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REVIEW ARTICLE

ROLE OF ARTIFICIAL INTELLIGENCE IN PROSTHODONTICS

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Abstract

The data-driven disruptive technology of the current era is artificial intelligence (AI). From space science to dentistry, AI is revolutionising every industry. Biomedical has a number of benefits over traditional diagnosis, treatment planning, patient documentation, and management. For the convenience of both doctors and patients, AI is being implemented in every sector. In the current work, an evaluation of AI\'s application in prosthodontics was conducted. Prosthetic dentistry, also known as prosthodontics, is one of the dental specialties that focuses on replacing and restoring lost teeth using implants, fixed and removable prosthetics, or other biocompatible replacements. Additionally, it aids in restoring the mouth\'s healthy soft and hard tissues, which enhances the overall health status of the oral cavity.

Introduction:-

Artificial Intelligence in Dentistry:

The use of Artificial Intelligence (AI) in dentistry has recently begun to take off, as it has in other sectors. Applications of AI in dentistry can be divided into four categories: diagnostics, decision-making, treatment planning, and treatment result prediction. The most well-liked dental AI application is diagnosis. The workload of dentists can be reduced by using AI to make diagnoses that are more precise and effective. On the one hand, dentists are using computers to make judgements more and more often (1,2). On the other hand, dental computer applications are improving in intelligence, accuracy, and dependability. All areas of dentistry are now engaged in AI research. The study design, data distribution (i.e., training, test, and validation sets), and model performance (i.e., accuracy, sensitivity, specificity, F1, AUC Area Under [the receiver operating characteristic (ROC)] Curve], recall) of the numerous journal articles on dental AI remain challenging to compare. Most articles only partially covered the information above. To achieve comparable levels of openness and usefulness in the application of AI in medicine, the MICLAIM (Minimum Information about Clinical Artificial Intelligence Modelling) checklist has been proposed (3).

Examine the scope of Machine Learning research in various dental disciplines:

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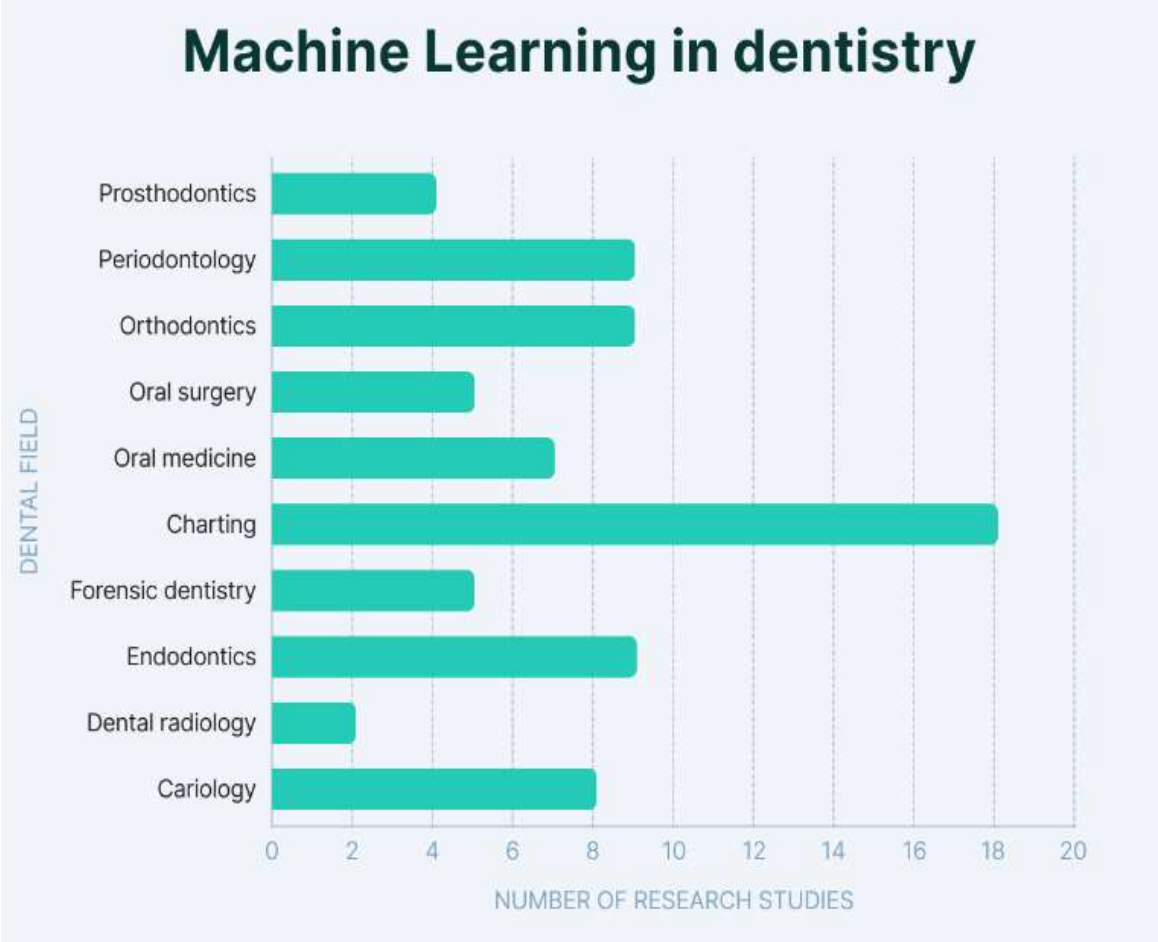

Figure 1:- Machine learning in Dentistry.

Artificial Intelligence in Prosthodontics:

The art and science of dentistry referred to as prosthodontics is concerned with the diagnosis, planning, rehabilitation, and preservation of the function, comfort, and health of patients with clinical issues related to missing or inadequate teeth and oral and maxillofacial tissues. It mostly addresses this through prosthesis replacement [4]. Prosthodontics is primarily concerned with the treatment and fabrication of removable and fixed dental prostheses, as well as with implant surgery, the fabrication of a maxillofacial prosthesis, and the preparation of finishing margins next to the tooth for better extension and fitting of the prosthesis. Additionally, it is utilised to preserve maxillomandibular relationships and choose the right tooth colour for aesthetic purposes [5].AI can be very helpful in a range of therapeutic treatment plans. Several applications of AI in prosthodontics which are summarized in Figure 1.

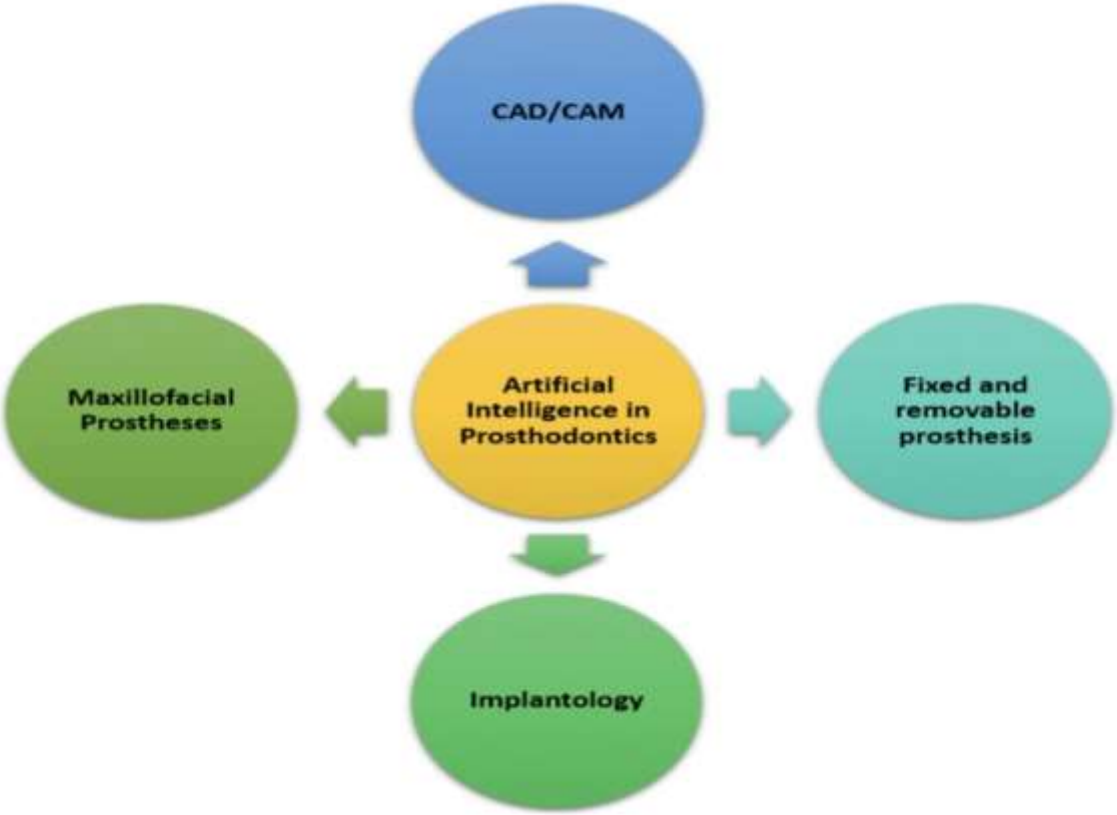

Figure 9:- Applications of AI in prosthodontics.

AI, artificial intelligence; CAD/CAM, computer-aided design/computer-aided manufacturing

1. Computer-Aided Design/Computer-Aided Manufacturing

Computer-aided design/computer-aided manufacturing, also known as CAD/CAM, is becoming more and more common in prosthetic dentistry. The use of AI at the chair side is increased via CAD/CAM integration. The computer features a designing and manufacturing unit that enables us to design mill or print based on the patient's choices, saving time and energy. Two- and three-dimensional models are often created by the CAD/CAM system, and then they are materialised using numerically controlled mechanics [6].

The CAD/CAM method facilitates the scanning of prepared teeth and the machining of restorations from ceramic blocks. Making prosthetic repair is now simple because no casting processes are required. CAD/CAM technology is used in the production of inlays, onlays, crowns, and bridges. It has taken the place of the arduous and drawn-out traditional casting procedure while also lowering the likelihood of human mistake in the finished prosthesis. Dentists are using artificial intelligence (AI) to help them build the best possible and visually acceptable prosthesis for patients while taking into account a variety of factors, such as facial proportions, ethnicity, anthropologicalcalculations, and even the patient's demand. [7]. CAD/CAM technology, such as additive manufacturing and subtractive milling techniques, like 3D printing, are now used to create the prosthesis.

In order to improve function and aesthetics, it aids in the design of the restoration and mills a restoration with extreme precision. Removable denture design and production using AI and CAD/CAM technology has increased denture quality while streamlining laboratory processes. The number of manual laboratory processes is reduced or eliminated, which enables the dental technician and the dentist to guarantee the precision and reproducibility of the prosthesis. The total amount of time needed for patient rehabilitation is reduced as a result.

Intraoral scanning technologies are among the additional 3D uses that have emerged outside of radiology. Using dental inspection software (Smart Margin and Scan Clarity Score, Pearl), the intraoral scans can be examined. This programme allows dental clinicians to analyse their own images and receive immediate feedback as they verify

preparations. In order to ensure that the case is handled by a qualified technician, laboratories can analyse these scans in great volume and rate dental professionals or classify their preparations according to the case's difficulty. Additionally, corporate entities like dental service organisation management can make decisions about who needs additional training and who is performing clinically well using this technology to rate their dental practitioners. The software may then automatically and accurately label the margins on tooth preparations if the margin is visible and the scan is precise (Fig. 10). Margin marking allows the preparation scans to go to milling and digital design. Additionally, it is possible to automatically match the design of single posterior crowns in the lab using an Al-based programme (Glidewell.io In-Office Solution, Glidewell).

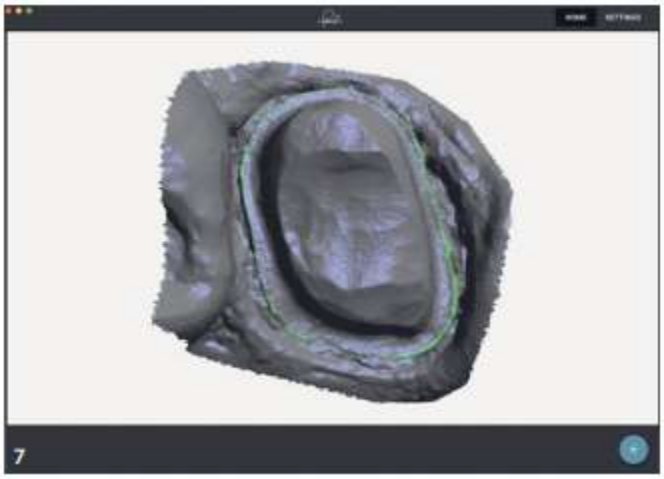

Figure 10:- Margin detection using AI technology.

2. Tooth-Supported Fixed and Removable Prosthesis

A less intrusive and more affordable option for replacing missing teeth is removable partial dentures (RPDs) supported by teeth or implants. The design of an RPD's numerous components is a crucial phase in the creation of a prosthesis [8]. The design of RPDs has also benefited by the development of AI algorithms. Fixed dental prosthesis will have their original tooth structure scanned, and software will be used to assess the situation and suggest different course of action. The application will make an RPD design recommendation for partial edentulism using software.

A clinical decision support model for removable prosthodontics that uses case-based reasoning and ontology has shown to be capable of suggesting the design of personalised RPDs. However, this model uses the database's most probable case as the foundation for its suggestions. Clinical environments continually change, therefore maintaining a sceptical approach to its output is vital. In fixed prosthodontics, a synthetic intelligence system is still being developed. The database of millions of doctor-approved crowns, which is routinely updated to the cloud, contains the core element of AI: its capacity to analyse and learn from it. According to the ideal occlusion, contacts, and margins suitable for each case, the computer analyses how each high-performance restoration is made to achieve optimal function in order to learn from successful crown designs [9].

Initially, dentists used a handpiece and a variety of burs to manually prepare the tooth margins during the creation of the fixed dental prosthesis. The prosthesis was kept in place and the gums and periodontium were given a healthy environment and protection thanks to the ideal contour and extension of the marginal line surrounding the teeth. These techniques demanded both more time and more sophisticated technical skills. The intention was to get rid of the errors and time-consuming manual labour. Deep learning (DL) model research was carried out by Zhang et al. to precisely extract marginal lines.In this study, there were 380 dental preparation models. A Convolutional Neural Network (CNN) model known as Sparse Octree (S-Octree) was used to retrieve the data. A sparse point cloud with labels was produced using the dental preparation process. An eight-depth octree structure was developed for the investigation. Training, verification, and testing sets of data were created. By assigning names to dental preparations, CNN models were created. In order to overcome the shortcomings of manual practise, a tooth preparation line was extracted along with back-projection and boundary extraction methods from the study. The

precision achieved on average was 97.43%. This improved accuracy demonstrated AI's capacity to correct human errors, making it an acceptable replacement [9].

3. Implantology

Cone-beam CT (CBCT) imaging and intraoral scans can be used together to create successful treatment regimens for dental implants. Future prosthetics may be created by fusing the two through the use of AI in implantology. Experts from the Alan Turing Institute, Planmeca, the University Hospital of Tampere, and the Finnish Centre for Artificial Intelligence proposed a new model to reliably and automatically determine the precise location of the mandibular canal for dental implant surgery. Implant systems can be identified from panoramic radiography scans using DL-based object identification. The use of AI in implant dentistry allows for the identification of implant types from periapical and panoramic radiographs [10].

Many limitations on fixed and removable prostheses can be removed with the development of implantology. In addition to offering greater support and keeping residual ridge in cases of distal extension, implants have the advantage of being more resistant to dental diseases. Dental implants are frequently used to replace missing teeth or to repair the mouth as a whole. Implant prostheses have been more well-liked recently because of their improved stability and appearance. Approximately 4,000 dental implants are sold globally. Regarding therapeutic protocols and organisational frameworks, they diverge. To prevent the need for replantation and repair due to mechanical and biological issues, a dentist must correctly identify and classify implants. CAD/CAM and panoramic radiography are the two fundamental methods for classifying implant structures [5]. The design and production of maxillofacial prosthesis as well as the planning and placement of extraoral implants may all be done digitally thanks to technology. Prior to surgery, clinicians can visualise the optimal implant placements and locations on a computer screen. Using rapid prototyping (RP) technology, a surgical guide can then be virtually generated and constructed.

Several issues can arise when standard CAD/CAM technologies are used for cementing implant prostheses. Errors may result from incorrect positioning, cementation, or occlusal or interproximal correction with an abutment [5]. An AI model was presented by Lerner et al. to lessen these inaccuracies. In order to facilitate the development of fixed implant prostheses with monolithic zirconia crowns, this AI model was created. the application of an AI model to help find abutment subgingival margins. Additionally, this model helped the dentist concentrate on tooth preparation and preserve interproximal and occlusal contacts.This convenience was designed to reduce mistakes and delays. The study employing posterior zirconia implant prosthesis examined patient data from 2016 to 2019. 90 patients made up the study's 90-patient gender diversity, with a 7:11 male-to-female ratio. A total of 106 implants were used in this investigation. Among the data sets used to create AI models (images) were intraoral scans, radiographs, photographs, and CAD scenarios. The employment of an AI model to create zirconia implants for the back teeth produced positive results, with a 91% survival rate and 93% success rate. The findings of the AI model confirmed the model's suitability for integration into this industry because they showed a high survival and success rate.

AI software has aided in the meticulous planning of surgeries prior to the procedure itself. Dental implant therapy will be standardised through the use of methodology and technology that is based on research and is clinically proven. Following the acquisition of an intraoral and CBCT scan, AI will automatically combine the two scans, design the future restoration, and then insert the appropriate implant with the proper design in the ideal position based on the tissue thickness, bone type and thickness, emergence profile, and the patient's unique medical history. The treatment can then be carried out when the surgical guide has been established. [11].

Dental implantology can benefit from predictive AI models in two different ways. First, predictive model designs focusing on bone levels and unique clinical outcomes were created using machine learning algorithms. A recurrent artificial neural network (ANN) with memetic search optimisation provided 99.2% efficiency in success rate forecasts by simultaneously assessing the implant system, patients' data, and surgical operations. Second, it was suggested that AI may take the place of current technologies in predicting the mechanical characteristics of a bioimplant system, lowering the high computational costs associated with optimising implant design factors. Further research is needed to apply AI to the risk optimisation of bioimplants. [12].

4. Maxillofacial Prostheses

Maxillofacial prosthesis rehabilitation replaces missing structures to restore function and appearance due to facial deformities or injuries. Patients experience hereditary diseases, cancer, or trauma that leads to maxillofacial abnormalities. Such abnormalities typically call for high-quality prosthetic treatment due to the associated aesthetic

and psychological difficulties. In many cases, it might be challenging to get outstanding cosmetic results while restoring maxillofacial anomalies. Maxillofacial prosthodontists provide patients with a range of options for prosthetic rehabilitation to enhance function and appearance. An attractive and useful maxillofacial prosthesis reduces patient anxiety and enhances their quality of life without the risks associated with surgery. Digital technology enables the design and production of maxillofacial prosthesis as well as the digital planning and placement of extraoral implants. Prior to CAD/CAM technology, a wax cast had to be skillfully carved by hand in order to reconstruct the facial form with a maxillofacial prosthesis. Maxillofacial prostheses can now be digitally designed because to advancements in computers [13]. When fabricating maxillofacial prosthesis with CAD/CAM technology, a typical treatment procedure starts with imaging methods that record the patient's soft and hard features (for example, MRI and CT). After that, using computer software (such as Materialise Mimics, Leuven, Belgium), this data is converted into an RP model. Replication techniques can be used to transfer RP models into a wax cast from acrylic resin or from wax directly. The final minute elements must be hand carved into the wax cast because RP methods cannot accurately replicate skin curvature. The silicone elastomer prostheses are ordinarily built after being fitted on the cast. A form selected from a computerised library can be used to build instant maxillofacial prosthetics when the natural facial structure is deformed, such as when the nose. This approach uses less time than the conventional approach.

Twelve blind persons have already undergone bionic eye trials, which were conducted in the United States. With the aid of these AI-powered devices, patients can obtain vision without having to undergo surgery. The user may read text or identify faces using this method, which involves a smart camera put on specialised glasses. An expert examines the data from the camera and transforms it into audio, which is then transmitted to the visually impaired person's ears via a wireless earpiece. Patients who have lost sensory function in such areas after having limbs removed. Artificial skin produced by scientists at the California Institute of Technology, Pasadena, CA, USA, and the Federal Polytechnic School of Zurich, Zurich, Switzerland, is transforming this picture. The tissue senses temperature changes between 5 and 50 °C because it is covered in a thin, transparent layer of pectin and water. Because it replicates the human olfactory system, which is capable of identifying distinct smells in a variety of fields including disease diagnosis, environmental monitoring, and issues of public safety, the food industry, and agricultural production, artificial olfaction is crucial in robotics. [11].

Conclusion:-

Artificial intelligence (AI) is being used more and more in prosthodontics. The implementation produces results that are on par with human performance, and sometimes even surpass it. Artificial intelligence (AI) can be seen as a potential aid in every area, including the classification of denture fixtures and maxillofacial prosthesis, the extraction of marginal lines, and the reduction of human error in implant cementation. AI cannot replace human knowledge, skill, or treatment planning; it can only support doctors as they carry out their professional duties. Although obstacles like those related to data collection, interpretation, computing power, and ethical issues do exist and need to be overcome, AI is generally thought of as a great assistant for dentists.

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