Limitations and Challenges in the Incorporation of Artificial Intelligence in Plastic Surgery: A Systematic Review

Limitações e desafios na incorporação da inteligência artificial em cirurgia plástica: Uma revisão sistemática

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Abstract

The present systematic review provides a comprehensive analysis of the current role of artificial intelligence (AI) in plastic surgery, focusing on its applications, outcomes, challenges, and limitations. Out of an initial pool of 213 articles, 74 studies were included after a rigorous selection process based on relevance and methodological quality. Among the AI technologies evaluated, augmented reality (AR) stands out as an emerging tool with significant potential to enhance visualization and planning in esthetic and reconstructive procedures. The use of AR facilitates advancements in volume projection, shape, and symmetry, helping to reduce patient anxiety and better align surgical expectations by offering more precise preoperative visualization. Despite the identified benefits, the implementation of these technologies faces considerable challenges. The lack of specific regulations and the need for adequate technical training for healthcare professionals are significant barriers to the full integration of AI into the clinical practice. Additionally, the heterogeneity of studies and the lack of standardized outcomes make it difficult to generalize the observed benefits. The review concludes that, although the advances are promising, there is a critical need for further studies that address existing gaps and for robust regulations to ensure the safe and effective adoption of AI in contemporary plastic surgery.

Keywords
- artificial intelligence
- diagnosis
- computer-assisted
- machine learning
- plastic surgery procedures
- surgery
- plastic

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Resumo

Esta revisão sistemática oferece uma análise abrangente do papel atual da inteligência artificial (IA) na cirurgia plástica, com ênfase em suas aplicações, resultados, desafios e limitações. A partir de uma base inicial de 213 artigos, 74 estudos foram incluídos após uma seleção rigorosa, considerando critérios de relevância e qualidade metodológica. Entre as tecnologias de IA avaliadas, a realidade aumentada (RA) destaca-se como uma ferramenta emergente com potencial significativo para melhorar a visualização e o planejamento de procedimentos estéticos e reconstrutivos. A utilização de RA permite avanços na projeção de volume, formato e simetria, e auxilia na redução da ansiedade dos pacientes e no alinhamento das expectativas cirúrgicas ao oferecer uma visualização pré-operatória mais precisa. Apesar dos benefícios identificados, a implementação dessas tecnologias enfrenta desafios consideráveis. A ausência de regulamentação específica e a necessidade de treinamento técnico adequado para profissionais de saúde são barreiras significativas para a integração plena da IA na prática clínica. Além disso, a heterogeneidade dos estudos e a falta de padronização nos resultados dificultam a generalização dos benefícios observados. Conclui-se que, embora os avanços sejam promissores, há uma necessidade crítica de estudos adicionais que abordem as lacunas existentes e que sejam acompanhados por regulamentações robustas para assegurar uma adoção segura e eficaz da IA na cirurgia plástica contemporânea.

Palavras-chave

- aprendizado de máquina
- cirurgia plástica
- diagnóstico por computador
- inteligência artificial
- procedimentos de cirurgia plástica

Introduction

Artificial intelligence (AI) has emerged as a new tool in several fields of medicine. Its ability to analyze large volumes of data and provide advanced decision-making support can transform clinical practices, improve surgical precision, and optimize patient outcomes.[1–3] Within plastic surgery, the incorporation of AI could theoretically improve diagnoses, surgical planning, and postoperative outcomes.

In recent years, the application of AI in plastic surgery has expanded significantly, ranging from preoperative planning, with the optimization of surgical design and planning, to intraoperative guidance, treatment decisions, and postoperative management of patients, denoting its versatility.[4,5] Some of the technologies that have been explored to improve the surgical practice include machine learning models, convolutional neural networks to assess mammograms and distinguish benign from malignant tumors, and natural language processing.[6–8] The use of neural networks to evaluate mammograms and differentiate benign from malignant tumors has shown results comparable to those obtained by medical experts, for example.[5]

The incorporation of AI also raises significant ethical and regulatory issues. Patient autonomy, respect for the general data processing law, informed consent, confidentiality, and proper metadata use are crucial considerations to ensure the ethical and effective implementation of AI in plastic surgery.[2,4] Collaboration between plastic surgeons and computer scientists is essential to develop clinically-relevant and interpretable algorithms, minimizing systematic biases and assuring data representativeness.[5,9] Transitioning these technologies into the daily clinical practice will require collaborative and ongoing efforts to validate performance and address recognized limitations.[6]

The present systematic review aims to explore the current AI applications in plastic surgery, discuss outcomes, challenges, and limitations, and outline future directions to integrate this technology into the daily clinical practice to understand its implementation within procedures and assess the quality and effectiveness of its interventions, as well as the potential limitations in the current literature. By providing a comprehensive overview of the capabilities and implications of AI, the current study aims to contribute to the advancement of plastic surgery and promote the safe and effective adoption of this emerging technology.

Materials and Methods

The present systematic review is registered in the International Prospective Register of Systematic Reviews (PROSPERO; ID 585318). A comprehensive search in the PubMed and LILACS databases was conducted in March 2024. The search strategy combined the descriptors *Artificial Intelligence* and *Plastic Surgery* to capture relevant articles in Portuguese, English, and Spanish on AI applications in plastic surgery, covering esthetic and reconstructive procedures.

Inclusion Criteria

The present review included articles meeting the following criteria:

Publication period – only articles published between January 2023 and March 2024 were eligible, ensuring that the studies reflected the most recent and relevant developments in AI applications in plastic surgery.

Language – we restricted inclusion to studies published in Portuguese, English, or Spanish, as long as they were available in full text, to enable a critical analysis with no language barriers.

Thematic relevance – we included only studies directly addressing the application of AI tools in plastic surgery procedures, such as augmented reality (AR), predictive algorithms, and machine-learning techniques.

Availability – we included only articles whose full text could be accessed, to ensure the availability of all relevant information for a detailed analysis.

Exclusion Criteria

We excluded articles that fell within the following categories:

Thematic relevance – we excluded studies that did not directly address the application of AI tools in plastic surgery, such as manuscripts that did not specifically focus on plastic surgery or did not provide significant empirical data to the analysis.

Methodological quality – we excluded opinion articles, editorials, and correspondences to ensure the quality of the data for analysis.

Article selection occurred in two sequential stages. In the first, we identified 213 potentially-relevant articles for an initial screening of titles and abstracts. The second consisted of the full-text review of articles meeting the inclusion criteria. The application of the inclusion and exclusion criteria led to the selection of 74 articles for a detailed analysis. This careful process ensured that the review only included studies with good methodological quality, providing a comprehensive and up-to-date overview of AI use in plastic surgery.

Results

During the systematic review process, we initially identified 213 potentially-relevant articles for analysis. A rigorous screening based on the inclusion and exclusion criteria resulted in the selection of 74 articles suitable to compose the final analysis. This significant reduction reflects the application of rigorous methodological criteria, ensuring the inclusion of relevant and high-quality studies alone. ►**Figure 1** details the flow of the screening process, from the initial identification to the final article selection.

We carefully extracted, synthesized, and organized the data from the selected studies. ►**Table 1** presents the relevant information for each study, including the title, authors, study type, sample size, interventions, main outcomes, and limitations. This synthesis provides a comprehensive overview of the available evidence on AI application in plastic

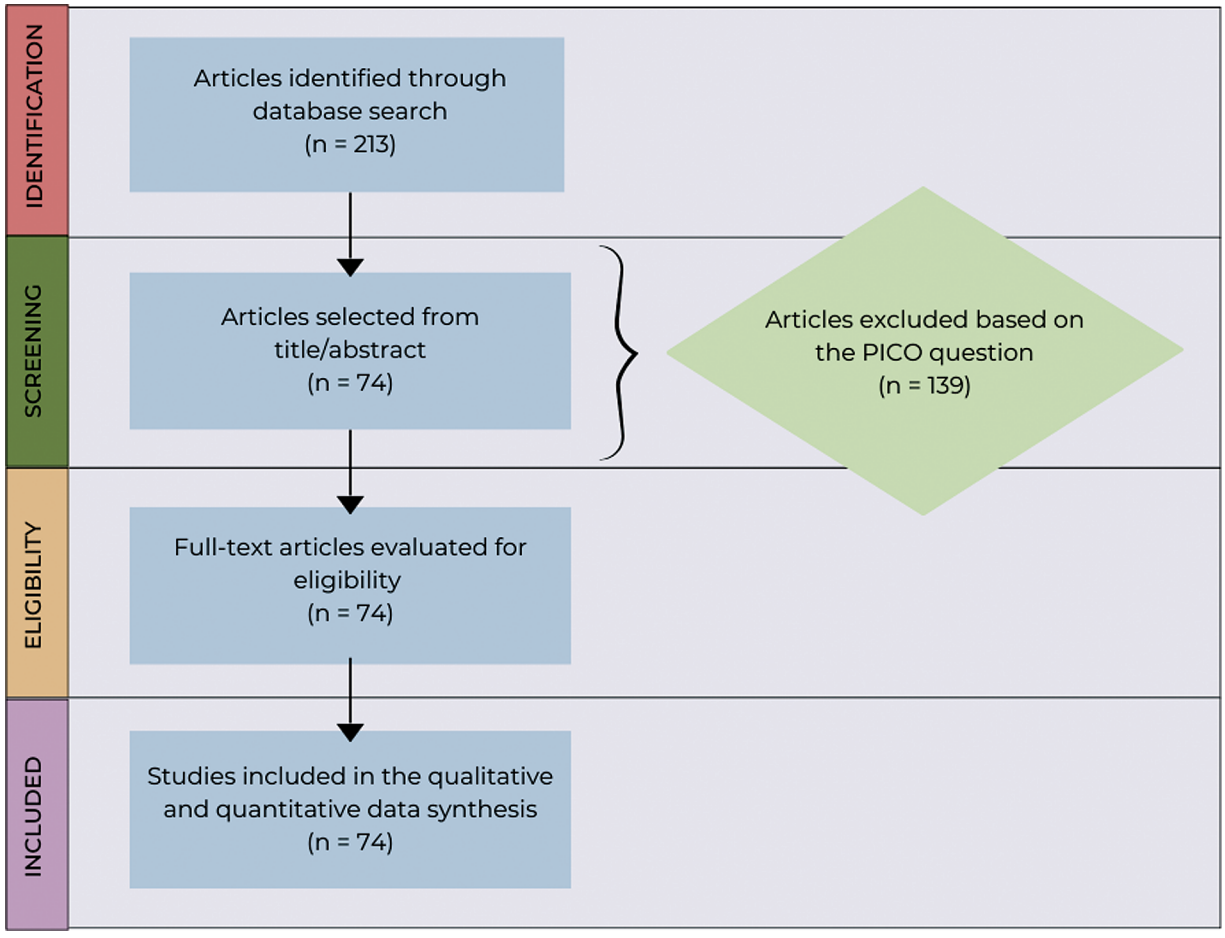

Fig. 1 Process of selection of articles. **Abbreviation:** PICO, patient, intervention, comparison, and outcome.

Table 1 Compilation of the articles included in the systematic review

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Artificial Intelligence Revolutionizing Plastic Surgery Scientific Publications	Mohd Altaf Mir	2023	Editorial	Not applicable, as this is an editorial about AI's impact on plastic surgery publications that did not involve patients.	The author analyzed AI's impact on plastic surgery publications, highlighting its precision, accuracy, and efficiency, revolutionizing the field by improving patient outcomes and providing valuable information for surgeons and researchers.	The author highlighted that AI could analyze a large amount of data, including medical images, patient records, and surgical outcomes, and identify patterns, predict potential complications, and suggest optimized treatments. Through image analysis, a surgeon can evaluate the potential esthetic outcome, generating simulations and helping in decision-making. The author also highlighted the ease with which AI can provide information by selecting published articles and providing key points, in addition to potential solutions to the ethical problems resulting from AI use.	The author highlighted the views against AI use: it can undermine the significance of skilled surgeons, the ethical concerns about privacy, consent, and potential cultural biases, the need for transparency and accountability in algorithms, the potential dehumanization of health care, and the limited and biased data.
Artificial Intelligence in Facial Plastic Surgery: A Review of Current Applications, Future Applications, and Ethical Considerations	Elizabeth Choi et al.	2023	Review of articles on current AI applications	Not applicable, as it is a review of current and future AI applications that did not involve patients.	The authors reviewed articles trying to elucidate the current AI applications, future uses, and existing ethical concerns.	The current AI applications include optimizing nonclinical tasks, such as documentation, to increase efficiency in the workplace; contributing to preoperative decision-making; creating more objective methods to assess postoperative outcomes; and surgical training and research. In the future, the authors predict that AI applications will continue to grow per advances in quality and accuracy and, in alignment with medical judgment, AI software can provide significant contributions to workflow and facial plastic surgery.	The authors highlighted points of ethical concern with AI use, including legal liability for AI-based medical recommendations, amplification of racial, socioeconomic, and gender biases, explainability of the AI model, and concerns about data security.
Face the Future—Artificial Intelligence in Oral and Maxillofacial Surgery	Maximilian F. Miragall et al.	2023	Systematic review	Not applicable, as it is a literature review based on database articles, with no direct patient involvement.	The authors thoroughly reviewed English-language PubMed/MEDLINE and Embase articles from their inception to December 1, 2022. They adapted the search format to each database syntax. To find pertinent material, they thoroughly examined each retrieved article and the systematic review reference list.	According to the literature, AI is under use in certain areas of oral and maxillofacial surgery, such as improving radiographic image quality, diagnosing cysts and tumors, and locating cephalometric landmarks. Through further research, it may provide different professionals with additional assistance to improve preoperative planning, intraoperative screening, and postoperative monitoring. In addition, the analysis of complex medical imaging data can support surgeons in preoperative assessments, virtual surgical simulations, and individualized treatment strategies. AI also assists surgeons in intraoperative decision-making through immediate feedback and guidance to improve surgical accuracy and reduce complication rates.	The authors highlighted the debate over AI limitations involving ethical considerations and data privacy. They discussed the Black Box problem, i.e., not knowing how AI makes its decisions, which contributes to distrust.
Aesthetic Surgery Advice and Counseling from Artificial Intelligence: A Rhinoplasty Consultation with ChatGPT	Yi Xie et al.	2023	Observational study	Not applicable, as it was based on nine questions to ChatGPT about rhinoplasty, and it did not involve patients.	This observational study evaluated ChatGPT's ability to provide informative and accurate answers to a set of hypothetical questions simulating an initial rhinoplasty visit.	ChatGPT provided coherent and easy-to-understand answers to the questions, demonstrating its understanding of natural language in a specific healthcare context. The answers emphasized the significance of an individualized approach, especially in cosmetic plastic surgery.	The study highlighted ChatGPT's limitations in providing more detailed and personalized advice to the patient, essential factors in a cosmetic surgery visit.

Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Evaluation of Artificial Intelligence–generated Responses to Common Plastic Surgery Questions	Libby R. Copeland-Halperin et al.	2023	Exploratory study to assess the feasibility of a larger research project	Not applicable, as this study did not involve patients.	The authors asked 10 questions about breast implant-associated diseases, large anaplastic lymphoma, and squamous cell carcinoma to Bing using the "most balanced" option and to ChatGPT, and 10 multiple-choice questions from the 2022 plastic surgery in-service examination to Bing using the "most accurate" option and to ChatGPT. The authors repeated the questions three times in consecutive weeks and used the AI-generated answers to assess their accuracy and validity.	Bing and ChatGPT answers were as accurate as those of the United States Food and Drug Administration (FDA) and the American Society of Plastic Surgeons (ASPS). Regarding the 30 multiple-choice questions, Bing answered 10 correctly, 9, incorrectly, and did not answer 11. ChatGPT answered 16 correctly and 14, incorrectly. In both cases, Bing's answers were shorter, less detailed, and used verified and unverified sources as references; ChatGPT did not provide citations.	None of the AIs consistently answered correctly questions requiring differentiated decision-making.
ChatGPT in Plastic and Reconstructive Surgery	Sanjeev Chaand Sharma et al.	2023	Literature review on ChatGPT use in plastic surgery.	Not applicable, as the study did not involve patients.	Based on a bibliographic review, the authors attempt to summarize existing applications of ChatGPT in plastic surgery.	The research revealed several ChatGPT applications in plastic surgery, including the ability to create academic literature and aid in research production. ChatGPT can also generate high-quality patient discharge summaries in seconds, freeing up busy junior doctors to complete other tasks. However, the need to enter clinical information manually remains, and doctors must consider data privacy implications. In addition, the literature widely reports AI use to aid in patient communication, education, and training.	The authors demonstrated the literature concerns regarding the ethical implications of chatbot use in scientific writing. In addition, they highlighted questions about the accuracy of the AI-generated answers, since the current versions of ChatGPT cannot access the most up-to-date sources.
Use of Artificial Intelligence in the Advancement of Breast Surgery and Implications for Breast Reconstruction: A Narrative Review	Ishith Seth et al.	2023	Narrative review of the current literature	Not applicable, as the study did not involve patients.	The study explored the role of AI in breast reconstruction through a systematic search in MEDLINE, Cochrane Library, Web of Science, Google Scholar, Clinical Trials, and Embase databases from January 1901 to June 2023, outlining its potential to refine surgical procedures, improve outcomes, and streamline decision-making.	AI can play a crucial role in advancing breast reconstruction by facilitating preoperative planning (breast volume, shape, and symmetry), surgical precision, personalizing reconstructions, and assisting in postoperative care by early complication detection. The authors highlighted the primary role of AI in breast cancer screening, currently involving objective detection and tumor classification as benign or malignant per the Breast Imaging Reporting and Data System (BIRADS).	The authors raised issues on data quality, privacy, and ethical considerations as obstacles to seamless AI integration into the medical field. The study contains information bias.

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Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Artificial Intelligence for Plastic Surgeons	Gloria R. Sue	2023	Opinion article	Not applicable, as the study did not involve patients.	The article did not discuss a specific intervention, but rather how AI can be a tool to support and improve plastic surgery practice.	The author described the different current AI applications, i.e., diagnosis and treatment planning, surgical simulation, outcome prediction, helping in decision-making, and personalized medicine.	The author highlighted several limitations to AI use, i.e., bias propagation, dependence on quality data, limitations in interpretation, and implementation challenges. Furthermore, since the article writing used ChatGPT, an AI system, there may be an inherent bias in the way AI processes and presents information, depending on the training data. The author acknowledged AI's contribution in the preparation of the article, but also emphasized that AI should not replace the experience and judgment of plastic surgeons.
The future of artificial intelligence in facial plastic surgery	Mariella Fortune-Elya et al.	2023	A short paper discussing the emerging role of AI in facial plastic surgery	Not applicable, as the study did not involve patients.	In the article, the authors discuss the application of AI in facial plastic surgery, exploring aspects such as personalized preoperative assessment, surgical planning, outcome simulation and postoperative monitoring.	The outcomes discussed included postoperative outcome assessment using learning algorithms, such as convolutional neural networks, identification of attractive facial features, personalization, and simulation, helping to reduce anxiety about uncertainty regarding surgical outcomes and improving decision-making.	The study discussed potential biases, such as training data that may not adequately represent ethnic and gender diversity, cultural and social influences resulting in bias in data collection, and human biases in data collection and outcome interpretation.
Using Generative Artificial Intelligence Tools in Cosmetic Surgery: A Study on Rhinoplasty, Facelifts, and Blepharoplasty Procedures	Bryan Lim et al.	2023	Systematic review	Not applicable, as the study did not involve patients.	The study analyzed the applications of generative AI tools, such as generative adversarial networks (GANs), i.e., DALL-E 2, Midjourney, and Blue Willow, in cosmetic surgery. The goal was to explore how these technologies can improve surgical practices, procedure planning, and patient education, in addition to discussing the challenges and future perspectives of this integration in plastic surgery.	The study indicated that generative AI tools, such as DALL-E 2, Midjourney, and Blue Willow, had significant potential to improve education and training in cosmetic surgery, each with its unique strengths. Additionally, AI's ability to create personalized patient images can improve the viewing experience by enabling subjects to see a projection of their postoperative results, which is crucial to manage expectations and can help alleviate anxiety about procedures.	The study identified some limitations and challenges in image quality. Although some tools showed promising results, the lack of representations from multiple angles and the emphasis on lighter skin tones limited the usefulness of these images for a comprehensive assessment. In addition, the study highlighted the lack of image diversity, with a predominance of female faces and lighter skin tones, potentially affecting medical education and practice.
Robotic Microsurgery in Plastic and Reconstructive Surgery: A Literature Review	Hussain S. H. Ghandourah et al.	2023	Literature review	Not applicable, as the study did not involve patients.	This study discussed the potential advantages of robotics in plastic and reconstructive surgery through literature reviews investigating "robotic microsurgery in plastic and reconstructive surgery" using the PubMed and Cochrane Library databases.	The authors found 19 relevant articles, including 5 directly comparing robotic and manual approaches. The robotic groups had longer surgical times and higher learning curves. The reported advantages of the sue of robotics included increased accuracy, precision, and flexibility, in addition to tremor elimination and ergonomic improvement.	The limitations to this study included the small amount of available research on robotic microsurgery in plastic and reconstructive surgery and the heterogeneous results of the reviewed articles, hindering the statistical analysis. Furthermore, this review aimed to study the effect of robotic microsurgery in a direct comparison with the traditional approach. However, due to the lack of such articles, it is difficult to provide a solid conclusion on the topic.

Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Artificial Intelligence in Plastic Surgery: Insights from Plastic Surgeons, Education Integration, ChatGPT's Survey Predictions, and the Path Forward	Yasser Farid et al.	2023	Cross-sectional observational study	153 plastic surgeons answering 34 questions.	The authors sent a 34-question survey to 564 plastic surgeons worldwide to assess the views of plastic surgeons and residents on the role of AI in plastic surgery. The survey explored aspects such as experience with AI use, data sources, ethical considerations, and future perspectives regarding AI. The researchers compared these responses with AI predictions using the same questions answered by ChatGPT.	The study found that most participants had little or no experience with AI. While some believed that AI could improve accuracy and visualization, opinions about its impact on surgical time, patient recovery, and satisfaction were mixed. Concerns included patient privacy, data security, costs, and informed consent. The authors identified valuable sources of AI training data and agreed on the significance of standards and transparency. The respondents anticipated the growing role of AI in reconstructive and cosmetic surgery, suggesting its integration into residency programs, and addressing administrative challenges and patient complications. They expressed their confidence in the enduring importance of human providers and interest in further AI research.	The study had some limitations, such as geographic bias, since most of the 153 surgeons answering the questionnaire were from South America, hindering the generalization of the findings. In addition, the study raised concerns about the difficulty that ChatGPT may have with moral decisions and individual patient preferences (data bias).
Artificial Intelligence Language Model Performance for Rapid Intraoperative Queries in Plastic Surgery: ChatGPT and the Deep Inferior Epigastric Perforator Flap	Connor J. Atkinson et al.	2024	Case study	Four plastic surgeons evaluated ChatGPT's performance in providing accurate, relevant, and specific answers. This study did not involve patients directly.	The authors proposed a series of six intraoperative questions specific to the deep inferior epigastric perforator (DIEP) flap procedure, derived from real-world clinical scenarios, to ChatGPT. The goal was to investigate the potential of ChatGPT to address intraoperative questions during this procedure.	Generative AI tools, such as ChatGPT, can act as supplementary tools for surgeons to provide valuable insights and foster intraoperative problem-solving skills. However, they lack consideration of individual patient factors and surgical nuances. Nevertheless, further refinement of their training data and rigorous scrutiny by experts to ensure the the accuracy and up-to-date nature of the information may lead to their use in the surgical field.	The authors highlighted existing limitations in terms of comprehensiveness, context specificity, and real-time audio feedback.
Evaluation of the Artificial Intelligence Chatbot on Breast Reconstruction and Its Efficacy in Surgical Research: A Case Study	Yi Xie et al.	2023	Observational case study	Two plastic surgeons as evaluators, with no patients involved.	The authors asked six questions to ChatGPT about postmastectomy breast reconstruction. The first two focused on current evidence and options for postmastectomy breast reconstruction, and the remaining four focused on autologous breast reconstruction. The goal of the study was to assess the accuracy and comprehensiveness of ChatGPT's answers and determine their suitability for use in esthetic plastic surgery research.	ChatGPT provided relevant and accurate information; however, it lacked depth. It could not provide more than a cursory overview in response to more esoteric questions, and it generated incorrect references. It created non-existing references and cited the wrong journal and date. All these mistakes pose a significant challenge in maintaining academic integrity, so its use must be cautious.	–

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Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Exploring artificial intelligence from a clinical perspective: A comparison and application analysis of two facial age predictors trained on a large-scale Chinese cosmetic patient database	Meng M. Zhang et al.	2023	Retrospective study	The study involved 1,821 patients aged from 18 to 80 years, from whom 10,529 facial images were collected.	The study intervention consisted of collecting facial images of patients who had undergone plastic surgery to train AI models to predict facial age.	The study demonstrated that AI-based facial age estimation models, specifically deep-learning models, could accurately predict facial age. This fact suggests that AI can be an effective tool to assist plastic surgeons in assessing facial age before and after cosmetic procedures. Furthermore, using AI to estimate facial age offers a more objective approach compared with traditional subjective assessments.	Uneven gender and age distributions, limited size of the apparent age database, lack of interpretability, dependence on training data, and challenges in database building.
Facial Feminization Surgery: Anatomical Differences, Preoperative Planning, Techniques, and Ethical Considerations	Sarah L. Barnett et al.	2023	Systematic review	Not applicable, as the study did not involve patients.	The study discussed the intervention called *facial feminization surgery* (FFS). The article explored the surgical techniques to align the facial features of transwomen with their gender identity. In addition, it addressed preoperative planning, anatomical differences between male and female faces, and FFS-related ethical considerations.	AI plays significant roles in FFS, including virtual surgical planning, outcome assessment, patient satisfaction analysis, and pattern identification, leading to improvements in surgical techniques and treatment personalization.	–
Application possibilities of artificial intelligence in facial vascularized composite allotransplantation—a narrative review	Leonard Knoedler et al.	2023	Review article	Not applicable, as the study did not involve patients.	This study had no specific intervention. It aimed to outline the possibilities of applying AI in facial vascularized composite allotransplantation (FVCA) and discuss the use of AI technology to simulate FVCA outcomes, diagnosis, prediction of rejection episodes, and malignancy screening.	The authors discussed the possibility of simulating outcomes with AI, which is difficult in FVCA because it requires the simultaneous integration of the facial characteristics of the donor and the patient; as such, reliable predictions are only possible after the identification of a donor. The study also discussed AI-assisted intraoperative imaging guidelines, rejection prediction, and malignancy tracking. The authors raised concerns about data security, since FVCA involves highly-confidential information.	–
Estimating apparent age using artificial intelligence: Quantifying the effect of blepharoplasty	Kendall Goodyear et al.	2023	Observational study using AI methods to quantify the rejuvenating effect of blepharoplasty	The study sample contained 103 patients, including 29 men and 74 women. The patients underwent different blepharoplasty types: 28 upper blepharoplasties, 33 lower blepharoplasties, and 42 quadrilateral blepharoplasties (simultaneous upper and lower blepharoplasties).	Patients underwent blepharoplasty, including upper, lower, and quadrilateral procedures, i.e., cosmetic surgeries, to remove excess skin and fat from the eyelids, improve facial appearance, and potentially rejuvenate their appearance. The study analyzes preoperative and postoperative photographs to estimate the apparent age of the patients before and after the surgical intervention using AI methods.	AI results indicated that the deep-learning model was effective in estimating the apparent age of the patients before and after blepharoplasty. The AI model could accurately predict the apparent age of the patients, also providing an objective measure of the rejuvenating effect of blepharoplasty. The model also enabled the analysis of different patient groups, revealing that men showed an apparent reduction of 3.37 years and women, a reduction of 2.19 years.	The study did not detail complications, but highlighted some AI limitations, including the small data set, the discrepancy between age groups, focus on facial features, and variability in treatment response (however, it did not discuss surgical complications or patient dissatisfaction with esthetic outcomes). The study also had some biases, including selection bias to train and validate the model, measurement bias of photograph quality (affecting visual perception), confirmation bias, generalization bias, and analysis bias.

Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Enhancing Complex Wound Care by Leveraging Artificial Intelligence: An Artificial Intelligence Chatbot Software Study	Subhas Gupta et al.	2023	Observational study	80 patients	The patients underwent a comprehensive assessment by a wound care provider who established a diagnosis and treatment plan based on their clinical expertise; next, the authors introduced an AI chatbot software as a supplementary tool to provide personalized treatment and lifestyle recommendations.	The AI chatbot accurately identified the most appropriate treatment plan for 91% of the patients, with a correlation higher than 90% with the initial assessment by the wound care provider.	It is worth noting that AI chatbots, including the software from this study, are limited by the information in their history and that they receive in a specific scenario.
Transforming breast reconstruction: the pioneering role of artificial intelligence in preoperative planning	Cevik J et al.	2023	Brief report	Not applicable.	The authors discussed the challenges, opportunities, and future directions of AI in preoperative planning for autologous breast reconstruction.	The authors highlighted some positive points consistent with a study showing that the AI algorithm reduced the time analyzing perforating vessels for implants from 2 to 3 hours to approximately 30 minutes per scan.	The authors concluded that the power of AI requires careful implementation, robust regulations, and ethical guidelines to ensure fair benefit distribution and mitigate potential misuse.
Artificial Intelligence as a Triage Tool during the Perioperative Period: Pilot Study of Accuracy and Accessibility for Clinical Application	Carter J. Boyd et al.	2024	Observational study	40 questionnaires	This study assessed the information, accuracy, and accessibility of AI-generated content regarding common perioperative issues in breast reduction surgery. The authors accessed ChatGPT in February 2023 and used it to ask 20 common patient questions or complications arising in the perioperative period of breast reduction surgery.	Of the 40 questionnaires, 97.5% were on the appropriate topic. Medical counseling was considered reasonable in 100% of cases. General consultations most frequently reported comprehensive basic information, while specific consultations more often provided prescriptive information ($P < 0.0001$). Specific consultations recommended discussion with the surgeon in 100% of cases, whereas general consultations recommended the same in 95% of cases.	With further calibration, AI interfaces could act as a tool to answer patient queries in the future. However, patients should always maintain the ability to bypass the technology and contact their surgeons.
Role of Robotics in Neuromodulator and Filler Injections of Face	Krishan Mohan Kapoor et al.	2023	Narrative review study	Not applicable.	The authors evaluated the advantages and disadvantages in the field of facial esthetics, particularly in the injection of facial fillers and neuromodulators.	The introduction of robots can revolutionize the field, offering several potential benefits, including increased precision, accuracy, and outcome consistency. However, significant disadvantages of robots are their high cost, lack of flexibility and personal touch, limited experience, and risk of injury due to malfunction.	Not applicable.
Predicting the severity of postoperative scars using artificial intelligence based on images and clinical data	Jemin Kim et al.	2023	Retrospective study	1,283 patients, including 1,043 in the main dataset and 240 in an external dataset.	Analysis of postthyroidectomy scars in patients referred for scar minimization treatment. The study used high-resolution medical images to classify scar severity.	The performance of the AI model to predict the severity of postoperative scars was significant. Furthermore, the analysis revealed that, among the 1,043 patients in the main dataset, 10.5% had mild scars, 67.6% had moderate scars, and 22.0% had severe scars, with clinical variables, such as body mass index, time after surgery, and scar characteristics, showing significant differences among severity groups. The algorithm's performance was consistent with that of 16 dermatologists, indicating the	The study identified complications associated with postoperative scars, such as itching/pain, adhesion/tightness, and induration/edema. The analysis of these complications concerning scar severity revealed some significant associations. For example, itching/pain had a positive correlation with severe scar severity, and adhesion/tightness and induration/edema showed negative

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Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
						potential use of the model in the clinical practice for scar management.	associations with high severity. Furthermore, the incidence of hypertrophic scars after surgical procedures can range from 40% to 70% without appropriate management.
Can a Machine Ace the Test? Assessing GPT-4.0's Precision in Plastic Surgery Board Examinations	Al Qurashi AA et al.	2023	Observational study	50 questions from 19 different chapters of a widely-used plastic surgery reference textbook.	The authors selected 50 questions and asked them to GPT-4.0. The GPT-generated answers were evaluated according to four parameters: accuracy, clarity, completeness, and conciseness. Correlation analyses verified the relationship involving these parameters and the overall performance of the model.	GPT-4.0 showed strong performance with high average scores for accuracy (2.88), clarity (3.00), completeness (2.88), and conciseness (2.92) on a 3-point scale. The completeness of the model's answers had a significant correlation with accuracy ($p < 0.0001$), but there was no significant correlation between accuracy and clarity or conciseness.	Performance variability across chapters indicates potential model limitations when dealing with some complex plastic surgery topics.
Risk predictions of surgical wound complications based on a machine learning algorithm: A systematic review	Zhang H et al.	2023	Systematic review	Not applicable, as it was a systematic review of nine articles.	The study intervention focuses on the application of machine-learning (ML) algorithms for the assessment and prediction of surgical wound complications. The study reviewed nine articles using ML to analyze different aspects of wound management, including surgical site infection (SSI) prediction, and wound classification.	The study revealed that ML is an effective tool to manage surgical wounds, including in plastic surgery. SSI evaluation in seven of the reviewed studies demonstrated its effectiveness in identifying risk factors. The most used algorithms were the Support Vector Machine (SVM) and Convolutional Neural Network (CNN), with the Artificial Neural Network (ANN) achieving 96% of accuracy in wound management in facial plastic surgery. The study also highlighted that CNN showed good accuracy in multiple surgeries, while SVM showed high accuracy in multiple surgeries and plastic surgery for burns. These results indicate that ML can lead to significant improvements in postoperative management and the development of improved care techniques, especially concerning surgical wounds.	The study had some limitations; the systematic review relied exclusively on English-language sources, which may have led to the omission of relevant articles in other languages, limiting the comprehensiveness and generalization of the results. In addition, there was a risk of publication bias, since the study did not address this issue, meaning that there may be a tendency to publish positive results alone, distorting the perception of the effectiveness of ML. The study also relied exclusively on open-access sources, which may result in the exclusion of a significant amount of data relevant to the analysis. Another point is that, although ML has shown potential, the practical implementation of AI-based tools in the clinical practice may face challenges, such as the need for adequate training for healthcare professionals and integration with existing systems. The effectiveness of ML algorithms can vary depending on the surgery type and patient characteristics.

Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Implementing AI Models for Prognostic Predictions in High-Risk Burn Patients	Chin-Choon Yeh et al.	2023	Retrospective analysis	224 patients	The study analyzed burn patients admitted to Chi Mei Medical Center from 2010 to 2019 and addressed supplementary information, such as previous comorbidities and laboratory results, to build models to predict graft surgery, prolonged hospital stay, and overall adverse outcomes using AI.	The random forest model produced the highest area under the curve to predict prolonged hospital stays (> 14 days) at 81.1%, followed by the XGBoost (79.9%) and LightGBM (79.5%) models. The AI techniques demonstrated exceptional capabilities in predicting prolonged hospital stays, the need for skin grafting, and the occurrence of overall adverse complications in burn patients.	The study did not discuss limitations.
Implementing AI Models for Prognostic Predictions in High-Risk Burn Patients	Yeh CC et al.	2023	Retrospective analysis	224 patients	AI use to predict hospital stays, skin graft needs, and general adverse complications in burn patients.	AI techniques have demonstrated exceptional capabilities in predicting prolonged hospital stays, the need for a skin graft, and the occurrence of general adverse complications in burn patients.	–
Does medication-related osteonecrosis of the jaw affect survival of patients with Multiple Myeloma?: Exploring a large single center database using artificial intelligence	Bittrich M et al.	2023	Retrospective analysis	52 patients.	AI use to analyze the long-term effects of medication-related osteonecrosis of the jaw (MRONJ).	Patients in the MRONJ group had a considerably longer survival time than those in the control group (126 versus 86 months).	–
Deciphering the contributions of cuproptosis in the development of hypertrophic scar using single-cell analysis and machine learning techniques	Song B et al.	2023	Case-control study	11 hypertrophic scar (HS) tissue samples	First-time investigation of the relationship between the occurrence and development of HS and cuproptosis, deepening our understanding of the underlying mechanisms of these scars and providing new potential therapeutic strategies and research bases to inhibit scar formation.	The study revealed that cuproptosis may play a significant role in the development of HSs. Using machine-learning techniques to analyze single-cell data, the researchers identified patterns and specific contributions of cuproptosis to HS formation.	–
Detecting Distal Radius Fractures Using a Segmentation-Based Deep Learning Model	Anttila TT et al.	2023	Diagnostic validation study	758 patients	The intervention was technical and involved the development and application of a segmentation-based deep-learning model.	The deep-learning model developed demonstrated effectiveness in detecting distal radius fractures. The study reported good model performance in terms of accuracy, sensitivity, and specificity to identify fractures in medical images.	No clinical comparisons or associated adverse effects.
A comprehensive evaluation of ChatGPT consultation quality for augmentation mammoplasty: A comparative analysis between plastic surgeons and laypersons	Yun JY et al.	2023	Comparative cross-sectional study	The study involvred 60 participants, including plastic surgeons and laypeople.	The study evaluated the quality of ChatGPT-generated queries regarding breast augmentation surgery. The comparative analysis involved plastic surgeons and laypeople, who evaluated the accuracy, clarity, and usefulness of the information provided by ChatGPT about breast augmentation surgery.	The study found that ChatGPT provided information of acceptable quality, with positive reviews from surgeons and laypeople. However, plastic surgeons were more critical of the technical accuracy of the answers, while laypeople found them clearer and more understandable. The study highlighted that ChatGPT can be a useful tool to provide initial information about medical procedures, but emphasized the need for supervision by healthcare professionals.	The study did not directly report complications, but it did mention concerns about the accuracy and depth of information provided by ChatGPT, especially on complex topics like plastic surgery.

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Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
A History of Innovation: Tracing the Evolution of Imaging Modalities for the Preoperative Planning of Microsurgical Breast Reconstruction	Cevik J et al.	2023	Historical review	Not applicable, as the study is a literature review that did not directly involve patients.	The study reviews the evolution of imaging modalities used in the preoperative planning for microsurgical breast reconstruction.	The review highlighted how innovations in imaging techniques, such as the introduction of high-resolution computed tomography angiography and magnetic resonance imaging, have revolutionized surgical planning, enabling better visualization of blood vessels and tissues. This has resulted in improved surgical outcomes, with reduced complications and improved viability of flaps for breast reconstruction.	While the study does not directly address complications in patients, it mentions how limitations of previous imaging techniques, such as low resolution and lack of vascular detail, could lead to intraoperative and postoperative complications.
Can AI Think Like a Plastic Surgeon? Evaluating GPT-4's Clinical Judgment in Reconstructive Procedures of the Upper Extremity	Leypold T et al.	2023	Cross-sectional study	The study involved 10 plastic surgeons who evaluated GPT-4's performance. It did not involve patients directly.	The study evaluated the ability of the GPT-4 AI model to perform clinical judgments in upper extremity reconstructive procedures.	The results showed that GPT-4 could provide reasonable clinical recommendations in many cases, demonstrating a good understanding of basic reconstructive practices. However, the study also highlighted significant limitations, especially in complex cases in which human clinical judgment, based on experience and intuition, was superior. AI was useful as a supportive tool, but it did not replace the expert clinical judgment of surgeons.	–
Accuracy and safety of robotic navigation-assisted distraction osteogenesis for hemifacial microsomia	Zhang Z et al.	2023	Method validation study	Four cases	The researchers evaluated the accuracy and safety of robotic-assisted navigation to perform distraction osteogenesis (a surgical procedure for bone lengthening) in patients with hemifacial microsomia.	The results showed that robotic-assisted navigation significantly improved the accuracy of the distraction osteogenesis procedure. The mean positioning error of the osteotomy plane was of 1.77 ± 0.12 mm, and the mean angular error was of $8.94° \pm 4.13°$. The mean positioning error of the distractor was of 3.67 ± 0.23 mm, and the mean angular error was of $8.13° \pm 2.73°$. Postoperative patient satisfaction was high, and no adverse events occurred.	The study reported no major complications when using robotic-assisted navigation. However, as with any surgical procedure, there was the possibility of minor complications, such as infections or postoperative discomfort, although these were not significant issues in the study.
Machine learning for prediction of delirium in patients with extensive burns after surgery	Ren Y et al.	2023	Cohort study	518 patients	The researchers used machine-learning techniques to develop a predictive model of postoperative delirium in patients with extensive burns.	The machine-learning model showed high accuracy in predicting postoperative delirium in patients with extensive burns. The random forest (RF) model outperformed the other eight models in terms of predictive performance (receiver operating characteristic curve: 84.00%). In an external validation, RF performed well (accuracy: 77.12%; sensitivity: 67.74%; and specificity: 80.46%).	The study reported no complications when using the machine-learning model.
ChatGPT's quiz skills in different otolaryngology subspecialties: an analysis of 2,576 single-choice and multiple-choice board certification preparation questions	Hoch CC et al.	2023	Observational study of AI performance	ChatGPT answered 2,576 questions. The study did not involve patients.	The study evaluated ChatGPT's abilities to answer questions regarding several otolaryngology subspecialties.	ChatGPT had a mixed performance across subspecialties. In some fields, such as otology, the model showed a high accuracy rate, and, in others, such as head and neck surgery, its performance was less effective. Overall, ChatGPT could answer a significant proportion of questions correctly, but with variations depending on the topic.	The study reported no complications, but highlighted the limitations of ChatGPT in dealing with issues requiring complex clinical interpretation or practical application of medical knowledge.
Machine-Learning Prediction of Capsular Contraction after Two-Stage Breast Reconstruction.	Chen Y et al.	2023	Cohort study	209 patients	The study applied machine-learning techniques to develop a predictive model for the occurrence of capsular contracture after two-stage breast reconstruction.	The machine-learning model demonstrated good predictive ability for capsular contracture, with high accuracy in identifying patients at risk. It identified several risk factors, including patient characteristics, surgical details, and postoperative variables.	The study did not report clinical complications directly associated with the machine-learning model.

Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Risk predictions of hospital-acquired pressure injury in the intensive care unit based on a machine learning algorithm	Tehrany PM et al.	2023	Systematic review	The authors did not specify the number of patients.	The researchers used a machine-learning algorithm to predict the risk of developing hospital-acquired pressure injuries in intensive care unit patients using the PubMed and ISI databases and the keywords *intensive care unit*, *bedsore*, *pressure injury*, and *machine learning* from November 1, 2022, to January 11, 2023.	The machine-learning model showed a high predictive ability to identify patients at risk of developing pressure injuries. The accuracy of the model was significant, with good sensitivity and specificity in predicting risk.	The study did not report clinical complications directly associated with the machine-learning model.
Workflow assessment of an augmented reality application for planning of perforator flaps in plastic reconstructive surgery: Game or game changer?	Berger MF et al.	2023	Cross-sectional study	7 patients	The researchers evaluated the application of augmented reality (AR) to plan perforator flaps in reconstructive plastic surgery.	AR was an innovative tool that could transform the planning and execution of reconstructive surgical procedures. According to the study, AR provided significant improvements in flap visualization and planning, offering a better anatomical understanding and facilitating procedural accuracy.	The study reported no complications.
HI-MViT: A lightweight model for explainable skin disease classification based on modified MobileViT	Ding Y et al.	2023	Comparative cross-sectional study	The study did not specify an exact number of patients, but used a dataset of skin images to train and evaluate the model.	The researchers developed and tested a low-weight, high-accuracy model to classify skin diseases called Hierarchical Image Transformer with MobileViT (HI-MViT).	The HI-MViT model had effective performance in classifying skin diseases, with high accuracy and explanatory power. The study highlighted the model's efficiency in processing and its ability to provide explanations for classification decisions.	The study did not report clinical complications in direct association with the model.
Quantization of extraoral free flap monitoring for venous congestion with deep learning integrated iOS applications on smartphones: a diagnostic study	Hsu SY et al.	2023	Cohort study	122 patients	The researchers developed and evaluated a deep learning-integrated application to monitor venous congestion in extraoral-free grafts using iOS smartphones.	The app showed high accuracy in detecting venous congestion compared with traditional monitoring methods. The integration of deep learning technology with mobile devices enabled more accessible and real-time monitoring.	The study did not report any direct complications in association with the app.
Machine learning approach for predicting inhalation injury in patients with burns	Yang SY et al.	2023	Cohort study	341 patients	The researchers developed and validated a machine-learning model to predict inhalation injuries in burn patients.	The machine-learning model had good accuracy in predicting inhalation injuries, with a significant ability to identify patients at risk. The approach helped improve patient screening and management, enabling earlier and more targeted interventions.	The study reported no direct complications associated with the model.
Application of multiple deep learning models for automatic burn wound assessment	Chang CW et al.	2023	Comparative cross-sectional study	4,991 initial burn images and 1,050 palm images	The researchers applied multiple deep-learning models for the automatic assessment of burn wounds.	Deep-learning models demonstrated effective performance in the automatic assessment of burns. The combination of multiple models helped improve the accuracy and consistency of the assessments, providing a valuable tool to monitor and manage burn wounds.	The study did not report clinical complications in direct association with the models.
Finetuning of GLIDE stable diffusion model for AI-based text-conditional image synthesis of dermoscopic images	Shavlokhova V et al.	2023	Comparative cross-sectional study	10,015 dermoscopic images	The researchers fine-tuned the Guided Language to Image Diffusion for Education (GLIDE) stable-diffusion model to generate dermoscopic images from textual descriptions. The goal was to create a system	The results indicated that the images generated had varying degrees of quality and realism. Melanocytic nevi and melanoma presented higher similarity to actual images than other conditions. Synthetic image integration improved the model's classification performance and resulted in higher accuracy	The study reported no clinical complications.

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Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
					that produces realistic and accurate images of skin lesions based on textual inputs describing specific dermatologic features.	and precision. The AI evaluation showed superior classification performance compared with the dermatologist.	
Feeling the beat: a smart hand exoskeleton for learning to play musical instruments	Lin M et al.	2023	Clinical trial	The study did not specify the number of human participants, as the main focus was developing and evaluating robotic exoskeleton technology to learn how to play musical instruments.	The researchers developed a smart hand exoskeleton to aid in learning how to play musical instruments.	The smart exoskeleton was effective in guiding users through specific movement patterns, helping them learn to play musical instruments more quickly and accurately. This technology has shown potential as a supportive tool in music learning, especially for beginners or subjects with motor difficulties.	The study did not report clinical complications. However, users may have difficulties in adaptation, comfort, and calibration.
Construction and Validation of an Image Discrimination Algorithm to Discriminate Necrosis from Wounds in Pressure Ulcers	Sakakibara S et al.	2023	Cohort study	50 patients	The researchers developed and validated a machine-learning algorithm to discriminate between necrosis and wounds in pressure ulcer images. The goal was to improve accuracy in identifying necrosis in ulcers, which is crucial for proper treatment.	The algorithm showed high accuracy in discriminating between necrosis and other wounds in pressure ulcers. The model validation indicated that it could be a useful tool for healthcare professionals, aiding in the fast and accurate assessment of wound conditions and facilitating clinical decision-making.	The main complications or limitations reported in the study included image variability (which may influence the accuracy of the algorithm), model generalization (algorithm training used a specific dataset), and the need for further validation (on a larger scale and in different clinical scenarios to confirm its robustness and practical applicability).
Analysis of Watson for oncology and clinicians' treatment recommendations for patients with breast cancer in Korea: A single center experience	Park H et al.	2023	Comparative observational study	183 patients	The researchers compared treatment recommendations provided by the Watson for Oncology (WFO) AI system with recommendations from human oncologists for breast cancer patients.	The study found a 73% overall agreement rate between recommendations from the WFO and oncologists. The field with the highest disagreement was the chemotherapy choice, since the WFO often suggested regimens different from those suggested by the physicians. Disagreements also occurred in more complex cases with multiple treatment lines available.	The study identified the following major complications or limitations: recommendation disagreements, training data reliance (which may not fully reflect local populations or clinical practices), and acceptance by physicians (depending on trust in AI systems and experiences with their suggestions)
The Composition of Antiaging Scales for Facial Rejuvenation: Assessed with Artificial Intelligence	Man-Lok L et al.	2023	Observational study using AI	The study did not directly specify the number of patients, as the focus was the analysis of facial rejuvenation scales using AI rather than objective clinical assessment of subjects.	The researchers used an AI system to evaluate and develop facial rejuvenation scales.	AI enabled a more accurate and objective analysis of facial rejuvenation scales, resulting in a better understanding of the critical components to consider when assessing the success of facial rejuvenation procedures.	Generalization limitations (i.e., limitation to generalize data to all populations), dependence on input data, data interpretation (which should be performed by professionals), and analysis biases (if the AI training data contains biases, they may negatively affect the composition and interpretation of the facial rejuvenation scales.)
Infrared spectroscopic laser scanning confocal microscopy for whole-slide chemical imaging	Yeh K et al.	2023	Experimental study on technological development	The study did not involve patients directly.	The study developed and evaluated a new imaging technique called Infrared Spectroscopic Laser Scanning Confocal Microscopy (ISLSCM), which was used to perform	The results showed that the ISLSCM technique can perform high-resolution chemical imaging on whole-tissue slides, overcoming the limitations of traditional chemical imaging techniques, such as low resolution and long acquisition time.	Technical challenges (requires careful calibration to ensure accuracy and reproducibility), applicability limitations, and processing time.

Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
					chemical imaging on whole-tissue slides samples to identify and map chemical components at high resolution.		
Unsupervised anomaly appraisal of cleft faces using a StyleGAN2-based model adaptation technique	Hayajneh A et al.	2023	Study on technological development	The study did not involve human patients directly. Instead, it used a dataset of facial images for AI model training and testing.	The study applied a model-adaptation technique based on StyleGAN2 to perform an unsupervised assessment of anomalies in cleft faces. The model was trained to generate facial representations and identify anomalies compared to regular faces with no need for explicit anomaly labels.	The StyleGAN2-based model could effectively detect and evaluate anomalies in faces with cleft lip and palate. The technique demonstrated the ability to identify anomalous facial features, which may help to improve the diagnosis and surgical planning for these patients.	Technical complexity, model generalization (the study used a single database, requiring validation in all patients), and data interpretation by a professional.
Convolutional neural network models for automatic diagnosis and graduation in skin frostbite	Sun J et al.	2023	Comparative cross-sectional study	Use of 71 images for training.	The researchers used convolutional neural network models to analyze images of skin frostbite and compared their performance with those of two residents from the burn department.	The approach correctly identified all grade-IV frostbite lesions (18/18, 100%), but with 1 error in grade diagnosis. The accuracy of the approach on the entire test set was of 97.39% (112/115). The accuracy of the two residents was of 77.39% and 73.04%.	Generalization limitations, dependence on training data, data interpretation by healthcare professionals, and potential analysis biases.
Comparative study of ChatGPT and human evaluators on the assessment of medical literature according to recognised reporting standards	Roberts RH et al.	2023	Comparative cross-sectional study	The study did not directly involve patients, as it focused on evaluating medical literature rather than on clinical interventions.	The researchers used ChatGPT and human raters to analyze and evaluate medical literature articles based on established reporting standards, such as Consolidated Standards of Reporting Trials (CONSORT), Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), and other quality criteria.	Human raters provided more detailed and contextual assessments, reflecting a deeper understanding of the nuances of medical studies. The study highlighted that, while ChatGPT can be a useful tool in the initial screening and evaluation of medical literature, the review and final judgment still rely heavily on human expertise to ensure accuracy and a comprehensive understanding of quality standards.	ChatGPT may not capture all the nuances and complexities of medical studies, resulting in less accurate or detailed assessments. ChatGPT's effectiveness depends on the quality of its training data and underlying algorithms, which may limit its ability to accurately assess the medical literature. The final assessment interpretation still requires human judgment to ensure the correct application of reporting standards and the consideration of all nuances.
Efficacy of navigation system-assisted distraction osteogenesis for hemifacial microsomia based on artificial intelligence for 3 to 18 years old: study protocol for a randomized controlled single-blind trial.	Liu X et al.	2024	Single-blinded, randomized, controlled clinical trial	22 patients	**Intervention group:** patients submitted to distraction osteogenesis using an AI-assisted navigation system that aims to help in the accuracy and effectiveness of the surgical procedure by guiding the surgeon during bone distraction. **Control group:** patients submitted to the same distraction osteogenesis procedure but with no AI-assisted navigation system.	**Primary:** evaluation of the effectiveness of the AI-assisted navigation system based on parameters such as the accuracy of the surgical procedure, facial deformity improvement, and postoperative clinical outcomes. **Secondary:** comparison of surgical times, complication rates, and quality of life assessment.	**Potential adverse events:** the potential risks and complications associated with the AI-assisted navigation system may included technology failures, navigation errors, or surgical complications. **Implementation challenges:** the study faced challenges in implementing and integrating the AI technology into the surgical environment and maintaining the blinding to ensure outcome impartiality.

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Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Predicting overall survival in chordoma patients using machine learning models: a web-app application	Cheng P et al.	2023	Cohort study	724 patients	Development and testing of several machine-learning models to predict the overall survival of patients with chordoma. These models used clinical and demographic data from patients. A web application integrated the models, enabling clinicians and researchers to use the tool to predict patient survival based on their individual data.	Machine-learning models had a significant ability to predict the overall survival of patients with chordoma. Their accuracy varied depending on the model and variables. The web application provided a practical and accessible interface to use predictive models, facilitating the integration of the results into the clinical practice.	**Data quality:** the quality and completeness of the clinical and demographic data can influence the model accuracy. **Model generalization, technological dependence:** the web application requires access to technology and training so that health professionals can adequately interpret and use the model-generated predictions.
Applications of the Natural Language Processing Tool ChatGPT in Clinical Practice: Comparative Study and Augmented Systematic Review	Schopow N et al.	2023	Comparative study and systematic review	The study did not involve a specific number of patients, as it focused on analyzing ChatGPT applications the in clinical practice, not on a clinical trial.	The study evaluated and compared ChatGPT in different clinical applications, including decision-making support, reporting, and assistance with administrative tasks. Through a systematic review, the authors compiled and evaluated the existing literature on ChatGPT in the clinical practice, highlighting its applications and limitations.	ChatGPT had the potential to improve efficiency and accuracy across several clinical tasks, although some challenges and limitations need to be addressed. Integrating ChatGPT into clinical practices could offer significant benefits but requires ongoing evaluation to ensure that applications are accurate and safe.	**Accuracy and reliability:** the accuracy of ChatGPT-generated answers may vary. ChatGPT use should be careful to ensure that the information provided is accurate and reliable. **Data security:** ChatGPT use in the clinical practice raises concerns about the security and privacy of patient data, especially regarding sensitive information.
Feasibility of intra-operative image guidance in burn excision surgery with multispectral imaging and deep learning.	Yu S et al.	2024	Viability study	The study did not specify directly the number of patients, as it focused on the feasibility and application of the technology during burn excision surgery performed on six pigs.	**Technology:** multispectral imaging plus deep learning. **Procedure**: the technology provided intraoperative guidance during burn excision to improve the accuracy and effectiveness of burn-tissue removal.	The technology helped to improve the accuracy in identifying and removing burn tissue, providing better intraoperative outcomes. Its application could increase surgical efficiency by facilitating a more targeted and less invasive approach.	**Clinical adaptation:** implementing technology in real clinical settings may face challenges related to surgical team adaptation and integration with existing systems.
Validation of ChatGPT 3.5 as a Tool to Optimize Readability of Patient-facing Craniofacial Education Materials	Vallurupalli M et al.	2024	Technology validation study	–	This study aimed to evaluate ChatGPT 3.5 as a tool to optimize patient-oriented craniofacial education materials.	ChatGPT 3.5 helped improve the readability of educational materials, making them more understandable for the target audience. The authors assessed the readability of the materials before and after AI intervention and observed significant improvements in text comprehension.	**Dependence on AI quality:** AI may present limitations in its ability to capture specific nuances or detailed medical contexts significant for patient education. Continued validation of optimized materials with direct feedback from patients and healthcare professionals is required to ensure that the materials are appropriate and effective.
Deep Learning-Based Diagnostic System for Velopharyngeal Insufficiency Based on Videofluoroscopy in Patients With Repaired Cleft Palates	Ha JH et al.	2023	Comparative cross-sectional study	714 cases	The researchers developed and applied a diagnostic system to assess velopharyngeal insufficiency (VPI) in patients with repaired cleft palate. The intervention consisted of analyzing videofluoroscopy scans using a deep-learning	The deep learning-based system demonstrated high precision in detecting VPI, with higher accuracy, sensitivity, and specificity rates than those of the conventional methods.	**Dependence on large data volumes:** the system requires large volumes of annotated data for proper training, which may not be available in all healthcare centers. **Clinical integration:** implementing the system the in clinical practice requires adaptation by healthcare

Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
					model to identify and classify the presence and severity of VPI.		professionals and integration with existing workflows.
Wearable Prophylaxis Tool for AI-Driven Identification of Early Warning Patterns of Pressure Ulcers	Gruenerbel L et al.	2023	Cohort study	60 patients	The researchers developed an AI-powered wearable tool for continuous monitoring of the patient's vital signs and movement patterns. The goal was to identify early patterns indicating the imminent development of pressure ulcers, enabling preventative interventions.	AI application as a wearable tool was effective in the early detection of patterns preceding the development of pressure ulcers. The system could identify risk situations accurately, providing an opportunity for early interventions to prevent the formation of these ulcers.	Several patients withdrew from the study due to discomfort with the sensor system.
Introduction of Deep Learning-Based Infrared Image Analysis to Marginal Reflex Distance 1 Measurement Method to Simultaneously Capture Images and Compute Results: Clinical Validation Study	Song B et al.	2023	Cohort study	77 patients	The researchers introduced a Marginal Reflex Distance 1 (MRD1) measurement method using infrared image analysis with a deep learning system. This method enabled simultaneous image capture and automatic result calculation.	The proposed method underwent clinical validation, and it was accurate and effective in measuring MRD1. The technology enabled process automation, improving the consistency and speed of the assessment compared with traditional methods. Furthermore, its application in clinical settings was easy.	**Dependence on image quality:** the system's accuracy depends on the quality of the infrared image captured. Problems with image capture may affect the results. **Need for continuous validation:** although the results are promising, the system's effectiveness requires continuous validation in different clinical settings to ensure broad applicability.
Comparison of large language models in management advice for melanoma: Google's AI BARD, BingAI and ChatGPT	Mu X et al.	2023	Comparative cross-sectional study	The researchers asked five questions to different AIs (ChatGPT, BARD, and BingAI).	The intervention consisted of testing and comparing the AI answers regarding melanoma management. The researchers analyzed how each model addressed different aspects of melanoma treatment and counseling.	The study demonstrated that ChatGPT marginally outperforms BARD and BingAI in providing reliable, evidence-based clinical advice. However, the models still faced limitations in depth and specificity. Future research should improve the performance of LLM by integrating specialized databases and expert knowledge to support patient-centered care.	**Answer variability:** the quality and accuracy of the answers varied among the models, which may negatively influence clinical decision-making. **Dependence on model training:** the effectiveness of the answers depends on the dataset training each model, which may not cover all the nuances of melanoma management. **Risk of inaccurate information:** there is an inherent risk that the models will provide inaccurate or outdated information, potentially affecting patient care if not properly verified by healthcare professionals.
The effect of double W tension-reduced suture technique on the abdominal scars following the da Vinci robot-assisted gastrectomy for severely obese patients	Chen W et al.	2023	Cohort study	Comparison of 40 incisions.	The study analyzed the effect of a new type of reduced tension suture, called the "double W reduced-tension suture technique," on abdominal scars after Da Vinci robot-assisted gastrectomy in severely-obese patients, and compared it with the conventional technique.	The results showed that the double W reduced-tension suture technique significantly decreased tension on the wound edges, resulting in more esthetic scars and fewer healing complications, such as wound dehiscence or hypertrophic scar formation.	Although it was not the primary focus, it was critical to monitor the suture technique for the risk of infection, which can be a common complication in obese patients. The technique may have different efficacy depending on the obesity severity. Need for adequate surgical training.

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Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Bard Versus the 2022 American Society of Plastic Surgeons In-Service Examination: Performance on the Examination in Its Intern Year	Najafali D et al.	2023	Comparative cross-sectional study	231 questions.	The intervention consisted of testing the Bard AI with questions from the American Society of Plastic Surgeons (ASPS) examination to assess its performance concerning the actual examination for plastic surgery residents.	The study included 231 questions. Bard answered 143 questions correctly, corresponding to a 62% accuracy rate. The best-performing section was the comprehensive portion (73%). When compared with integrated residents nationally, Bard scored in the 74th percentile for postgraduate year (PGY)-1, in the 34th percentile for PGY-2, in the 20th percentile for PGY-3, in the 8th percentile for PGY-4, in the 1st percentile for PGY-5, and in the 2nd percentile for PGY-6. Bard outperformed over half of the integrated first-year residents (74th percentile).	No clinical complications. **Clinical practice applicability:** while AI may perform well on theoretical examinations, the practical application of medical knowledge may require skills and clinical judgment that an AI does not have yet. **Question interpretation:** AI may face challenges in correctly interpreting questions or applying clinical knowledge to specific scenarios.
Validating a novel natural language processing pathway for automated quality assurance in surgical oncology: incomplete excision rates of 34,955 basal cell carcinomas	Ali SR et al.	2023	Retrospective, multicentric, pan-specialized analysis	34,955 lesions in 15,657 patients.	The intervention applied AI to analyze medical records and identify incomplete excision rates in surgeries for the removal of basal cell carcinoma.	The study validated AI effectiveness, demonstrating its potential use for automatic assessment of incomplete excision rates of basal cell carcinomas, which can help improve surgical quality and patient follow-up.	**Natural language processing accuracy:** the accuracy of natural language processing depends on the quality of the input data and the ability of the algorithm to correctly interpret the information.
Robotic Microsurgery in Extremity Reconstruction - Experience with a Novel Robotic System	Besmens IS et al.	2023	Evaluation study on the use of a new system for robotic microsurgery	6 patients.	Use of the Symani Surgical System for extremity reconstruction.	Microvascular anastomoses were slower than with conventional microsurgery, but all anastomoses were patent. The platform's motion scaling enabled the surgeon to perform precise micromovements with minimal tissue manipulation alone, and difficult-to-reach anatomy became more easily accessible.	Currently, the system has a narrow field of application. Although it can effectively suture vessels and nerves, it cannot dissect these structures. Surgeons must still rely on established microsurgical techniques for surgical approaches and preparation of vessels and nerves.
Computer-aided designed 3D-printed polymeric scaffolds for personalized reconstruction of maxillary and mandibular defects: a proof-of-concept study	Mattavelli D et al.	2024	Preclinical study to investigate the feasibility, reproducibility, and efficacy of a reconstruction algorithm	6 cadaver heads.	Reconstruction algorithm with 3 phases: 1) scaffold production (computer-aided design and three-dimensional printing in polylactic acid); 2) surgical simulation on cadaver heads (navigation-guided osteotomies and scaffold fixation); and 3) reconstruction evaluation (bone and occlusal morphological conformity, symmetry, and mechanical stress tests).	The reconstructive algorithm was feasible and reproducible in a preclinical setting. Functional and esthetic results were satisfactory regardless of the complexity of the defect.	The limited sample size prevented any statistical analysis, and the reconstruction algorithm test could only be performed twice for each defect type, i.e., the minimum to verify reproducibility. This small sample size limited the validity of the mechanical stress tests and prevented further analyses on the risk of infections, assessment of new bone formation, and long-term integration of the scaffold.
VGG19 demonstrates the highest accuracy rate in a nine-class wound classification task among various deep learning networks: a pilot study	Lee JW et al.	2024	Study of development and validation of a classification system	8,173 training data images and 904 testing data images.	Establishment, training, and testing of 6 deep learning networks based on VGG16, VGG19, EfficientNet-B0, EfficientNet-B5, RepVGG-A0, and RepVGG-B0 on the same wound images (divided into 9 classifications).	The overall accuracy ranged from 74.0% to 82.4%. VGG19 achieved the highest accuracy (82.4%) among all networks.	A critical limitation was that wound photography was performed at a single institution under the same settings (e.g., lighting, distance from lens to objects). This system may demonstrate lower accuracy for wound photographs in different settings at different institutions. Further research is required involving a larger dataset from multiple hospitals.

Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Robot-Assisted Pelvic Dissection for Enlarged Lymph Nodes in Melanoma Improves Recovery with Equivalent Oncological Outcomes to Open Pelvic Dissection	Roshan A et al.	2024	Retrospective observational cohort study	22 patients.	The authors reviewed all patients who underwent pelvic lymph node dissection for macroscopic melanoma at a single institution and the methods used (open pelvic lymph node dissection [oPLND] or robot-assisted pelvic lymph node dissection [rPLND]).	rPLND is an effective way to remove bulky pelvic lymph nodes in patients with melanoma, with shorter recovery time and shorter interval to initiate adjuvant therapy compared with oPLND.	There were no statistical differences between the groups regarding the overall reported postsurgical complication rate.
Natural language processing to automate a web-based model of care and modernize skin cancer multidisciplinary team meetings	Ali SR et al.	2024	Analysis and validation study of information-extraction model	893 patients (1,045 lesions).	The authors used a web application with a custom application programming interface to provide an automated clinical decision support system for skin cancer.	The accuracy of the natural language processing-based tool was higher than human predictions, with an overall value of 0.92.	The article highlighted that these findings are preliminary and hypothesis-generating. As such, the next essential step in establishing the validity of this tool would be to apply it prospectively in an independent cohort, enabling a real-time assessment of its performance and reliability.
Revisiting basal cell carcinoma clinical margins: Leveraging natural language processing and multivariate analysis with updated Royal College of Pathologists histological reporting standards	Ali SR et al.	2023	Consecutive, multicentric, and pan-specialized retrospective analysis study	1,447 basal cell carcinomas.	The authors used a validated natural language processing information extraction model to analyze basal cell carcinomas treated with surgical excision using a predetermined clinical margin.	Larger clinical peripheral margins than those indicated by current guidelines may be required to achieve excision rates $\geq$ 95%.	Although the study used natural language processing on more than 34 thousand basal cell carcinomas throughout 17 years, only 5% had complete data, limiting the credibility of the results. Therefore, result interpretation should be made with an additional degree of caution.
Easing the Burden on Caregivers- Applications of Artificial Intelligence for Physicians and Caregivers of Children with Cleft Lip and Palate	Chaker, Sara C et al.	2024	Analysis and validation study of an AI tool for patient assistance	13 questions.	The authors asked questions about cleft lip, palate, or both to ChatGPT and compared the answers with those generated by senior pediatric plastic surgeons.	ChatGPT presented a 69% accuracy rate in answering postoperative questions when compared with experts; the major errors were regarding information.	Not applicable.
Artificial Intelligence in Plastic Surgery: Insights from Plastic Surgeons, Education Integration, ChatGPT's Survey Predictions, and the Path Forward	Farid, Yasser et al.	2024	Qualitative analysis of knowledge research	153 plastic surgeons.	The authors sent a 34-question survey on the role of AI in plastic surgery for plastic surgeons worldwide.	A significant proportion of plastic surgeons had limited experience with AI, with only 17.3% reporting moderate or extensive experience with AI in plastic surgery. One of the concerns raised by plastic surgeons is the potential over-reliance on AI technology and its impact on clinical judgment.	Most respondents were from South America, limiting the generalization of the findings. Regional disparities in healthcare infrastructure, economic factors, and educational resources may influence plastic surgery practices and the integration of AI technologies.
Artificial Intelligence in Plastic Surgery: ChatGPT as a Tool to Address	Wang, Anya et al.	2024	AI tool analysis study	Not applicable.	The authors used ChatGPT to transform informative material available on the internet about	ChatGPT could not unequivocally simplify health-related articles from a wide range of websites or replace physician-patient interactions. However, its ability to significantly	Not applicable.

(*Continued*)

Table 1 (*Continued*)

Article	Author	Year	Study type	Sample size	Interventions	Outcomes	Complications
Disparities in Health Literacy					"breast reconstruction" into a 5th-grade language level.	increase the readability of patient resources led the authors to recommend ChatGPT as a tool for patients searching for information about plastic and reconstructive procedures and as an aid to medical professionals in understanding how to simplify their explanations of medical procedures to patients.	
Expanding Cosmetic Plastic Surgery Research with ChatGPT	Gupta, Rohun et al.	2023	Case study	Not applicable.	The authors asked ChatGPT to "give new systematic review ideas" for the top 6 surgical procedures and top 6 non-surgical procedures in esthetic plastic surgery.	ChatGPT was a viable tool to help clinicians develop new systematic review ideas. The overall accuracy was of 55%. Furthermore, ChatGPT was significantly more accurate when receiving specific prompts, resulting in an accuracy rate of 35% for general topics and 75% for specific topics.	The study had limitations, since the program training used a dataset that was last updated in September 2021. Some previously unpublished proposed systematic review topics were published in late 2021 or after that.

Abbreviation: AI, artificial intelligence.

surgery, enabling a critical analysis of the methodological quality and the impacts of the reported interventions. Data organization aims to facilitate comparisons between studies and identify gaps in current knowledge, contributing to a deeper understanding of AI implications in this medical field. ►**Table 1** compiles information from the 74 articles.

Discussion

The use of AI in surgical procedures has undergone significant developments in recent years. The studies in the current review show that integrating machine-learning methods with surgeons' practices helps to achieve better outcomes in routine surgery. Four studies[10–12] addressed AI integration in breast reconstruction surgery. This technology improved the visualization of blood vessels and tissues compared with reconstructions performed without the use of AI. As such, AI enabled the earlier identification of risk factors for the procedure, reducing intra- and postoperative complications.[10–12]

Another significant issue is the evaluation of the performance of ChatGPT (OpenAI, Inc., San Francisco, CA, United States) in the provision of answers about plastic surgery.[13–15] Fourteen studies reported on counseling provided by AI and demonstrated that ChatGPT can act as a supplementary tool for surgeons, offer crucial information to patients, and solve problems related to the surgical procedure.[16] Studies[13–15] also analyzed the surgeons' view regarding the answers provided by ChatGPT when asked about daily procedures within plastic surgery. The surgeons pointed out that the answers provided by ChatGPT were relevant and accurate for simple questions. However, ChatGPT provided superficial answers for highly-complex topics, that is, a mere general overview.[13–15]

One topic worth highlighting is the use of deep learning, that is, machine learning based on algorithm predictive analysis, deemed an efficient tool for surgical wound management. Using this evaluation method, AI could identify infections and predict complications of postoperative wounds with a 96% accuracy rate.[17] Furthermore, one article analyzing this same tool in burn patients demonstrated AI's ability to predict graft-requiring sites, complication occurrence, and prolonged hospital stays due to skin lesions.[18–20]

Regarding the intraoperative period, the articles mostly addressed AI-provided AR. This tool significantly improves the visualization and planning of perforating flaps in reconstructive plastic surgery for a better understanding of the anatomy to increase the accuracy of the procedure. It is also worth noting that this visualization enables a projection of the volume, shape, and symmetry of the structures for reconstruction, rejuvenation, or beautification in the preoperative period.[21,22]

Although the current study presented promising results on AI use in plastic surgery, some critical limitations remain. First, AI is an emerging technology, and the lack of specific regulation represents a significant challenge. The absence of clear and standardized guidelines can compromise the safety and reliability of the data processed by AI tools, raising questions about result validation.[23]

Another relevant limitation is the bias associated with ethical and legal responsibility in AI-based medical decisions. The lack of regulation by health agencies leaves the role of AI in supporting clinical decisions undefined, creating uncertainty about liability in cases of errors or undesirable outcomes. This scenario highlights the urgent need for a regulatory framework considering patient protection and the legal security of health professionals.[24–26]

Furthermore, the effective use of AI tools in plastic surgery requires a high level of technical knowledge by medical teams, limiting its widespread adoption. The need for specialized training can create barriers to technology implementation in clinics and hospitals without sufficient resources for ongoing training.[27,28]

Finally, the black box concept inherent in many AI algorithms represents another crucial limitation. The lack of transparency in automated decision-making processes hinders the understanding of the origin and reason for certain recommendations. This opacity limits control over data and interferes with a critical result evaluation, potentially reducing the confidence of healthcare professionals in applying these tools.[23]

In summary, despite the advances, the full integration of AI in plastic surgery faces significant challenges that need to be addressed through adequate regulation, specialized training, and greater transparency in decision-making processes.

Conclusion

The analysis of the results highlights the growing incorporation of AI in plastic surgery. In different subspecialties, AI has shown its potential, such as in breast reconstruction, in which machine-learning techniques are used to improve the visualization of anatomical structures and identify risk factors early, contributing to the reduction of intra- and postoperative complications. The reduction in the time required for the analysis and selection of recipient vessels, demonstrated in one of the studies, illustrates the efficiency AI can provide to surgical planning.

In addition, the assessment of ChatGPT's performance revealed its value as a supplementary tool, providing support in clinical decision-making and improving communication with the patients. However, its limitations in more complex topics highlight the need for careful and judicious integration of this technology into the clinical practice. Other innovations, such as deep learning in surgical wound management and AR in reconstructive plastic surgery, have demonstrated positive impacts in optimizing clinical outcomes and improving the patient experience. Thus, AI adoption, with adequate regulation and ongoing training of healthcare professionals, can transform the practice of plastic surgery, leading to significant advances in esthetic and reconstructive medicine.

Authors' Contributions

CGH: data analysis and/or interpretation, final manuscript approval, conceptualization, study conception and design, project management, investigation, methodology, writing – original draft. preparation, writing – review & editing, and supervision; GMJ: data analysis and/or interpretation, final manuscript approval, study conception and design, project management, methodology, writing – original draft, and writing – review & editing; APD: data analysis and/or interpretation data collection, conceptualization, methodology, writing – original draft, writing – review & editing, and supervision; VUP: data analysis and/or interpretation, statistical analysis, data collection, methodology, and writing – review & editing; GPA: data analysis and/or interpretation statistical analysis, final manuscript approval, data collection, and writing – review & editing; RDAN: data analysis and/or interpretation statistical analysis, data collection, and methodology; AMS: data analysis and/or interpretation study conception and design, and methodology; and DSV: data analysis and/or interpretation final manuscript approval, conceptualization, study conception and design, project management, methodology, writing – original draft, writing – review & editing, and supervision.

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Clinical Trials

None.

Conflict of Interests

The authors have no conflict of interests to declare.

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