



Artificial Intelligence in Prosthetic Dentistry: Revolutionizing Diagnosis, Design and Treatment Outcomes

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Citation of this Article: Dr Chandan Verma, Dr Shilpa, “Artificial Intelligence in Prosthetic Dentistry: Revolutionizing Diagnosis, Design and Treatment Outcomes”, IJDSIR – June – 2026, Volume – 9, Issue – 3, P. No. 242 – 247.

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Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Digital along with artificial intelligence has revolutionized the field of dentistry. Prosthodontic is branch of dentistry, which deals in fabricating oral and maxillofacial prosthesis. The treatment planning is most crucial step for a successful treatment. AI has made the diagnosis more precise and provide the best treatment outcome for patient considering factors like facial proportions, Skin color, ethnicity, demographics etc. CAD/CAM incorporated with AI has resulted in more precise, accurate and physiological prosthesis fabrication. AI models and Convolutional neural networks have been used to classify dental arches into fully edentulous, arches with posterior tooth loss, bounded arches, and intact arches with 99.5% and 97.5 % accuracy in maxilla and mandible respectively. Different AI model include Regression analysis, decision tree learning, logistic regression and classified neural network is useful to predict implant success. AI incorporation in maxillofacial prosthesis has made prosthesis more lifelike. AI CNN

powered prosthetic eyes by mimic the human neurons and have the potential to read and see in visually impaired individual without surgery. AI application need robust infrastructure and quantum computer which limit its use in daily practice. AI also raise some ethical concerns regarding breach of confidentiality and privacy breach.

Keywords: AI application, Dentistry, Diagnosis, Ethnicity, Prosthodontics

Introduction

Digitalization have paved its way in every aspect of life, making life easier and more comfortable. Digitalization involves creation of large amount of data and dataset which is a prerequisite for incorporation of artificial intelligence. In 1955, the term AI was first used by the arithmetician John McCarthy.¹ AI have been created as tool to imitate human behavior and influence human experiences. AI incorporated machine can mimic human intelligence to offer precise decision support and manage complex situations.² Dental set up involve creation of

large amount data which increase its relevance and applicability in dentistry.³ The precise and accurate diagnosis of dental problem through AI is the most remarkable achievement of AI in dentistry.^{4,5} Prosthodontics is specialized branch of dentistry which deals in replacement of missing teeth and tissue with artificial prosthesis. This branch of dentistry stands out for its unique ideas to generate prosthesis both practical and cosmetic in nature especially maxillofacial prosthetics.⁶ With growing digitalization along with AI can enhance decision making and provide better treatment outcome with precision and accuracy. This article discusses the application of Artificial intelligence in branch of prosthodontics.

AI and diagnosis in prosthodontics

Accurate diagnosis plays an important part in formulating a treatment plan. Use of three-dimensional scanner and CBCT gather large amount of data and AI can compute that data into relevant clinical information for an optimal diagnosis.⁷ AI can help in determining the type of prosthesis, its design and component and placement of component especially in removable prosthetic, to improve the accuracy of the prosthesis.⁸ AI can help to identify the occlusal pattern and model with faster speed and accuracy which are challenging to human. AI has been to identify periodontal compromised premolars and molars with 90% and 95 % accuracy, respectively.⁹ The information gathered by means of AI along with digitalization will help in formulating treatment protocols and improve the accuracy of overall prosthetic outcomes, especially in complex cases that require more personalized approach.¹⁰

AI and removable prosthesis

Removable prosthesis is the most cost effective and less invasive treatment option in prosthodontics. AI can gather the data collected by means of intraoral scanner

and suggest the different framework designs for prosthesis fabrication.¹¹ Customization of removable prosthesis according to patient needs is the most important factor in designing the prosthesis. AI can be used in fabrication of prosthesis using 3D printing technology with individualized approach. AI models and Convolutional neural networks have been used to classify dental arches into fully edentulous, arches with posterior tooth loss, bounded arches, and intact arches with 99.5% and 97.5 % accuracy in maxilla and mandible respectively.¹² AI can analyze the stress on abutment teeth, implant and surrounding structure in collaboration with numerical and experimental models.¹³ AI and computer aided analysis can provide the measurement to evaluate the fit and overall function of removable prosthesis. This analysis aid in diagnosis and correction of issues with prosthesis which further improved the patient satisfaction.¹⁴ A prototype decision model has been developed with help of AI for inexperienced dentist to choose the appropriate prosthetic option.¹⁵

AI and Fixed prothesis

The success of fixed prosthesis depends on margin preparation and its design. Intraoral scanner with AI can detect the margin design in tooth preparation while scanning the details and help in improving the accuracy of tooth preparation. AI can analyze the large database of successful tooth preparation design and provide insight according to each case.¹⁶ A study by Zhang et al used a CNN model called Sparse Octree (S-octree) to extract the marginal accuracy with average precision of 97.43%.¹⁷ AI can analyze the occlusal pattern and edentulous space to design prosthesis with personalized approach. The analysis of edentulous space and the tooth preparation, CAD incorporated with AI can fabricated prosthesis with emergence profile and better aesthetics.¹⁸

AI and CAD/CAM

From past decade, CAD/CAM system along with digital scanning has revolutionized the field of prosthodontics. CAD/CAM system uses the intraoral scan to design and fabricate prosthesis with precision and accuracy, thereby reducing chances of human error. CAD/CAM system integrated with AI intelligence have been developed, this software analyzes the digital scan, detect the margin and automatically design the prosthesis according to occlusal contour and crown morphology of adjacent and opposing tooth.¹⁹ AI model can detect the subgingival margin, thereby increasing the prosthodontic focus on occlusal and interproximal contacts.²⁰ AI can account the patient factors like skin color, facial proportions, ethnicity and anthropological data to fabricate the prosthesis which is more personalized in nature.²¹ AI and CAD/CAM together has made the prosthesis fabrication and designing easier, improving the quality and accuracy, reduced the unnecessary laboratory equipment's and time require for prosthesis delivery.

AI and Implantology

The success of implant dentistry depends upon factor like bone density, bone anatomy, implant position and angulation. AI can analyze three dimensional images to create 3-D model of patient jawbones.²² The data gather by AI through CBCT images help the clinician to get accurate measurement for implant placement. AI algorithms can also determine the quality and quantity of bone which is crucial for implant success. AI can make algorithms by analyzing the patient data and factors such as bone quality and implant length and diameter to predict probability of implant success.²³ Clinician can make informed decisions during implant planning phase and give more accurate information to patients about treatment outcomes.

Different AI model include Regression analysis, decision tree learning, logistic regression and classified neural network is useful to predict implant success.²⁴⁻²⁶ Lee J et al. used CNN based AI to categories implant using panoramic and periapical radiography. The study found that AI-CNN is almost good as human in categorizing implant procedures.²⁷ A study was done employing Zirconia implant in posterior teeth using patient data from 2016 to 2019. AI model was created using patient radiograph, photograph, intraoral scan and CAD scenes. The results show high survival and success rate, showing suitability of AI models in manufacturing of zirconia implant in posterior teeth.²⁸ Predictive AI models have its application in two areas of implantology. The first area uses machine learning algorithms to predict clinical outcomes. Simultaneous evaluation of patient data, implant system and surgeon operation by Recurrent ANN can predict success rate of 99.2 % with efficiency.²⁹ The other area of AI in implantology is to anticipate mechanical properties of bioimplant system.³⁰ However more research is required in field of AI in risk assessment of bioimplants.

AI and Maxillofacial prosthesis

Resection of facial structures due to trauma and malignant lesion can lead to facial disfigurement. Maxillofacial prosthesis such as ear, eyes, maxilla, mandible and palatal have been used to reconstruct the lost tissue. AI using Convolutional neural network has created significant impact on fabrication of prosthesis. AI-CNN can mimic human neurons give more lifelike and cosmetic appearances to individual by creating characterization in the prosthesis. Prosthesis fabricated using AI can give physiological appearances by identifying patient preferences, ethnicity, facial dimension and anthropological calculation, hence positively impacting the physical and psychological

health of individual. AI CNN powered prosthetic eyes by mimic the human neurons and have the potential to read and see in visually impaired individual without surgery.³¹ AI incorporated artificial skin grafts can provide long term solutions. These grafts have revolutionized the field of tissue engineering, function as artificial tissue which can give oxygen, prevent dehydration and guard against infections.³² Nose prosthesis incorporated with AI-CNN have been developed to mimic the olfactory neural systems.³³

Limitation of AI

Artificial intelligence work on basis of data collected over the years. Any fault in data collection and its assortment can lead to bias and error in AI programs. Dataset created for AI programs must be authentic, correct and accurate to prevent unfair and discriminatory outcomes. AI integration in dentistry has ethical concerns, patients are concerned with breach of their privacy and confidentiality.³⁴⁻³⁵ AI technology is complex and has the ability to change its program autonomously lead to bias.³⁶ There is need for quantum computers to process large amount of data. These equipment's are expensive and unavailable for common use which acts as barrier for AI use in day today practices.³⁷ AI software need to be understood fully before its application, any half knowledge can create confusion in mind of practitioners and can alter the outcomes. Robust infrastructure and supports are need to process the huge data to supports AI in dentistry. Concerns have been raised regarding the job security of technician as CAB/CAM powered with AI overtake the most of their tasks.³⁸

Conclusion

Use of AI in prosthodontics have shown promising results, creating its impact on diagnosis, treatment planning, design and patient experiences. Practitioners

will be benefit with speed and accuracy of AI, to solve complex cases and getting better treatment outcomes. CAD/CAM integration with AI makes dental technician works easier and result in fast delivery of prosthesis. AI powered prosthesis will provide lifelike experiences to the patients. AI was developed as a tool to assist practitioner to formulate the treatment plan with best outcomes rather than replacing them. Concerns regarding misuse of data, transparency and algorithms fairness should be considered to increase its use in healthcare. Need of large infrastructure and quantum computer are the limiting factors for its use in day to day practice.

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