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The Use of AI for Prosthodontic Restoration: Predictable and Safer Dentistry †

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Abstract: This scientific article proposal explores the potential benefits of using artificial intelligence (AI) in prosthodontic restoration to achieve predictable and safer dental outcomes. Prosthodontic restoration involves designing, fabricating, and placing dental prostheses to restore oral function and aesthetics. Although traditional prosthodontic techniques have evolved significantly, incorporating AI into the workflow can revolutionize the field by enhancing accuracy, efficiency, and patient satisfaction. The proposed study aims to investigate the integration of AI algorithms and techniques into various stages of prosthodontic restoration, including treatment planning, digital impression acquisition, prosthesis design, and fabrication. By leveraging machine learning algorithms and image processing, AI can assist in diagnosing dental conditions, predicting treatment outcomes, and optimizing prosthesis design to ensure optimal fit and function. This technology can also aid in identifying potential challenges and risks before proceeding with the restorative procedures, minimizing errors, and improving patient safety. Furthermore, AI-powered systems can facilitate real-time assessment and feedback during fabrication, ensuring precise milling or 3D printing of prosthetic materials. These advancements have the potential to streamline workflows, reduce human error, and shorten treatment times, ultimately leading to enhanced treatment outcomes and increased patient satisfaction. The proposed research methodology includes a comprehensive literature review, an analysis of existing AI applications in prosthodontic restoration, and the development of a prototype AI-assisted system for prosthesis design and fabrication. The evaluation of this prototype will involve quantitative and qualitative assessments, comparing its performance with traditional methods. Overall, this article proposal seeks to highlight the transformative role of AI in prosthodontic restoration, emphasizing its potential to revolutionize traditional approaches and deliver predictable and safer dentistry. The findings from this research can contribute to advancing dental technology, fostering innovation, and improving patient care in prosthodontics.

Keywords: prosthdontics; dentistry; artificial intelligence; rehabilitation

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1. Introduction

In recent years, the field of dentistry has witnessed unparalleled advances, with artificial intelligence (AI) emerging as a cornerstone in redefining prosthodontic restorative approaches. Prosthodontic restoration encompasses the design, fabrication, and fitting of dental prostheses to restore the oral function and aesthetics of patients [1]. This article delves deep into the transformative role of AI in prosthodontic restoration, striving to elucidate how this integration can forge a path to predictable and safer dentistry [2].

1.1. Historical Context

Traditionally, prosthodontic restoration has been heavily reliant on the expertise of dentists and technicians, involving manually intensive techniques with substantial room for error. While modern approaches have mitigated these errors to an extent, the incorporation of AI can revolutionize the entire continuum of prosthodontic restoration, with impacts from diagnosis to treatment planning and execution [3–5].

1.2. AI in Treatment Planning and Digital Impression Acquisition

The advent of AI has introduced an unprecedented level of precision to treatment planning. By employing machine learning algorithms and image processing techniques, AI assists in diagnosing dental conditions with a higher degree of accuracy than traditional methods. Furthermore, AI fosters the development of comprehensive treatment plans by predicting outcomes based on a repository of extensive data collected over the years [6]. Digital impression acquisition has also transformed with AI. Advanced systems facilitate the real-time assessment of the obtained digital impressions, pointing out discrepancies and offering feedback instantaneously. Such a mechanism mitigates errors and substantially reduces the time taken to acquire impressions, enhancing the efficiency of the process manifold [7–10].

1.3. AI in Prosthesis Design and Fabrication

AI offers various benefits when transitioning into prosthesis design and fabrication, including the optimizing of design to achieve the best fit and functionality. The system utilizes data-driven insights to identify potential challenges and risks, thereby allowing for preemptive measures to minimize errors during the restorative procedures. Furthermore, AI-powered systems ensure the meticulous milling or 3D printing of prosthesis materials, adhering to the highest precision standards. These systems conduct real-time assessments during the fabrication phase, ensuring precise adherence to the predetermined specifications and hence guaranteeing optimal results [11,12].

2. Discussion

The central hypothesis steering this research is the potential of AI to transform prosthodontic restoration into a realm of higher predictability and safety. The preliminary findings from a comprehensive literature review and analysis of existing AI applications in prosthodontic restoration affirm AI's significant strides in this field. Developing and evaluating a prototype AI-assisted prosthesis design and fabrication system is pivotal in this research. The prototype leverages cutting-edge AI technologies to facilitate a streamlined workflow, significantly reducing human error and shortening treatment times [13–18]. It also promises enhanced treatment outcomes and heightened patient satisfaction. Comparative analysis with traditional methods through quantitative and qualitative assessments paints a promising picture, showcasing the prototype's superiority in various facets of prosthodontic restoration [19]. Figure 1 illustrates the dentist positioned centrally, acting as the physician and the clinician overseeing all aspects of patient care. Meanwhile, artificial intelligence serves as a co-pilot, aiding in case planning by providing data analysis and potentially offering suggestions based on a large knowledge repository, thus facilitating a more comprehensive and informed approach to dental care (Figure 1).

In dental prosthetics, various AI-based software applications are in use or development. These range from designing and manufacturing dental prosthetics to diagnosis, treatment planning, and patient monitoring. Here are some examples of software and technologies that can be used:

1. CAD/CAM Software:

Software like 3Shape, Exocad, and CEREC employ CAD/CAM (computer-aided design/computer-aided manufacturing) technologies to design and manufacture dental

prosthetics. Some software applications incorporate AI-based functionalities to enhance accuracy and efficiency.

2. Diagnostic Imaging Software:

Software like Dentsply Sirona Sidexis 4 can use AI to analyze radiographic images and other imaging data, aiding in diagnosis and treatment planning.

3. Aesthetic Simulation Software:

Smile Designer Pro is an example of software that uses AI technology to simulate the aesthetic outcomes of prosthetic rehabilitation, allowing patients to visualize the final result.

4. Patient Monitoring Apps:

Patients can use various AI-based apps to monitor their oral health and report any issues to their dentists. These apps can help in the early identification of complications.

5. Patient Data Management Platforms:

Software like Dentrix and Eaglesoft can incorporate AI-based functionalities for managing patient information and identifying risk factors.

6. Training and Decision Support Systems:

Some software utilizes AI to provide training and decision support to dentists based on the analysis of scientific data and clinical cases.

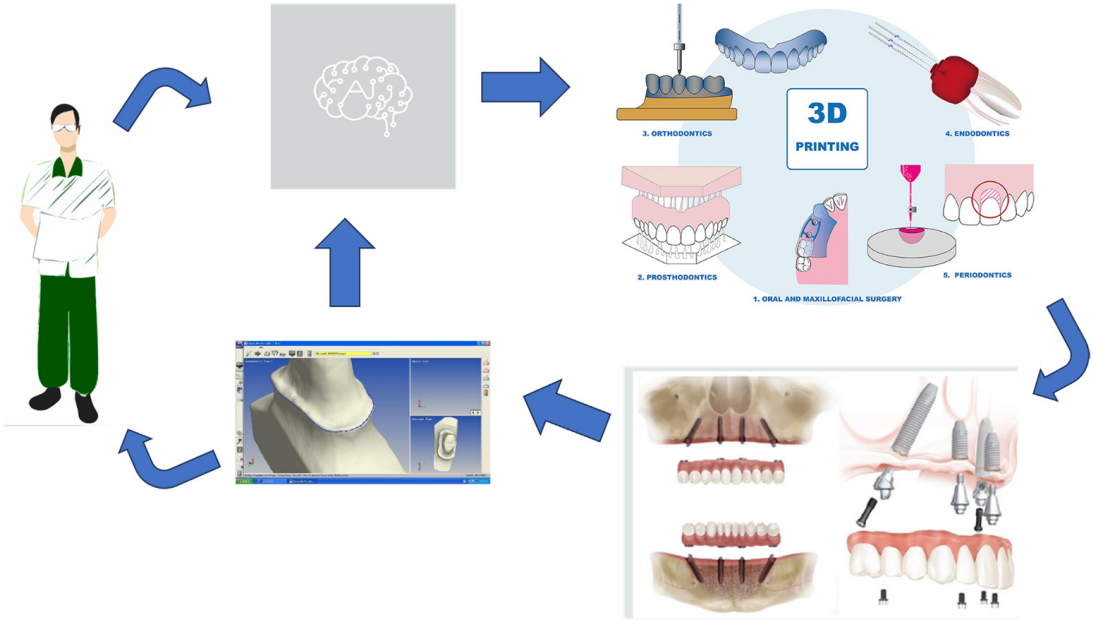

Figure 1. Workflow of dental practice with A.I. co-piloting.

It is important to note that this software should always be accompanied by critical evaluation from industry professionals, as artificial intelligence can aid in decision making but cannot replace the clinical judgment of a dentist. AI can have various applications in dental prosthetic rehabilitation, improving diagnosis, treatment planning, prosthetic production, and complication prevention. For instance:

1. Design and Production of Prosthetics:

Example: An AI system can analyze 3D images of a patient's mouth to design custom dental prosthetics. Using 3D printing, the system can produce precise and personalized prosthetics, reducing the required time and improving fitting.

2. Diagnosis and Treatment Planning:

Example: AI software can analyze radiographs and other imaging data to identify abnormalities and plan prosthetic treatment. It can suggest the most suitable type of prosthetic and optimal placement and predict potential complications.

3. Post-operative Monitoring:

Example: After the insertion of a prosthetic, an AI app on a patient's smartphone can monitor reported symptoms like pain or swelling and suggest whether and when a check-up with the dentist is necessary. This can help prevent or promptly manage complications.

4. Training and Support for Professionals:

Example: An AI system can provide dentists with virtual training and decision support, suggesting best practices based on scientific data and similar cases. This can enhance the quality of prosthetic rehabilitation.

5. Patient Information Management:

Example: AI systems can organize and analyze patient information, identifying risk factors and aiding dentists in customizing prosthetic treatments.

6. Simulation of Aesthetic Outcome:

Example: AI software can simulate the final appearance of a patient's smile after prosthetic rehabilitation, allowing the patient to visualize the expected outcome and the dentist to make any adjustments based on the patient's preferences [20–22].

These are just some examples of how artificial intelligence can be utilized in dental prosthetic rehabilitation. With its ability to analyze vast amounts of data and learn, AI has the potential to revolutionize this field, enhancing treatment efficacy and patient satisfaction.

3. Conclusions

As we stand on the cusp of a revolution in prosthodontic restoration, embracing AI's transformative potential is imperative. Our research unequivocally underscores AI's substantial accuracy, efficiency, and patient satisfaction improvements. Even with the strides made, it is pertinent to address the challenges that lie ahead. The road to widespread adoption is fraught with hurdles, including the substantial financial outlay and the requisite for training the existing workforce to navigate these sophisticated systems adeptly. As we forge ahead, the focus should be on fostering innovation and facilitating the seamless integration of AI into prosthodontic restoration. The research outlined thus far paints a promising trajectory, one where AI does not just assist in but revolutionizes traditional approaches, delivering a brand of dentistry that is predictable, safer, efficient, and capable of guaranteeing satisfaction to patients. The findings from this research stand as a testament to the transformative role of AI in prosthodontic restoration, paving the way for advanced dental technology that promises to enhance the realm of dental care substantially. It is an exciting frontier, offering a glimpse into the future of dentistry, one characterized by precision, efficiency, and safety, steering prosthodontic restoration into a new era of excellence.

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