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REVIEW PAPER

Application of Artificial Intelligence in Different Fields of Oromaxillofacial Surgery

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Abstract

Aim: The mechanization of today's world and the recent developments about robots and its use in industry and medicine, as well as the replacement by these tools instead of human labor with the ability to make them intelligent, have made artificial intelligence (AI) and robots hot topics these days. Artificial intelligence is the ability of intelligent machines to predict unknown variables by using algorithms and internal statistical patterns and information structures. In the structure of AI, which are divided into two general categories, machine learning and deep learning, human neural patterns are in the form of neural networks. The working areas of AI in maxillofacial and plastic surgery are wide and in the fields of rhinoplasty, orthognathic surgery, cleft lip and palate, augmentation in implants, and diagnosis and determination of survival rate in cancer patients. In this review article the different functions of AI in the fields of maxillofacial surgery and the extent of its effectiveness in helping to improve the acceleration of work are discussed.

Methods & Materials: This study examines articles from 2000–2023. Google Scholar and PubMed databases were used for searching and keywords such as artificial intelligence-machine learning, deep learning were investigated. The inclusion criteria for this study were all the articles that were written and reviewed in the years in question, in English, and the field of research was maxillofacial or plastic surgery.

Results:

Rhinoplasty: The application of artificial intelligence (AI) in the field of examining bone shape, examining the beauty of patients based on the evaluation of pre-treatment photographs and predicting the results of the operation based on radiographic interpretation.

Orthognathic surgery: AI can be used in the field of lateral cephalometric tracing, scanning of patients' occlusion, examination of periodontal diseases and dental problems, as well as making oral appliances and predicting the operation using machine learning (ML).

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Cleft palate and lip: Examining the success rate of bone grafting in the alveolar cleft area and predicting the results of grafting and the risk of infection and failure of grafting in the area is one of the applications of AI in this field.
Oral cancer: Oral squamous cell cancer is one of the most common head and neck cancers and due to the high rate of recurrence, morbidity and mortality, it is of great concern in medical sciences today. The application of AI and the interpretation of risk factors and samples using complex neural algorithms can reduce the mortality rate through faster disease prediction and at earlier stages.
Conclusion: In this review article, the applications of AI and its sub-branches, including ML, deep learning, in various branches of maxillofacial surgery, including orthognathics, rhinoplasty, cleft lip and palate, and oral cancer are discussed. Making decisions smarter by using complex neural algorithms and its involvement in decisions can reduce human errors and increase patient satisfaction.

Keywords: artificial intelligence, machine learning, deep learning, orthognathic surgery, squamous cell carcinoma, cleft palate, rhinoplasty

1. Introduction

The mechanization of today's world and the recent developments about robots and its use in industry and medicine, as well as the replacement by these tools instead of human labor with the ability to make them intelligent, have made artificial intelligence and robots hot topics these days. Artificial intelligence (AI) is the ability of intelligent machines to predict unknown variables by using algorithms and internal statistical patterns and information structures. The history of using machines instead of humans dates back to 1950. What makes the human mind dynamic and able to make decisions and process information is non-linear neural networks and the creation of advanced neural networks [1, 2]. In the structure of AI, divided into two general categories, machine learning (ML) and deep learning (DL), human neural patterns are used in the form of neural networks [3] (Figure 1). Convolutional Neural Network (CNN) is one of the most common types of Artificial Neural Networks (ANN) used in the fields of medicine and dentistry to process digital signals such as audio, image and video [4].

The difference between ML and DL is that in ML, information is interpreted using linear algorithms and pre-given information, and conclusions are made; while in DL algorithms are based on ANNs based on neuronal stimulation. The human brain is capable of examining complex structures without patterns [5]. ML is divided into two types; supervised, i.e. information processing and algorithm construction based on photos and pre-existing information, and unsupervised, i.e. information processing and algorithm construction based on concepts defined and

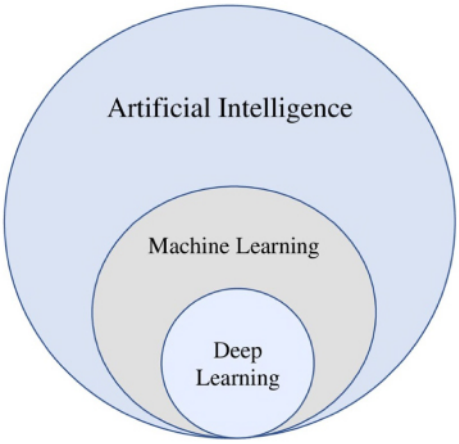

Figure 1. Artificial intelligence classifications chart.

labeled by the user [6]. In medicine, these technologies are widely used to help physicians with the help of computers. Although AI was introduced to the healthcare system in the early 1980s, the first use of neural algorithms was in 2005 in the plastic surgery system [7–9]. In the past decades, AI has had many applications in the fields of radiology, dermatology, neurology, and ophthalmology [10]. But today it is known as a practical tool in the field of jaw and face surgery and plastic surgery and its various branches. The working areas of artificial intelligence in maxillofacial and plastic surgery are wide and in the fields of rhinoplasty, orthognathic surgery, cleft lip and palate, augmentation in implants, Determination of cysts and tumors and their differentiation, diagnosis of osteoporosis from orthopantograph (OPG) images, examination of the need to extract teeth in orthodontic treatments before orthognathics or teeth under dentures, and diagnosis and determination of survival rate in cancer patients, positive or negative examination of tumor margins during surgery in the operating room, examination of cancer diagnosis biomarkers [11]. In this review article, the different functions of artificial intelligence in different fields of maxillofacial surgery and the extent of its effectiveness in helping to improve the acceleration of work are discussed [12].

2. Methods & materials

This study examines articles from 2000–2023. Google Scholar and PubMed databases were used for searching and keywords such as artificial intelligence-machine learning, deep learning were investigated. The inclusion criteria for this study were all the articles that were written and reviewed in the years in question, in English language, and the field of research was maxillofacial or plastic surgery.

3. Results

3.1. Rhinoplasty

An essential feature of artificial intelligence with ANNs is the ability to recognize nasal bones and pink landmarks. AI can make many predictions by examining the photos before and after the operation and minimize the level of dissatisfaction with the results of the operation and the treatment plan. In a study by Dorfman *et al.* [13], 68 pink measurements and 128 points were defined for each photo, and with a random neural network algorithm, it can estimate human age and minimize human errors. Zeng and colleagues designed a virtual planning system that accurately measured forehead flap dimensions to reconstruct nasal defects [14]. Chinski and colleagues designed an AI model that can accurately predict surgical outcomes by examining detailed images [15, 16]. Advances in the field of DL are made using a predictive software about rhinoplasty [17, 18].

3.2. Orthognathic surgery

On the topic of orthognathic surgery, several things are important. The discussion of molding and surgery model that is collected as the patient's pre-operative documents, interpretation of photos and prediction of surgery, and performing orthosurgery and cutting accuracy, which becomes more important especially in the case of syndromic and cleft patients. Regarding surgery model, what is important is the accurate determination of clinical and radiographic landmarks and their quick analysis, and Ai has helped physicians in this field, by determining specific points on the patient's lateral cephalometry, it performs radiographic tracing and reports the results for planning [19, 20]. The design of splints designed based on CT scan and 3D images of the patient and the registration of the device with the patient and the possibility of scanning the patient's face can determine the limit and amount and direction of soft and hard tissue movements for surgical intervention [19]. The advancement of AI devices to create advanced intraoral scanners for imaging the occlusion of patients and improving their aesthetic and attractive results by using CNN algorithms has turned AI into a powerful and useful tool in orthosurgery [21]. The techniques used in ML have provided the possibility of superimposition in diagnostic devices such as CBCT, digital photography and intraoral scanners [22] to determine and examine the upper airway, especially in the treatment of obstructive sleep apnea patients [19, 20].

AI can also predict intraoperative blood loss and systemic infections following orthosurgery [4, 20, 23].

The accuracy of the evaluation of the surgery model by AI for genioplasty, the correct placement of screws and plates and orthodontic brackets is estimated to be 75% in Hong's study [23] and 94.4% by the circular neural network model [24].

3.3. Cleft palate and lip

Cleft lip and palate is a maxillofacial hypoplasia with a prevalence of 6.64 per 10,000 births worldwide, along with midface deformities such as incomplete formation of the lips, alveoli, and palate, along with appearance, pronunciation, and nutrition problems [25, 26]. One of the important issues in cleft palate and lip and alveolus is bone grafting, which is not only for cleft repair but also for supporting alar base, closing oroantral fistula and helping canine growth in cleft area [27]. ML, a branch of AI, shows the analysis of the association between the size of the gap and the grafted bone, as well as the three-dimensional evolution of the maxilla after surgery [28].

Agrawal et al explained that the deformed margin of the periform and derived from the attachment of the lateral and lateral cartilages of the crura is consequently stretched to the caudal side, leading to a tilt of the nose towards the fissure and then an increase in the width of the maxilla [29].

AI can be effective in detecting and classifying cleft palate, determining facial phenotypes of genetic disorders, cleft analysis and predicting the genetic risk of non-syndromic oral clefts.

3.4. Diagnosis of jaw cysts

Advances in AI, ML, and DL have been widespread in medical fields. Analysis of medical images using AI can detect tuberculosis patients from chest radiographs [30, 31]. AI in the field of dentistry is also proficient in the field of examining radiographic images and it has the ability to distinguish cyst-like radiolucent lesions such as radicular cyst, dentigerous cyst, odontogenic keratocyst, ameloblastoma and other lesions [32]. These can be diagnosed by using OPG in the early stages and in dental offices as a screening tool and CT scan in more advanced stages as a therapeutic tool in the office of maxillofacial surgeons. and be helpful.

3.5. Osteoporosis of the jaw

Osteoporosis is one of the most common diseases that occurs frequently in women older than 50 years and is the result of an imbalance between bone formation and loss [33–35]. Despite the importance of bone and its role in the skeleton and strength of the body and jaw, treatment of this disease will be important. Several drug treatments have been provided to prevent and stop the process of bone loss, as well as drugs to stimulate bone formation. In this study, it examines the effectiveness of drugs for the production of osteoblasts or the use of drugs that suppress the activity of osteoclasts, and the results are interpreted in the form of preparing cross-sectional images of bones using AI. It is divided into smaller parts and the contrast of the images and the degree of resolution of the images are provided to AI for more accurate interpretation by improving the segmentation and augmentation [36, 37].

3.6. OPG

One of the collaborations that occurs between OPG images and AI is checking for dental caries, periapical lesions of teeth, checking the amount of bone loss in periodontal diseases, the need to extract teeth in orthodontics to complete the treatment, and checking the need for tooth extraction. Subprosthesis and prediction of BRONJ (bisphosphonate-related osteonecrosis of the jaw) incidence following tooth extraction in patients using bisphosphonate. This is done by using image segmentation and evaluation of more than 5000 images prepared to reduce the amount of error and human interpretation [38–42].

3.7. Squamous cell carcinoma

They are one of the most common forms of head and neck cancers and have the lowest survival rate worldwide despite extensive research and treatment. The prognosis of oral cancers has not improved significantly yet and is a constant challenge [43]. Cancers of the lip, mouth and oropharynx are the 13th most common cancer in the world. Early diagnosis of oral squamous cell carcinoma (OSCC) is crucial for successful treatment, increasing the chance of survival and lower mortality rate [44, 45]. The gold standard of diagnosis is based on the histology of tissue samples and the diagnosis and grading of cancer, which will be very slow and time-consuming [46].

Othmans Landini pioneered the development of an AI tool with automatic morphological reconstruction to recognize the characteristics of the epithelium for the diagnosis of oral cancers [47].

AI technology is mainly used to diagnose OSCC [48, 49], distinguish between normal and malignant situations [50, 51], predict patient survival [52, 53] and the severity and severity of the disease [54]. Early diagnosis of oral cancer can reduce the survival rate to 84%, while late diagnosis in stage 3, 4 can reduce the survival rate to 39% [55]. Das and his colleagues improved the ability of AI to detect keratin pearls and the amount of keratinized layer of oral mucosa in cancer patients through quantitative analysis of microscopic images of oral tissues [48].

One of the most dangerous types of squamous cell cancer is laryngeal cancer, which due to difficult access to the glottis, supraglottis and subglottis areas has a low success of treatment. DL helps using algorithms and data analysis of variables such as age, gender, TNM stage, the success of implementation and treatment methods and the survival rate have been remarkable [56]. AI technology by introducing nanodiagnostics as a technique for revealing the latent and oral potentially malignant disorders (OPMD), which was first proposed by Shanmugam and his colleagues, was able to conjugate nanocarriers with anti-EGFR monoclonal antibodies in-vivo and radiographic and tissue and brush samples in laboratory mice

to investigate the depth of penetration of malignant lesions and the induction of carcinogens [57, 58]. Chakraborty studied the challenges of nanodiagnostics for the detection and monitoring of OSCC [59]. Jayaram proposed the design of an advanced AI interpretation model for oral cancer progression [60]. Today's hot discussion of AI science, ChatGPT is an AI model with a wide language application that has been able to help to a certain extent about the common questions of breast cancer and liver cancer, including methods of prevention, screening and diagnosis [61, 62]. It is hoped that this smart chat software can be helpful in the field of jaw and face, especially in the diagnosis and screening of oral cancers [63].

3.8. Examining positive/negative margins in the operating room during cancer surgery

An important diagnostic aid in the operating room during surgery is frozen-section, which is essential for decision-making in the operating room. Examining the margins of the lesion and whether or not it is involved in the disease can help to continue or complete the surgery. But like any other method, this method also has disadvantages such as time requirements and high rate of non-diagnosis. Although freezing the tissue preserves the tissue markers well, it breaks the structure of the tissue and causes artifacts [64]. AI model was trained using DL technology by a computer and with the help of segmentation by sample sent from the lesion inside the operating room, which can report the result with less time and more accuracy [65].

3.9. Pre cancer biomarkers

Saliva biomarkers are used to diagnose periodontal diseases, dental caries, oral cancer, temporomandibular joint diseases and salivary gland diseases. AI represents one of these simultaneous approaches that may help to optimize the selection and validation of salivary biomarkers in the diagnosis and management of oral and maxillofacial diseases [66]. AI can be effective in the field of classification, progression or regression of diseases, screening and risk of diseases, diagnosis of halitosis, lichen planus, oral mucositis, osteoarthritis of the jaw joint based on the information obtained from salivary biomarkers [67, 68].

3.10. Prognosis of oral cancer

ML is not a new topic in the discussion of cancer research, but according to the published articles for diagnosis, differentiation and classification in the field of tumors and malignancies, prognosis always remains a challenge. Various parameters such as family history, age, diet, high-risk habits and exposure to carcinogenic environment can predict the rate of recurrence and prognosis [69, 70].

4. Discussion

AI can be used as a practical tool in maxillofacial surgery today. The possibility of evaluating images before and after surgery and minimizing the level of patient dissatisfaction with the results of the operation, especially in operations that have a cosmetic aspect, including rhinoplasty and orthognathic surgery, is one of its uses. Making orthodontic appliances, using internal scanners, oral examination of occlusion and dental and periodontal problems, prediction of treatment results in orthognathic surgeries [71] and examination of nasal bone problems and deformities in rhinoplasty has made AI a great help for maxillofacial surgeons. Diagnosing, predicting and calculating the survival rate in oral cancer patients as one of the most common head and neck cancers and helping patients by using complex neural network patterns as well as the application of ML and specifically and more advanced DL using the algorithms obtained from histopathology samples and examination of the epithelium of healthy and diseased samples is another application of AI in maxillofacial surgery [72, 73]. AI also has a useful application in the field of cleft palate and lip. It will be possible to check the quality of grafted bone in the area of the alveoli with a gap, to check the effectiveness of the graft secondarily or primarily along with closing the cleft palate and lip using the deep learning neural network algorithm model [27, 74]. AI can help pathologists and help in the diagnosis and differentiation of jaw and facial cysts such as periapical, dentigerous, odontogenic keratocyst, etc. On the other hand, diagnosing osteoporosis and osteonecrosis caused by bisphosphonate from OPG radiography, as well as predicting the occurrence of periodontal diseases, cancers, caries, etc. through biomarkers can be other specialized areas of artificial intelligence.

The upcoming future in the field of robotics and AI, and its application in the world of maxillofacial surgery can, in addition to modernizing this science, reduce human errors, improve treatment techniques, and increase the survival rate of patients. Although, the constraints include the high cost of devices and equipment, training of personnel and surgeons in contact with AI, providing space and space in operating rooms and offices, and increasing the time of examination and announcement of definitive results about the issue of decision making. was oblivious until now. Various devices have been introduced using robots for microneurosurgery, lymphovenous surgeries and anastomosis of perforator vessels in flaps for transplantation, repair of abdominal hernia and microvascular anastomoses [75–77] which are supported by AI and ML and have become more powerful tools with decision making power.

5. Conclusion

This review article discussed the applications of AI and its sub-branches, including ML and DL in various branches of maxillofacial surgery, including orthognathics,

rhinoplasty, cleft lip and palate, and oral cancer. Making decisions smarter by using complex neural algorithms and its involvement in decisions can reduce human errors and increase patient satisfaction, although it still takes time to fully accepted by patients and fully embrace AI in treatment.

Conflict of interest

The author declares no conflict of interest.

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