Exploring the role of artificial Intelligence In Prosthodontics

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Introduction:

Artificial Intelligence (AI) is the ability of machines to perform tasks that normally require human intelligence. The term artificial intelligence was first used by john McCarthy in the year 1955 [1]. John McCarthy was an arithmetician and is known as the father of artificial intelligence. Artificial intelligence means the aptitude of a machine to imitate human knowledge and behaviour. Machine learning is a field of artificial intelligence that was first mentioned in 1959 by Arthur Samuel and he defined it as the process that enables computer to learn without definite programming [2]

One of its definitions is "the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision making, and translation between languages". Artificial intelligence is gaining attention all over the globe as it has marked a high impact, breakthrough in the field of intelligence innovation. "Digital transformations", "digitized workflows", "and technical developments": these terms describe some of the game changers of the 21st century, both in social life as well as dental medicine. The use of mobile devices, tablets, and smartphones, and the easy access to technology and the WorldWideWeb, have changed the cultural habits of our society in general [3]. It is not surprising that more advanced technologies, such as

artificial intelligence (AI), are also finding increasing application in daily life. AI applications are commonplace in digital everyday life, for example in the form of virtual assistants such as “Siri” or “Alexa” [4].

AI has been adopted in many fields of industry, such as robots, automobiles, smart city, and financial analysis, etc. It has also been used in medicine and dentistry, for example, medical and dental imaging diagnostics, decision support, precision and digital medicine, drug discovery, wearable technology, hospital monitoring, robotic and virtual assistants. Technological advances are increasingly noticeable in dentistry, but are still restrained compared to medicine. Digital dental processes are continuously being standardized and are becoming part of routine treatment protocols [5-7]

The study of dental prostheses, or prosthodontics, is a crucial topic that has a significant impact on various stages of a dentist's career. Prosthodontics had exponential growth in the area of materials used, diagnostic and treatment planning, and even prosthesis production as a result of favorable changes in digital dentistry. Dental prosthetics can be made using a variety of methods. The creation of prostheses as fixed dental prostheses, removable partial dentures, or implants offers an alternative in cases of tooth loss [8-10]. How rehabilitation is done depends on the type of implant used and the condition of the remaining alveolar ridge. During this rehabilitation process, several approaches are needed [11,12].

Combining AI technologies with prosthodontics could result in a wide range of novel options, including AI systems for generating occlusal surface designs for crowns that take into account intraoral wear facets, automatic complete denture set-up designers, for determining the emergence profile in implantology, or for automatically designing frameworks for removable partial dentures.

Convolutional neural networks (CNNs) based on AI were used to classify implants by Lee J et al. [13], utilising panoramic and periapical radiography. According to the findings of this study, the AI-CNN system is nearly as efficient as humans at classifying implant procedures. Incorrect placement, subpar cementation, occlusion, and interproximal repair are

examples of potential error-causing factors. Lerner et al. [14] suggested an AI model to reduce the risk of these errors. Takahashi et al. [15] conducted a thorough investigation to create an AI framework that would classify dental arches and make use of CNN to help with denture production. The training dataset was categorised using methodologies for computer-based autonomous learning. AI augmented reality decreased patient anxiety and increased pleasure. AI will get better at scheduling appointments, playing the patient's preferred music and entertainment, and even assisting with relaxation

.

In Fixed and Removable Prosthesis:

A critical step in the development of a prosthesis is the design of the multiple components that make up an RPD [16]. AI algorithm development has also been advantageous for RPD design. Dental prosthesis that is fixed will have their original tooth structure analysed, and software will be utilised to evaluate the circumstance and make suggestions various line of action. A recommendation for RPD design for partial edentulism will be provided by the application software.

It has been demonstrated that a case-based reasoning and ontology-based clinical decision support model for detachable prosthodontics is capable of making recommendations for the creation of customisedRPDs. This model, on the other hand, bases its recommendations on the most likely case in the database. Keeping a critical eye on the results of clinical environments is essential because they are constantly changing. The development of a synthetic intelligence system in fixed prosthodontics is ongoing. The cloud-based database of millions of doctor-approved crowns comprises the fundamental component of artificial intelligence (AI), which is its ability to assess and learn from data. The computer assesses how each high-performance restoration is constructed to achieve optimal function in order to learn from successful restorations. This is done based on the ideal occlusion, contacts, and margins appropriate for each situation.

Conventional protocol using using manual tooth preparation kits resulted in more time consumption and error incorporation. Zhang et al. researched the deep learning (DL) model to precisely extract marginal lines.There were 380 dental preparation models used in this investigation. The data was retrieved using a Convolutional Neural Network (CNN) model called Sparse Octree (S-Octree). The dental preparation method resulted in a sparse point cloud with labels. For the inquiry, an eight-depth octree structure was created. Data sets for training, verifying, and testing were produced. CNN models were established by giving names to dental preparations. A tooth preparation line was removed from the study along with back-projection and boundary extraction techniques in order to address the drawbacks of manual practicing, Back-projection, boundary extraction, and preparation line were all taken out of the study. The average level of precision was 97.43%. This increased accuracy showed how AI can repair mistakes made by humans, making it a suitable successor [17]

In CAD CAM in prosthodontics:

It is the area of dentistry where applications are made to restore the patient's lost esthetics and function by treating them with the proper prosthetic materials. Functional and esthetic losses caused by inadequacies in teeth and surrounding supporting tissues. Prosthetic restorations must go through a number of precise preparation and construction steps that can be completed using traditional methods or digital techniques such as CAD/CAM (computer-aided design/computer-aided manufacturing), which has become increasingly popular in recent years. It describes a method of producing materials needed for prosthetic treatment using computer design and production expertise.

One of the problems required to optimize the digital phases of CAD/CAM systems is frequently intelligent software. It has been determined that the novel soft computing optimization technique presented in the study will greatly lower the expenses associated with setting up and altering machine operations while also increasing the efficiency of businesses in optimizing machine parameters for industrial processes [18]. Artificial intelligence (AI) is used by dentists to produce prostheses; it aids in developing the greatest and most aesthetically pleasing prosthetic by taking into account a variety of factors, including anthropological calculations, face measurements, and patient expectations.

There are a number of issues that can occur when typical CAD/CAM technologies are used in implant prosthesis cementation, including positioning mistakes, cementation errors, and errors that may happen during occlusal correction using an abutment. An AI model was used in the production of zirconia implants for posterior teeth, with a 93% success rate, in a study that aimed to remove these mistakes and time losses [19]. An accuracy rate of 97.43% was attained in a study that used the CNN model to create the segmentation network structure for tooth preparations [20]. CNN can automatically extract the margin line by learning the features of the margin line region of the tooth preparation. According to reports, results from a study seeking to create a single molar dental prosthesis that resembles the morphology of a normal healthy tooth by learning the tooth characteristics from the remaining teeth were acquired with acceptable accuracy. This was made possible by a developed AI algorithm.

According to the results of this study, the applicability of artificial intelligence in the design of single-molar dental prostheses has been demonstrated, and it has been emphasized that the accuracy of biomimetic artificial intelligence-designed dental prostheses can be further increased with further training and optimization of the algorithms [21]. Advances in AI applications promise to autonomously create innovative dental restorations that meet the highest standards in terms of fit, function, and esthetics. Advances in this area will also have a significant impact on orofacial and craniofacial prostheses.

In Implantology

Dental implant treatment plans can be successfully developed when cone-beam CT (CBCT) imaging and intraoral images are combined. Utilising AI in implantology may enable the creation of future prosthetics that combine the two. The Alan Turing Institute, Planmeca, University Hospital of Tampere, and Finnish Centre for Artificial Intelligence experts proposed a new model to accurately and automatically predict the mandibular canal's position prior to dental implant surgery. DL-based object recognition can be used to recognise implant systems from panoramic radiography data. An implant's type can be determined from periapical and panoramic radiographs using artificial intelligence (AI) in implant dentistry [22].

After acquiring an intraoral and CBCT scan, artificial intelligence (AI) will automatically combine the two scans, design the future restoration, and then insert the right implant with the right design in the ideal position based on the tissue thickness, bone type and thickness,

emergence profile, and the patient's particular medical history.Once the surgical guide has been set, the procedure can begin. [23].

Lerner et al. introduced an AI model to reduce these errors. This AI model was developed to simplify the construction of fixed implant prostheses with monolithic zirconia crowns. The use of an AI model is to assist in locating abutment subgingival margins. The dentist was also able to concentrate on tooth preparation and maintain interproximal and occlusal contacts thanks to this model. This convenience was created to decrease errors and holdups. Using patient data from 2016 to 2019, the study using posterior zirconia implant prostheses looked at the data. With a 7:11 male-to-female ratio, the study's 90 patients represented a variety of genders. In this experiment, a total of 106 implants were utilised. Intraoral scans, radiographs, pictures, and CAD scenarios were some of the data sets used to generate AI models (images). Positive outcomes were achieved using an AI model to make zirconia implants for the back teeth, with a 91% survival rate and 93% success rate. The AI model's results, which demonstrated a high survival and success rate, supported the model's readiness for integration into this sector of the economy.

Predictive AI models can be useful for dental implantology in two different ways. First, utilising machine learning algorithms, prediction model designs with a focus on bone levels and distinct clinical outcomes were made. By simultaneously evaluating the implant system, patient data, and surgical operations, a recurrent artificial neural network (ANN) with memetic search optimisation delivered 99.2% efficiency in success rate forecasts. Second, it was proposed that AI may eventually replace existing technologies in predicting the mechanical properties of a bioimplant system, reducing the high computational costs associated with optimising implant design parameters. Applying AI to the risk optimisation of bioimplants requires more study. [24].

In Maxillofacial Prosthesis:

Maxillofacial prosthesis rehabilitation restores function and aesthetics by replacing missing structures caused by facial injuries or abnormalities. Patients develop anomalies of the maxillofacial region as a result of inherited illnesses, cancer, or trauma. These anomalies frequently necessitate high-quality prosthetic care because of the cosmetic and psychological issues they raise. In many circumstances, it may be difficult to achieve excellent

cosmetic outcomes while correcting maxillofacial abnormalities. Patients can choose from a variety of prosthetic rehabilitation solutions from maxillofacial prosthodontists to improve function and appearance. Without the risks associated with surgery, a beautiful and practical maxillofacial prosthesis lowers patient anxiety and improves their quality of life. Digital technology makes it possible to plan and put extraoral implants digitally as well as design and manufacture maxillofacial prosthetics. A wax cast had to be expertly carved by hand in the days before CAD/CAM technology in order to recreate the facial form with a maxillofacial prosthesis. Because of computer advances, maxillofacial prosthetics can now be digitally created [25]

A typical treatment protocol for maxillofacial prosthesis fabrication using CAD/CAM technology begins with imaging techniques that capture the patient's soft and hard features (such as MRI and CT). Then, this data is transformed into an RP model using computer software (like Materialise Mimics, Leuven, Belgium). Replication methods can be employed to convert RP models into an acrylic resin or wax-based wax cast. Because skin curvature cannot be precisely replicated using RP techniques, the last minute details must be manually carved into the wax cast. Typically, silicone elastomer prosthesis are constructed after being fitted to the cast. When the natural facial structure is distorted, such as when the nose, an instant maxillofacial prosthetic can be constructed using a form chosen from a computerized library. The typical procedure takes longer than this one. Twelve blind people have already participated in bionic eye experiments that were carried out in the US. These AI-powered devices enable people to regain their vision without the need for surgery. Using this technique, which requires wearing a smart camera on specialized glasses, the user may read text or recognize faces.

The data from the camera is examined by a specialist who converts it into audio, which is then sent to the visually impaired person's ears via a wireless earpiece. patients whose sensory function in these areas has been lost as a result of limb removal. This image is changing thanks to the creation of artificial skin by researchers at the Federal Polytechnic School of Zurich in Zurich, Switzerland, and the California Institute of Technology in Pasadena, California, in the United States. The tissue is covered in a thin, translucent coating of pectin and water that allows it to perceive temperature changes between 5 and 50 °C. Artificial olfaction is essential to robotics because it mimics the human olfactory system, which is capable of distinguishing between different smells in a range of disciplines such as disease diagnosis, environmental monitoring, and issues of public safety, the food business, and agricultural output.

In Forensic dentistry:

An important topic in forensic studies is identifying the gender and age of an individual from their skeletal remains. From identifying people and helping the injured after natural disasters to solving forensic cases, age estimation is a useful tool. Because teeth are among the human body's most durable tissues, their shape is preserved even after a person passes away. Forensic dentistry plays a significant role in identification because of this. One of the approaches that works well is comparing the numbers and forms of the teeth in a dental radiograph taken from a corpse with previous records.

Teeth have been shown to be a useful tool in forensic medicine literature for identifying people [26]. More study is required to evaluate the accuracy of studies that imply neural networks can be a valid way for predicting age and gender [27,28,29]. One study on the topic discovered that neural networks had 95% accuracy in identifying gender in anthropological skulls [27]. Studies utilizing trained neural networks to determine skeletal age from hand-wrist X-rays have also shown successful results. Additionally, bite marks and mandibular shape can be predicted using AI algorithms [30].

A study using 1142 digital X-ray images for age and gender assessment achieved 96% accuracy [31]. Of these, 80% were used for educational purposes while the remaining 20% were dentistry images. The use of root length in age determination, which had not previously been studied, was covered by Patil et al. in a recent study. According to the study, the right third molar tooth's mesial root length is a reliable age indicator and the Deep Learning model outperformed the Machine Learning model. It is stressed that in order to further improve, diversify, and implement the algorithms in clinical practice, the training dataset should be increased to incorporate additional radiographs from other sources [32].

In Dentistry education:

Research is still ongoing in artificial intelligence applications that seek to alter the conventional structure of dentistry education at faculties. To reduce potential educational risks, AI apps are frequently employed to generate situations that imitate clinical work on patients. It has been noted that the students' preclinical virtual patient feedback has greatly

improved. The major objective is to develop excellent learning environments that enable students to assess their work and contrast it with the ideal product

Before they interact with patients, dental students undertake preclinical instruction to hone their manipulative abilities. The learner learns by getting feedback from the trainer in research on skill development using the conventional phantom models employed in this training. Instead, the feedback that the virtual patient gives to pupils during the same practices while being supervised by a trainer might enhance the learning process. Studies investigating the efficiency of these systems have revealed that students progress more quickly toward the desired skill level. These days, there are even robotic models that can express pain, move the head in response to pain, move the mouth and tongue, and mimic actions like bleeding and salivation. In preclinical laboratories for dentistry education, the use of robotic models has grown to help students improve their fundamental motor abilities [33]. Robotic applications will be used more frequently in dentistry institutions as a result of increased research in this area and falling robotic instrument hardware and software costs.

The incorporation of AI-based subjects in the curriculum is another crucial issue in the use of AI in education, in addition to improving education. It is obvious that dental candidates will be both users and developers of these applications in the future given the continuous research in practically every field and the applications that are now in use. Teaching fundamental AI concepts and terminology to dental students will enhance this area that was created with human intelligence.

Conclusion:

In prosthodontics, artificial intelligence (AI) is being employed more and more. The outcomes of the implementation are on par with human performance, and occasionally even better. Every aspect of medicine could benefit from artificial intelligence (AI), including the classification of denture fittings and maxillofacial prosthetics, the extraction of the elimination of marginal lines and the lowering of implant cementing human error. AI can only assist doctors in the performance of their professional responsibilities; it cannot take the place of human knowledge, skill, or treatment planning. Although there are still challenges to be solved, such as

those involving data collecting, interpretation, computer capacity, and ethical concerns, AI is usually regarded as a great helper for dentists.

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