IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Artificial intelligence in plastic surgery a review article.

Authors: Rakesh Ashok Kadam [1], Sweety Polachira Binny [1], Abhirami Satheesh [1], Tripti Bisht [1]

Institution: MD Student, Ivane Javakhishvili Tbilisi State University-Faculty of medicine, Tbilisi, Georgia

Abstract

Background: Due to the industrial use of machines and robotics, autonomous instruments, and the quick advancement of computer-based systems, artificial intelligence (AI) has been well-established in many aspects of daily life for a long time.

Objective: Demonstration of current AI breakthroughs and future potential in plastic surgery. Especially in breast surgery, craniofacial surgery, and wound care.

Methods: Evaluation of different modalities of AI in press releases and original articles from journals and discussion of reviews.

Results: The use of 3D imaging systems provides objective feedback on surgical results in terms of volume and aesthetics in breast surgery. Intelligent robots assist plastic surgeons in microsurgical anastomoses of increasingly smaller vessels which helps in craniofacial surgery and the implementation of AI in the field of wound care helps in prognosis.

Conclusion: Artificial intelligence can address clinically relevant problems in several domains of plastic surgery, including breast surgery; craniofacial surgery and wound care. This article provides a brief introduction to current research and suggests limitations, ethical concerns and future projects that will allow plastic surgeons to explore this new frontier of surgical science.

Keywords: 3D imaging; Artificial intelligence, robotics, plastic surgery, machine learning.

Introduction

The medical industry is introducing a lot of new technology, including robotic surgery, 3D printing, virtual and augmented reality, and artificial intelligence (AI). The field of craniofacial surgery has access to a vast amount of information, including pictures, CT scans, and audio files.

These facts serve as a foundation for the use of AI. As demonstrated by AI models used in radiology and pathology, image recognition technology is currently the most widely used use of AI in medicine. AI can be used to identify, measure, and classify lesions as well as to improve the quality of images. Natural language processing and speech recognition both perform significantly better now. However, no AI models created for plastic and reconstructive surgery have yet received FDA approval. The US Food and Drug Administration (FDA) has approved several medical AI applications in fields like cardiology, endocrinology, radiology, neurology, internal

medicine, ophthalmology, emergency medicine, and oncology (1). Nevertheless, medical AI has a lot of potential for advancement across all medical specialities, including plastic surgery.

The potential of using medical AI in plastic surgery, particularly in the subspecialties of breast surgery, craniofacial surgery, and wound care, is what this review will look into.

Understanding AI in plastic surgery

Medical professionals utilize artificial intelligence models to analyze patient records and derive insights that can be used to improve patient care and health outcomes. A key element of modern healthcare, artificial intelligence (AI) has recently achieved tremendous advancements in computer science and informatics. In clinical settings and ongoing research, medical professionals use AI algorithms and other technologies. (2)

As a cutting-edge surgical specialty, plastic surgery is anticipated to incorporate AI into both current and future procedures. All plastic surgeons need to be aware of any potential risks and understand how artificial intelligence (AI) may impact their present and future practices. (3)

Plastic surgery is changing as much as any other area in this era of rapid technological innovation and revolution. In many contexts, AI has grown to be extremely significant in plastic surgery. Artificial intelligence (AI)-based technology such as big data, machine learning, deep learning, natural language processing, and facial recognition are examples that plastic surgeons are starting to use to better their surgical practice.

Aesthetic medicine and plastic surgery are two fields where AI has the potential to be fully utilized. Thinking robots could expedite routine cognitive processes including pre-operative assessment, case planning, and post-operative decision-making, resulting in enhanced productivity and better patient care. (4)

Potential applications of AI in plastic surgery

A) applications of AI in breast surgery –

Breast surgery is a surgical procedure that involves removal or performing certain modifications on female or male's breast(s). Depending on the underlying reason, this surgery is performed for either medical purposes, such as in breast cancers, to remove lumps and even to prevent future breast cancers, or for cosmetic purposes like breast reconstruction, augmentation, reduction and so on.(5)

With the upcoming of new technical and scientific knowledge, there has been improvements in the screening process for breast surgeries, especially for breast cancer. And this has been made possible by the advanced technology of artificial intelligence. Many AI tools has been introduced in the past few years which has improved the screening process of breast cancers. It has helped to access the high risk of reoccurrence of breast cancer in patients. In this way we get to know the patients who need early treatments and also spare low-risk patients, thus avoiding over-diagnosis (6). AI also helps to identify patients with missed, masked or fast growing breast cancers (7). Apart from this, a recent study showed that AI could also help to reduce work load, by acting as an secondary readers for mammograms (8). This helps to increase the sensitivity and reduce recalls. This is aided by the shift from digital mammography to an advanced screening system known as breast tomosynthesis screening, which uses high resolution limited-angle. Other advantages include improved quality, patients safety, optimized workflow and productivity, thus followed by reduction in mortality.

B) applications of AI in craniofacial surgery –

Free flaps are monitored during head and neck reconstruction at 1-hour intervals on postoperative day (POD) 1, 2-hour intervals on POD 2, and 4-hour intervals on POD 3–7 using ocular inspections or Doppler ultrasonography.

In the investigations that have been published so far, flaps used in breast reconstruction have been subjected to NIRS monitoring. To our knowledge, only few studies have discussed NIRS-monitored flap monitoring after craniofacial reconstruction procedures, although it is also possible to employ NIRS to track free flaps used during craniofacial reconstruction. (9) In order to monitor invisible and buried free flaps used for craniofacial reconstruction, it would be conceivable to use NIRS, which has the benefit of being able to monitor muscular flaps with deep tissue (such as those used in facial palsy reconstruction). The bio signal data that can be gathered from these NIRS measurements is enormous.

It has been mentioned that 3D visualization using liver imaging can be used to ascertain the cause of a disease and direct surgical procedures. Liver imaging can show surgeons the anatomy of the liver, including the locations of various arteries and lesions. By using a comparable approach to create a 3D model of a patient's skull, artificial intelligence (AI) technology may let craniofacial surgery adapt to each unique patient.

By using a comparable approach to create a 3D model of a patient's skull, artificial intelligence (AI) technology may let craniofacial surgery adapt to each unique patient. ANNs could be used by plastic surgeons to predict postoperative difficulties following craniofacial surgery.

Because the bone may continue to grow improperly despite remedial surgery, syndromic craniosynostosis may produce recurring cranial deformities. In such circumstances, medical augmentation of surgery may be enhanced by AI and precision medicine to maximize postoperative results.

Artificial neural networks (ANNs) could be used by plastic surgeons to foresee postoperative difficulties following craniofacial surgery. Because the bone may continue to grow improperly despite remedial surgery, syndromic craniosynostosis may produce recurring cranial deformities. In these situations, medical augmentation of surgery may benefit from both AI and precision medicine to improve postoperative results. (10) Researchers used a special convolution neural network to analyze the facial attractiveness of images of the forehead and sides of ten patients with left cleft lips and ten controls, and they came to the conclusion that the ML method can be a useful tool to describe facial attractiveness.

In order to assess the bone mass of the surgical area, calculate the implant area's bone mineral density, and aid in the creation of a static guide plate system, CBCT images and machine learning models can also be used.

C) applications of AI in wound care –

Burns are terrible injuries that place a heavy health impact on both the patient and the healthcare system. Victims of burn injuries present with considerable clinical, psychological and social sequel (11). AI-enabled computer-aided diagnostics (CAD) technologies have the potential to restructure the medical imaging industry. Clinical practice makes considerable use of medical imaging, such as ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI). Dermoscopy and confocal microscopy in the field of dermatology enables more accurate in vivo observation of lesioned characteristics and risk stratification.(12) Burns are the 4th most common trauma worldwide and are considered one of the most difficult situations to treat and it requires the input from specialists for a holistic care. Stratifying data to enhance outcomes for a systemic injury presents a difficulty because of the wide variation in presentation and results. However, what makes burning special is that huge and frequent datasets are accessible globally. The chance to change the paradigm in favor of bettering burn patient outcomes has arisen as a result of technological advancement. According to IBM, a patient's lifetime will generate around one million terabytes of healthcare data, with that amount doubling every two to five years.(13)

Limitations of AI in plastic surgery

AI has innumerable applications and is a futuristic approach in plastic surgery. But it's not possible to unsee its downsides and limitations. It's main challenge is in its data and the ethical issues. (Table 1)

The algorithm of AI for surgery is built on the database of patients, thus creating a space of negligence of privacy. But this can be solved by introducing autonomous surgeries. But there still exists other ethical issues. Since AI works on data and algorithms, a mismatch of data can create a havoc. This can further affect the doctor-patient relationship, which is the foundation of an healthcare. (14) Also using artificial intelligence in a facial recognition platform can create confusions due to different beauty standards in different places.

Also, we need to understand the fact that artificial intelligence can be used only as a tool. It cannot replace surgeons completely. Moreover, a surgical approach need proper conversation and empathy towards the patient, which AI lack. (15)

Table 1 : Ethical consideration of AI in plastic surgery.

Ethical Issues	Explanation	Example
Informed consent regarding the use of data	The requirement for data-use contracts on the part of data aggregators and suppliers.	A patient's permission to use their information in a HER Obtaining permission to use patient photos in a training data set
Quality assurance of data	High-quality data are required that accurately reflect the patient group for which the Al system is intended.	Inclusion of individuals from various racial and ethnic groups in facial recognition systems and other types of AI that rely on visual data Knowledge of potential biases in the data set by the provider
Integrity of the patient-physician relationship and the human dimension of health care	Ensuring that AI does not jeopardize the patient-physician connection, which is based on empathy, trust, and collaborative decision-making	The incorporation of AI technology into clinical practice focused on patients Job automation in the medical field

Future of AI in plastic surgery

AI comes out to be an optimistic approach that may help individuals with birth defect and/or palate. Currently, it's been used for predicting the chance of development of non-syndromic cleft lip and palate, for diagnosis—prenatal, photographic, and identification of cephalometric characteristics and mid-facial plane in participants. (16) This will reduce the no. of X-rays or CT scans a infant would need . The power of measuring bone mineral density and to evaluate the surgical bone mass area will help surgeons to construct a static surgical guide.

Discussion

The collaboration between artificial intelligence and plastic surgery is still in its infancy, with the majority of attempts still in the "proof of concept" stage, but advancements are quick and encouraging.

Around 750 scholarly articles describing AI and medical imaging were published in 2016–2017, with medical imaging taking the lead. (17) Convolutional neural networks have been used to construct machine learning models that analyze breast mammography as correctly as specialized radiologists. Current screening results in over diagnosis, morbidity, and time inefficiencies (18, 19). According to (20), AI could enhance breast screening's accuracy and effectiveness while reducing human error.

The diagnosis of dermatological conditions also wound care can potentially benefit from AI. Similar to or better than experienced dermatologists, a convolutional neural network system trained using pattern recognition from 129,450 photos can distinguish between benign and malignant skin malignancies. (21,22) When paired with the opinions of human pathologists, a similar network that identified breast cancer metastases from sentinel lymph node biopsy samples reduced human error by 85%. By enhancing our capacity to identify specific illnesses, we can use scarce resources to treat people who have a diagnosed illness.

Cross-sectional imaging has been successfully integrated by AI during difficult craniofacial reconstructions as well as resections of facial tumors. In order to observe the pathology from all sides, the surgeon uses a headset that enables them to superimpose three-dimensional radiological pictures onto the patient. The surgeon can then decide which surgical approach is most appropriate to achieve maximal tumor resection and minimize complications. (23)

Conclusion

Although the relationship between AI and plastic surgery is still developing, progress is quick and encouraging. The field of medical imaging is leading the way and has the potential to increase screening program efficiency and accuracy while reducing human error.

AI has the potential to guide reconstructive and cosmetic surgical procedures in the future. Surgeons do not need to be experts in artificial intelligence technology at the level of engineers who specialize in the field, but it is crucial for them to comprehend its fundamental principles and technical framework as well as learn how to assess the effectiveness and qualities of developed technologies.

It is crucial for surgeons to work with computer scientists so that results are focused on improving patient care. Surgeons should also be aware of key ethical issues and limitations related to integrating AI into routine surgical practices.

References

1) Benjamens S, Dhunnoo P, Mesko B. The state of artificial intelligence-based FDA-approved medical devices and algorithms: an online database. NPJ Digit Med 2020;3:118.
2) Moellhoff N, Giunta RE. Künstliche Intelligenz in der Plastischen Chirurgie : Aktuelle Entwicklungen und Perspektiven [Artificial intelligence in plastic surgery : Current developments and perspectives]. Chirurg. 2020 Mar;91(3):211-215. German. doi: 10.1007/s00104-019-01052-2. PMID: 31650203.
3) Liang X, Yang X, Yin S, Malay S, Chung KC, Ma J, Wang K. Artificial Intelligence in Plastic Surgery: Applications and Challenges. Aesthetic Plast Surg. 2021 Apr;45(2):784-790. doi: 10.1007/s00266-019-01592-2. Epub 2020 Jan 2. PMID: 31897624.*****†****

4) Murphy DC, Saleh DB. Artificial Intelligence in plastic surgery: What is it? Where are we now? What is on the horizon? Ann R Coll Surg Engl. 2020 Oct;102(8):577-580. doi: 10.1308/rcsann.2020.0158. Epub 2020 Aug 11. PMID: 32777930; PMCID: PMC7538735.

5) Jarvis T, Thornburg D, Rebecca AM, Teven CM. Artificial Intelligence in Plastic Surgery: Current Applications, Future Directions, and Ethical Implications. Plast Reconstr Surg Glob Open. 2020 Oct 29;8(10):e3200. doi: 10.1097/GOX.0000000000003200. PMID: 33173702; PMCID: PMC7647513.

6) Chandawarkar A, Chartier C, Kanevsky J, Cress PE. A Practical Approach to Artificial Intelligence in Plastic Surgery. Aesthet Surg J Open Forum. 2020 Jan 8;2(1):ojaa001. doi: 10.1093/asjof/ojaa001. PMID: 33791621; PMCID: PMC7671238.

7) Welch HG, Prorok PC, O'Malley AJ, Kramer BS. Breast-cancer tumor size, overdiagnosis, and mammography screening effectiveness. N Engl J Med 2016; 375: 1438–1447.

8) Phillips M, Marsden H, Jaffe W, Matin RN, Wali GN, Greenhalgh J, McGrath E, James R, Ladoyanni E, Bewley A, Argenziano G, Palamaras I. Assessment of Accuracy of an Artificial Intelligence Algorithm to Detect Melanoma in Images of Skin Lesions. JAMA Netw Open. 2019 Oct 2;2(10):e1913436. Doi: 10.1001/jamanetworkopen.2019.13436. Erratum in: JAMA Netw Open. 2019 Nov 1;2(11):e1916430. PMID: 31617929; PMCID: PMC6806667.

9) Turner AE, Abu-Ghname A, Davis MJ, Ali K, Winocour S. Role of Simulation and Artificial Intelligence in Plastic Surgery Training. Plast Reconstr Surg. 2020 Sep;146(3):390e-391e. doi: 10.1097/PRS.0000000000007102. PMID: 32496378.

10) Ryu JY, Chung HY, Choi KY. Potential role of artificial intelligence in craniofacial surgery. Arch Craniofac Surg. 2021 Oct;22(5):223-231. Doi: 10.7181/acfs.2021.00507. Epub 2021 Oct 20. PMID: 34732033; PMCID: PMC8568494.

11) Liu J. Artificial Intelligence Is Still Far from Truly Revolutionizing Plastic Surgery. Plast Reconstr Surg. 2020 Sep;146(3):390e. doi: 10.1097/PRS.0000000000007101. PMID: 32842131.

12) E Moura FS, Amin K, Ekwobi C. Artificial intelligence in the management and treatment of burns: a systematic review. Burns Trauma. 2021 Aug 19;9:tkab022. doi: 10.1093/burnst/tkab022. PMID: 34423054; PMCID: PMC8375569.

13) Luan F, Gao X, Zhao S, Cai X. The Roles of Plastic Surgeons in Advancing Artificial Intelligence in Plastic Surgery. Aesthetic Plast Surg. 2022 Apr;46(Suppl 1):184-185. doi: 10.1007/s00266-021-02302-7. Epub 2021 Apr 28. PMID: 33913020.

14) McDougall RJ. Computer knows best? The need for value-flexibility in medical AI. J Med Ethics 2019; 45: 156–160.

15) Koimizu J, Numajiri T, Kato K. Machine learning and ethics in plastic surgery. Plast Reconstr Surg Glob Open 2019; 7: e2162.

16) Kim YJ, Kelley BP, Nasser JS, Chung KC. Implementing precision medicine and artificial intelligence in plastic surgery. Plast Reconstr Surg Glob Open 2019; 7:e2113.

17) Pesapane F, Codari M, Sardanelli F. Artificial intelligence in medical imaging: threat or opportunity? Radiologists again at the forefront of innovation in medicine. Eur Radiol Exp 2018; 2: 35.

18) Tsochatzidis L, Costaridou L, Pratikakis I. Deep learning for breast cancer diagnosis from mammograms: a comparative study. J Imaging 2019; 5: 37.

19) Geras KJ, Wolfson S, Shen Y et al. High-resolution breast cancer screening with multi-view deep convolutional neural networks. arXiv 2018: 1703.07047v3.

20) Esteva A, Kuprel B, Novoa RA et al. Dermatologist-level classification of skin cancer with deep neural networks. Nature 2017; 542: 115–118.

21) Brinker TJ, Hekler A, Enk AH et al. Deep learning outperformed 136 of 157 dermatologists in a head-to-head dermoscopic melanoma image classification task. Eur J Cancer 2019; 113:47–54.

22) Eldaly AS, Avila FR, Torres-Guzman RA, Maita K, Garcia JP, Palmieri Serrano L, Forte AJ. Simulation and Artificial Intelligence in Rhinoplasty: A Systematic Review. Aesthetic Plast Surg. 2022 Apr 18. doi: 10.1007/s00266-022-02883-x. Epub ahead of print. PMID: 35437664.

23) apoQlar. Virtual surgery intelligence: head & neck/ENT. https://vsi.health/en/vsisurgery/vsi-head-neck (cited June 2020).