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ARTIFICIAL INTELLIGENCE IN PROSTHODONTICS AND IMPLANTOLOGY –A OVERVIEW

Sonal Shah*, Vinod Viswanathan, Abhisheik Sachdeva, Nikita Sadafule, Rajat Mahajan, Aditi Tripathi

Rama Dental College, Hospital and Research Centre, Rama University,
Mandhana, Kanpur, India
Email id: sonalshah280289@gmail.com

Abstract:

The integration of artificial intelligence (AI) into dentistry is indeed transforming the field, particularly in prosthodontics, where the restoration and reconstruction of missing teeth play a vital role. AI is revolutionizing various aspects of dental care, from designing prostheses to patient management, offering a range of benefits for both dental professionals and patients.

One of the significant advantages of AI in dentistry lies in its ability to enhance efficiency and accuracy in tasks such as designing prostheses and fabricating maxillofacial appliances. By leveraging AI algorithms, dental professionals can streamline processes and achieve more precise outcomes, ultimately improving patient care.

Moreover, AI facilitates better patient documentation, diagnosis, and treatment planning by analysing vast amounts of clinical data and providing valuable insights. This not only helps in identifying dental issues more accurately but also allows for the development of personalized treatment plans tailored to each patient's specific needs.

However, it's essential to recognize that while AI is incredibly valuable in assisting dental professionals, it cannot replace the expertise and human touch provided by dental surgeons. Dental surgery involves not only diagnosing diseases but also treating patients and interpreting findings in the context of other clinical data. Thus, while AI can augment and enhance certain aspects of dental care, it cannot entirely replace the role of skilled dental practitioners.

To fully harness the potential of AI in dentistry, it's crucial to ensure the availability of accurate and comprehensive data. Dental surgeons play a pivotal role in this process by gathering and entering precise patient data into databases. This ensures that AI algorithms have access to high-quality information, enabling them to make informed decisions and recommendations.

Looking ahead, the integration of AI and digitization represents a new paradigm in dentistry, with promising future applications. As technology continues to advance, we can expect AI to play an increasingly significant role in prosthodontics and oral implantology, further enhancing patient outcomes and revolutionizing dental care. However, it's essential to address current limitations, such as the need for more extensive and more accurate data, to unlock the full potential of AI in dentistry.

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INTRODUCTION

Digitalization has indeed become ubiquitous, revolutionizing various aspects of life, including dentistry. This technological advancement has not only made living easier but has also significantly enhanced the quality of dental care. The human brain has long been a subject of fascination throughout history, and efforts to replicate its functioning have led to the development of artificial intelligence (AI).

AI represents the culmination of years of research and innovation aimed at accurately mimicking the complexities of human intelligence. Defined as a branch of science and engineering focused on understanding intelligent behaviour computationally and creating artifacts that exhibit such behaviour, AI has permeated numerous fields, including dentistry.[1]

In dentistry, AI and machine learning have had a profound impact, revolutionizing how oral healthcare professionals diagnose and treat patients. By leveraging AI algorithms and machine learning techniques, dental practitioners can analyse vast amounts of data more efficiently and accurately than ever before. This enables them to make more informed decisions, leading to improved patient outcomes.

Moreover, AI has enhanced the efficiency of various dental processes, such as treatment planning, prosthetic design, and patient management. Through automation and data analysis, AI streamlines workflows, allowing dental professionals to focus more on patient care and less on administrative tasks.[2]

However, it's essential to recognize that while AI can augment and improve certain aspects of dentistry, it cannot replace the expertise and human touch provided by dental professionals. The relationship between a dentist and their patient is built on trust, empathy, and personalized care, elements that AI cannot replicate.

As AI continues to evolve and integrate further into dentistry, it holds the promise of even greater advancements in oral healthcare. By harnessing the power of AI and digitalization, dental professionals can continue to innovate and deliver the highest standard of care to their patients, ultimately improving oral health outcomes for individuals worldwide.

Machine learning systems are like the skilled detectives of the digital world, capable of deciphering complex patterns within data sets. They come armed with an arsenal of algorithms and methods that excel at recognizing statistical patterns, making them invaluable tools for prediction tasks.

Supervised training is akin to teaching with a roadmap in hand; the system learns from input-output pairs of training data, making it adept at tasks like classification and regression. On the other hand, unsupervised training is more like exploring uncharted territory, where the system uncovers hidden features within the data, useful for tasks like clustering and dimensionality reduction.

Deep learning, the wunderkind of machine learning, relies on artificial neural networks and boasts an impressive ability to generalize across various domains. This versatility has seen it

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find applications in a plethora of fields, from picture recognition to natural language processing.

In industries spanning from telecommunications to aerospace, AI has become the go-to toolkit for tasks ranging from expert systems to game playing. The past decade has witnessed significant technological advancements, ushering in a new era in medicine and dentistry.

In dentistry, AI is not merely a buzzword but a transformative force, capable of lightening the workload and enhancing the efficiency of dental healthcare professionals. Machine learning-enabled decision support systems serve as invaluable companions, leveraging vast amounts of healthcare data to provide optimal learning resources for practitioners. These systems navigate the intricacies of clinical variabilities, elevating diagnostic accuracy to new heights.

With the advent of cloud computing and the proliferation of data, AI's adoption in healthcare, including dentistry, has skyrocketed. Radiology, for instance, has witnessed firsthand the benefits of AI-driven algorithms, which aid in diagnosis and treatment planning, offering a beacon of hope for patients and practitioners alike.[5]

The potential applications of AI in dentistry are vast and multifaceted, spanning disciplines such as prosthodontics, orthodontics, oral surgery, and periodontics. From condition analysis to treatment planning, AI stands poised to revolutionize every facet of dental care, ushering in a new era of precision and efficacy.

DISCUSSION

The review article delves into the wide array of applications that artificial intelligence (AI) brings to the realm of prosthetic dentistry and oral implantology. From CAD/CAM systems to implant prostheses and studies of orofacial anatomy, AI's impact is profound and multifaceted.

In the world of prosthodontics, AI technology plays a crucial role in shaping treatment approaches, facilitating meticulous planning, and ensuring the seamless execution of prosthetic reconstructions. One notable example is the use of AI for the precise diagnosis of periodontal deficiencies in premolars and molars, achieving remarkable accuracy.

However, it's essential to acknowledge the limitations that AI faces in the dental field. For instance, while AI excels at certain tasks, such as diagnosing periodontal deficiencies, it may struggle to differentiate between early lesions or offer definitive diagnoses of complex conditions like periodontal disease. This challenge arises from the redundancy of imaging characteristics and the limitations of the visual field in periapical radiographs.

Despite these limitations, the review underscores the immense potential of AI in enhancing prosthodontic care. By leveraging AI's capabilities, dental professionals can improve diagnostic accuracy, streamline treatment planning, and ultimately enhance patient outcomes. However, the journey towards realizing the full potential of AI in dentistry is ongoing, calling for further research and innovation in this dynamic field.[7]

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Application of AI in Prosthodontics

Artificial intelligence (AI) can assist in many aspects of prosthodontics, such as treatment planning, rehabilitation, and prosthetic replacement. AI can help in predicting the success rate of dental implant surgery, identifying the most suitable type of prosthesis for a patient, and providing accurate shade selection for the prosthesis to enhance its appearance. AI can also help in the diagnosis of periodontal disease and tooth decay, and in identifying and analysing orofacial anatomy. The use of AI in prosthodontics can improve the accuracy and efficiency of diagnosis and treatment planning, leading to better outcomes for patients.[9]

AI and removable dental prosthesis

AI can be used in the fabrication process of RPDs through 3D printing technology. 3D printing technology enables the fabrication of RPDs in a more efficient, accurate, and cost-effective manner compared to traditional methods. AI algorithms can also aid in the development of a more personalized and customized approach to RPD design, as it can analyse patient data and create a design that is unique to the individual patient's needs and anatomy [10]. Furthermore, AI can be used in the evaluation of RPD fit and function. Computer-aided analysis of RPD fit can provide accurate measurements and assessments of the prosthesis' fit, occlusion, and overall function. This can aid in the diagnosis and correction of any issues with the prosthesis, leading to improved patient satisfaction and outcomes.[11]

In summary, AI has the potential to revolutionize the design and fabrication process of RPDs, leading to more personalized and efficient treatment options for patients with partial edentulism. Its use in the evaluation of RPD fit and function can also lead to improved patient outcomes and satisfaction.[12]

AI and fixed dental prosthesis

The use of AI in fixed prosthodontics can also help in improving the accuracy and efficiency of tooth preparation. AI algorithms can analyse and learn from a large database of successful crown designs, providing insights into the optimal contour, extension, and marginal line surrounding the teeth for each case. In addition, AI can assist in the tooth margin preparation process by automating the extraction of marginal lines with precision, which traditionally required advanced technical skills and time-consuming manual labour. A study by Zhang et al., [13] utilized a deep learning model to extract marginal lines with high accuracy. The study utilized a convolutional neural network (CNN) model called Sparse Octree (S-Octree) and achieved an average precision of 97.43%. These findings demonstrate AI's potential to improve the accuracy and efficiency of tooth preparation in fixed prosthodontics.

AI and Maxillofacial Prostheses

AI has been making significant contributions to the field of maxillofacial prosthodontics. By using convolutional neural networks (CNNs) to mimic human neurons, AIpowered prosthetic devices can help patients with maxillofacial abnormalities or injuries to restore both their function and aesthetics. For instance, AIpowered prosthetic eyes can help patients see without surgery, while smart reading glasses with voice-activated technology can assist the visually challenged in reading text and identifying faces.[14]

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In addition, tissue engineering has also been utilizing AI to develop skin replacements for wound regeneration. Artificial skin grafts can provide temporary wound coverings or long-term skin replacements, and their primary functions are to give oxygen, prevent dehydration, promote healing, and guard against infections.[15]

Another field where AI has shown its potential is in artificial olfaction, which has been captivating scientists for about four decades. The electronic nose model is an example of an artificial olfactory system that mimics the human olfactory detection system using a variety of electronic sensors. This technology can be used in various sectors, such as disease diagnosis, environmental monitoring, public safety issues, the food industry, and agricultural production.[16]

AI and Implant Prosthodontics

AI has been used to optimize implant placement and planning by analyzing CBCT images and creating a 3D model of the patient's jawbone. This can help to identify the ideal location and angle for implant placement, which can improve the overall success rate of the procedure.[17]

AI algorithms have also been used to detect bone quality and quantity, which is crucial for implant success. By using AI to analyse CBCT images, clinicians can obtain measurements that are more accurate and detect areas of potential bone loss or pathology.[18]

AI has also been used in implant dentistry to predict implant stability and success rates. By analysing patient data and factors such as bone density, implant length, and implant diameter, AI algorithms can predict the probability of implant success.[19]

This can help clinicians to make more informed decisions when planning implant procedures, and can provide patients with more accurate information about the potential outcomes of their treatment. The use of AI in implant dentistry has the potential to improve treatment planning, implant placement, and overall success rates. By analysing patient data and images, AI algorithms can provide clinicians with valuable insights that can help to optimize treatment outcomes. However, it is important to note that AI should be used as a tool to assist clinicians, rather than as a replacement for human expertise and decision-making.[20]

The use of digital technology in implantology has revolutionized the field, allowing for precise planning and placement of implants, as well as the design and fabrication of prostheses. Digital planning software allows clinicians to create a virtual surgical guide that can be used to guide implant placement during surgery. Rapid prototyping technology can then be used to create the physical surgical guide, which can be used during surgery to ensure accurate placement of the implants. This approach allows for greater accuracy and precision in implant placement, reducing the risk of complications and improving the overall success rate of the procedure. Overall, the use of digital technology in implantology and prosthodontics has transformed the field, allowing for greater precision, accuracy, and customization in treatment planning and implementation.[21]

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AI and CAD/CAM

The use of intraoral scanners, CAD/CAM technology, and AI in prosthetic dentistry has revolutionized the way dental restorations are designed and fabricated. These advancements have made the process faster, more accurate, and less labour-intensive. The use of AI in margin detection and designing prostheses has improved the overall quality of the restorations. With the integration of AI and CAD/CAM, prostheses can be customized to each patient's unique needs, resulting in improved aesthetics and function. Additionally, the use of AI and CAD/CAM technology in removable denture design and manufacture has simplified laboratory operations, reduced human error, and minimized overall patient rehabilitation time.[29]

AI and aesthetic dentistry

However, with the development of digital tools and technologies, smile designs are now created using digital software, which allows for more accurate and precise planning. This has resulted in more predictable and aesthetically pleasing outcomes for patients. Virtual smile design software allows dental professionals to customize each aspect of a patient's smile, from the shape and size of their teeth to the colour and position. This customization helps create a unique smile that suits the patient's facial features and personality.[30]

AI and occlusion

AI has opened up several innovative opportunities in prosthetic dentistry. For example, in crown contemplation, AI can generate the occlusal morphology of the crown based on the opposing teeth, even in cases of wear or fracture. This helps to ensure a proper fit and function of the crown. Similarly, AI can also be used for programmed teeth setting in dentures, which ensures a proper bite and function of the denture. Additionally, AI can be used for automatic framework designs for removable dental prostheses, reducing the time and effort required in the design process. All of these applications can help to improve the accuracy and efficiency of prosthetic dentistry procedures, leading to better patient outcomes.[33]

AI and education

AI can be used as an educational tool to guide dental students, both at the undergraduate and postgraduate level. AI can assist in teaching various aspects of dentistry, such as diagnosis, treatment planning, and even the execution of procedures. For example, virtual simulators can be used to help dental students practice procedures in a safe and controlled environment, allowing them to hone their skills before performing procedures on real patients. AI-powered educational software can also provide personalized learning experiences for each student, tailoring the curriculum to their individual needs and abilities. Additionally, AI can assist in grading and assessment, providing objective and standardized evaluations of students' performance.[34]

AI & Future Scope

Overall, the future of AI in dentistry is promising. With the ability to improve diagnosis accuracy, assist in treatment planning, and enhance the precision of prosthetic design, AI has the potential to revolutionize the dental field. However, it is important to address ethical concerns, such as data privacy and algorithmic fairness, and for dental practitioners to have a

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fundamental understanding of AI technology to ensure its proper use. As AIbased services continue to join the market, dental practitioners should keep up to date with the latest developments to choose the right AI service and improve the patient experience.[40]

CONCLUSION

AI has great potential to revolutionize the field of dentistry by improving diagnosis, treatment planning, prosthetic design, and patient experience. However, ethical concerns such as data privacy, informed consent, safety, transparency, and algorithmic fairness must be addressed to maximize the benefits of AI in healthcare. AI should be viewed as a tool that can assist dental surgeons in performing their jobs professionally, rather than as a replacement for human knowledge and expertise. As AI continues to evolve, it is important to prioritize human interests while improving its ability to handle large amounts of data. With careful design and long-term clinical validation, AI can be an unbiased, reproducible, user-friendly, and transparent auxiliary for dental surgeons. By utilizing AI in a multidisciplinary approach, researchers and practitioners can improve both oral and overall health outcomes for patients.

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