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A literature review on various applications of AI in the field of prosthodontics

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Abstract
Artificial intelligence is gaining very much popularity in various fields, out of which dentistry is also one of it. It is also owing a significant impact in different fields of science and innovations. Artificial intelligence is emerging as a key beneficiaries particularly in the field of dentistry. In the field of prosthodontics artificial intelligence has its major role in terms of machine learning, deep learning and neural networks. Along with streamlining the diagnosis and treatment planning as well as fabrication of the prosthesis. Artificial intelligence helps in designing the custom fits crowns as well as custom fit bridges, as well as custom fit dentures, this helps in reducing the chair side time of the dentist and helps in improving the better results. in the field of Implantology, artificial intelligence plays an important role in diagnosis as well as treatment planning, by checking the bone quality, by checking the bone quantity, by checking the amount of the bone available for the placement of the implant, these all findings will be done by using CBCT, which is known as cone beam computed tomography, this imaging technique provides the better results with three dimensional view of the anatomy of the bone, and this is providing promising results in the diagnosis and treatment planning protocols and enhancing the better results after the placement of the implant. Artificial intelligence tools also helps in assessing the occlusal scheme of the patient, it also helps in guiding the shade selection.

In removable prosthodontics, Convolutional Neural Networks (CNNs) enabled the automated classification of partially edentulous arches and supports facial aesthetics prediction. For maxillofacial prostheses, AI facilitates digital rehabilitation with smart devices, improving comfort and esthetics. Despite these advantages, challenges such as data privacy concerns, lack of standardization, high implementation costs and the necessity of clinical validation remains. Importantly, human expertise and clinical judgment are indispensible, as AI functions best when combined with professional oversight. With responsible integration, AI has the potential to advance dental education, streamline prosthodontics practice and support precision-driven, patient-centered care. Thus AI marks a transformative shift in prosthodontics, paving the way for greater efficiency, personalization and innovation in dental treatment.

Keywords: Artificial intelligence, Prosthodontics AI, machine learning, dental innovation, patient centered care

Introduction
Artificial Intelligence (AI) is a tool, intended to mimic human behavior, and ultimately, influence human experiences. In 1955, the term "AI" was first used by the arithmetician John McCarthy. The rapid progress of Artificial Intelligence in the 21st century has brought a significant transformations across various industries, with healthcare emerging as one of the most impacted fields. Within healthcare, Dentistry has particularly benefited from AI-driven innovations. By integrating predictive, preventive and individualized approaches, AI has revolutionized clinical decision making and patient management. AI incorporates advanced computational models such as machine learning, deep learning and convoluted neural networks, which mimic human cognition to solve complex task. These technologies not only enhance accuracy and efficiency in clinical practice but also assist in simplifying procedures, reducing human errors and personalizing treatment strategies [1-4]. Data and datasets form the backbone of AI processing algorithms which provides a conducive learning input to machines, enhancing decision outcomes, improving the relevance and applicability of AI in dentistry. It is used for diagnosis, decision making, treatment planning, and treatment predictability. The precise and accurate diagnosis of dental problems through AI is the most remarkable achievement of AI in dentistry.

Prosthodontics is a specialized branch of dentistry dealing with replacement of missing teeth and tissues with artificial prosthesis. AI has undoubtedly forayed into this branch with its active engagement in fabrication of removable and fixed prostheses, preparation of finish margins, color/shade selection, implant prostheses, maxillofacial prostheses, establishment of stable maxillo-mandibular relationship, and a variety of other treatment plans. Conventional prosthodontics is limited to human intelligence and the use of manual methods for diagnosis, treatment planning, and fabrication of both intraoral and extra oral prostheses. The integration of AI has substantially increased accuracy, precision, and dependability, thereby providing impactful outcomes. Increasing number of dental setups, and educational institutes are getting accustomed to 3-D digital dentistry [4-8]. Therefore, it is of interest to discuss the application and limitations of artificial intelligence in prosthodontics. AI applications range from wearable health devices that track physical activity to algorithms that filter online data and provide personalized recommendations-demonstrating its broad utility in improving human experiences. In dentistry, AI has shown remarkable potential in diagnostics, treatment planning and prosthesis design. Prosthodontics in particular has embraced AI for tasks such as crown designing, bridges, dentures and maxillofacial prostheses with improved precision and patient comfort. With the ability to analyze the large data sets and predict clinical outcomes AI offers opportunities to enhance prosthodontics care through efficiency, accuracy and patient centered solutions [21].

AI (artificial Intelligence has the potential to transform implantology by accurately guiding the orientation and placement of dental implants. Factors such as bone density, thickness and the proximity of vital anatomical structures like arteries, veins, nerves can be carefully assessed with the help of AI, reducing the risk of complications [12-16].

AI Across Prosthodontics

- **AI as a diagnostic tool**

Deep learning models particularly, convolutional neural networks (CNN) have been trained on panoramic radiographs, periapical and CBCT data sets to detect caries, periapical pathology, periodontal bone loss and to evaluate quality as well as quantity of remaining bone present. Automated landmarks identification reduces human induced errors [15-21].

- **AI in Implantology and Surgical planning**

Implant treatment planning requires precise assessment of bone quality and quantity, critical anatomical landmarks like inferior alveolar nerve, mental foramen, maxillary sinus and prosthetic emergence profile. Ai systems have been developed to quantify bone density on CBCT and propose optimal implant positions while avoiding vital anatomical structures. Procedural guided system that integrate AI with static or dynamic surgical guides can reduces human errors and improve reproducibility [8-14].

- **AI in Prostheses Designing and CAD-CAM Integration**

AI augment CAD-CAM work flows by automating steps that previously requires extensive technician input. Ai assist in automated crown morphology generation, margin detection, occlusal surface design and denture tooth arrangement. Ai assisted designs reduces time, standardized restorative contours and reduce dependency on manual digital sculpting. For removable prosthodontics AI algorithms analyzes facial and intra oral scans to recommend tooth size, shape and position that harmonize facial features accelerating the digital denture process [21].

- **AI in Predictive analytics and outcome forecasting**

Beyond planning and designing AI can create large data sets including radiographic variables, periodontal status, systemic health factors and prostheses parameters to predict outcomes such as implant survival, restoration, longevity or risk of biological complications. Predicted models can help clinicians stratify cases by risk, personalize maintenance intervals and discuss prognosis with the patient [19-21].

AI in maxillofacial prosthesis

Maxillofacial prosthesis replaces missing facial structures caused by injuries or anomalies, restoring form and function with enhanced aesthetics. Because of the visual and psychological issues that are induced by these anomalies, high-quality prosthetic care is needed. In some circumstances, it might be challenging to repair maxillofacial abnormalities while providing excellent aesthetic results. Avoiding the surgical complication, an attractive and functional maxillofacial prosthesis reduces patient anxiety and improves quality of life. Maxillofacial reconstruction creates a life like prosthesis by placing an artificial substitutes for intraoral and extra oral features such as the eyes, ears, nose, palate, maxilla and mandible. Artificial intelligence aids in the construction of orbital prosthesis, restoring patient vision without the need for surgery. AI can also provide artificial olfaction, color and shade of maxillofacial prostheses based on patients expectations.

Challenges in AI

Although AI has shown great potential in revolutionizing prosthodontics care had a huge influence on the society, several limitations restrict its seamless integration in routine clinical practice. One of the foremost concerns is the over dependency of AI on large and high quality data sets. In dentistry such data set are often limited in consistent and lack universal standardization which can compromise the accuracy and reliability of AI based outcomes. Another limitations of AI such as lack of data privacy, high implementation costs, UN trained dental practitioners, absence of human compassion, continue to prevent its implementation. There is no established implementation policy. Due to reduced data security and patient privacy, artificial intelligence is still facing ethical concerns. Because of limited number of studies on AI in dentistry, it needs excellent application on a larger populations to improve its scope and future interventions. AI demands extensive training and support for people who want to use the databases in clinical practices. AI encounters problems due to overloaded algorithms causing system crashes [14-20].

Discussion

AI in prosthodontics used for diagnosis, decision making, treatment planning, and treatment predictability. These technologies not only enhance accuracy and efficiency in clinical practice but also assist in simplifying procedures, reducing procedural human errors and personalizing

treatment strategies. AI is useful for margin detection, tooth preparation, occlusal morphology, shade selection, aesthetic makeover, and error identification, prediction of implant success and fabrication of digitally smart maxillofacial prosthesis. However, AI along with its unlimited advantages is also associated with limitations, ethical and legal concerns that require attention before practical applications [7-8].

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