source of information when compared to accessing textbooks or published literature for such queries [21–23]. Future developments should consider incorporating voice recognition and synthesis technologies to enable hands-free communication so the technology can seamlessly blend into the surgical environment. The forthcoming ChatGPT mobile application, scheduled for release in late 2023, holds promise in addressing this challenge through the introduction of audio prompts. This development is in line with the scientific understanding of the benefits of auditory cues in surgical settings. Therefore, future investigations of the incorporation of a udio prompts in ChatGPT's mobile application should be performed with the hypothesis of its usability in real-time surgical scenarios, catering to the specific needs of surgeons who require immediate and hands-free access to information.

ChatGPT and other generative AI LLM tools have a compelling potential to become integrated into the intra-operative environment. The status of these tools lacks immediate application to this field, as the knowledge provided is broadly basic and not beyond that of a plastic surgeon. However, the stimulation of critical thinking and reduction in cognitive

load should not be discarded. Given ChatGPT is a pre-trained tool, it is restricted to the information available within its training data. This limitation applies to both ChatGPT-3.5, the free version, and ChatGPT-4, the paid version, with the data confined to information up until September 2021 [10]. Future developments should incorporate the ability to update in real-time to ensure the most recent medical information is accessible to the user. Furthermore, it is crucial to consider the ethical and legal implications of integrating AI chatbots into medical practice. While ChatGPT demonstrated a high degree of accuracy in this study, occasional errors and the potential for misinterpretation are concerns that remain. As such, the accountability for decision making and patient outcomes must continue to rest with the surgeon, who should use the chatbot as an adjunctive tool rather than a replacement for clinical judgment and expertise.

5. Conclusions

This study demonstrated the potential of ChatGPT as a supplementary tool for intraoperative decision making in plastic surgery procedures, particularly in DIEP flap reconstruction. It can be asserted that ChatGPT's role in augmenting human expertise aligns more closely with the knowledge level of a resident rather than that of an expert surgeon. Although it may not currently provide additional information to experienced surgeons, we posit that ChatGPT serves as a valuable resource to stimulate critical thinking and problem solving among plastic surgeons. It offers immediately accessible information, lightening the cognitive load for both surgeons and trainees. As a clinical decision support system, ChatGPT has the potential to contribute to improved surgical outcomes and patient care. However, we recognize its existing limitations in comprehensiveness, context specificity, and real-time audio feedback. While promising to enhance learning and operational efficiency, further development is needed to address these limitations.

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