

## INNOVATIVE TECHNOLOGIES IN RESTORATIVE DENTISTRY

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### ABSTRACT

Oral rehabilitation is a crucial aspect of dental medicine, focusing on restoring and enhancing the function, aesthetics, and overall quality of life for patients with missing or compromised teeth. The use of technology in restorative dentistry has significantly advanced the field, offering various options for dental prostheses, including implant-supported caps, micro-supported dentures, fixed partial dentures, and removable dentures. Increasing the performance of restorations was the major objective of these digital techniques. Computer-aided design and manufacturing (CAD/CAM) technology is utilized for the production of dentures, record bases, radiographic guides, conversion dentures, and verification jigs. This technology has revolutionized the fabrication process, offering precision and efficiency in creating dental prostheses.

Keywords: Innovative technology, restorative dentistry, technological procedures.

### INTRODUCTION

Functional oral rehabilitation is a crucial aspect of dental medicine, focusing on restoring and enhancing the function, aesthetics, and overall quality of life for patients with missing or compromised teeth. The use of technology in oral rehabilitation has significantly advanced the field, offering various options for dental prostheses, including implant-supported caps, micro-supported dentures, fixed partial dentures, and removable dentures. [1]

Computer-aided design and manufacturing (CAD/CAM) technology is used for the production of dentures, record bases, radiographic guides, conversion dentures, and checking jigs. This technology has revolutionized the fabrication process, offering precision and efficiency in creating dental prostheses [2].

When a definitive prosthesis is sought, the impression must have accurate and clear information about every aspect of the prosthetic field. It was for this reason that digital approaches gained traction, but after a while the results were examined.

### DISCUSSIONS FROM LITERATURE

*The materials used for recording impressions in removable prosthodontics play a crucial role in creating accurate and functional dental prostheses. Various impression materials are utilized in prosthodontics for recording accurate impressions of the oral cavity. These materials include alginate, silicone, zinc oxide/eugenol paste, and elastomeric materials like addition-cured silicones and polyether. The choice of impression material is essential to capture fine details*

and ensure a precise fit of the dental prosthesis [3-5].

*Innovative technologies in removable denture fabrication are represented by:*

Computer-aided design/computer-aided manufacturing(CAD/CAM) has revolutionized the fabrication of removable dentures. This technology allows for precise digital design and manufacturing of dentures, leading to improved fit, reduced clinical time, and lower costs for both dental professionals and patients [2].

The use of 3D printing technologies for removable denture fabrication offers advantages such as saving working time, satisfying clinical results, and securing patient records. While 3D printing provides benefits like efficiency and accuracy, challenges related to strength, aesthetics, and material biocompatibility need to be addressed for optimal outcomes [3].

Digital denture techniques have emerged as a promising innovation in removable prosthetics. These techniques offer time efficiency, reduced clinical time, improved retention, and the ability to digitally archive patient data. Despite challenges in communication between clinicians and laboratories, digital denture methods show potential for enhancing outcomes and reducing the number of appointments required for denture delivery.

*The advantages of CAD/CAM systems for removable dentures:*

**Reduced Clinical Time** CAD/CAM dentures offer significantly reduced clinical chair time compared to conventional dentures, allowing for quicker fabrication and fewer visits for the patient. This efficiency enhances the overall treatment process and patient experience[6-8].

**Improved Retention** CAD/CAM dentures provide better retention, ensuring a more secure fit for the patient. This enhanced retention contributes to the comfort and functionality of the removable dentures[5].

The ability to save digital records for patients with CAD/CAM dentures

allows for easy replacement of prostheses in case of loss or damage. This digital archiving feature simplifies the restoration process and ensures continuity of care for patients (Fig.1)

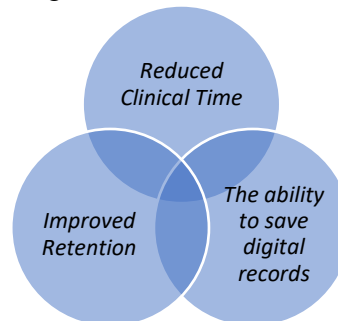


Fig.1 The advantages of CAD/CAM systems for removable dentures

*The advantages of using digital impressions in removable dentures:*

**Efficiency** Digital impressions offer increased efficiency in the fabrication process of removable dentures by reducing the number of clinical appointments and simplifying laboratory procedures. This streamlined workflow saves time for both dental professionals and patients [9-11].

**Patient Satisfaction** Studies have reported higher patient satisfaction with digital clasp-retained removable partial dentures compared to conventional methods. The accuracy and precision of digital impressions contribute to better-fitting dentures, enhancing patient comfort and overall satisfaction.

**Improved Fit** Digital impressions result in better fit and accuracy of removable dentures, leading to enhanced functionality and comfort for the patient. The detailed digital data captured by intraoral scanners ensures a precise fit of the prosthesis [12-14].

**Reduced Errors** Digital impressions help eliminate errors that can occur in traditional stone models, ensuring a more accurate representation of the oral cavity. This reduction in errors contributes to the overall quality and precision of the removable dentures[15-18].

The advantages of using digital impressions in removable dentures include increased efficiency, higher patient satisfaction, improved fit, and reduced errors, all of which contribute to the successful fabrication of high-quality dental prostheses tailored to individual patient needs.

According to Lo Russo et al., digital processes for removable complete dentures are substantially less expensive than the traditional method. [8].

Through their studies, Zhang YJ et al. showed that angled implants offer a fingerprint with a higher precision than photographs obtained on partially edentulous prosthetic fields with parallel implants. [9].

Benic et al consider that an impression registration with impression material, using the closed-mouth impression technique and occlusal registration at the same time, requires less time than a digital impression.

*The most common causes of inadequate retention in CAD/CAM removable dentures:*

*Fit Issues* Inadequate retention in CAD/CAM removable dentures can often be attributed to fit issues. Poor fit due to inaccuracies in the fabrication process can lead to compromised retention, affecting the stability and functionality of the dentures[19-22].

*Design Parameters* Problems with the design parameters of CAD/CAM removable dentures can result in inadequate retention. Issues such as improper alignment, fit, or occlusal relationships can contribute to retention challenges in the prosthesis [23-25].

*Material Selection* The choice of materials used in CAD/CAM removable dentures can impact retention. Inappropriate material selection, especially in terms of strength, durability, and compatibility with the oral environment, can lead to inadequate retention of the prosthesis.

*The disadvantages of using mouth-temperature wax impressions for removable partial dentures include:*

*Time-Consuming* The wax fluid technique can be time-consuming, requiring meticulous attention to detail and precise timing during the impression-taking process. This can lead to longer chair times and potentially impact the overall efficiency of the procedure[26-28].

*Excessive Tissue Displacement* The use of mouth-temperature wax impressions may result in excessive tissue displacement, which can affect the accuracy of the final impression. This displacement can lead to inaccuracies in the fit of the removable partial denture, compromising its functionality and comfort for the patient. [29-31]

*Thermal Expansion* Waxes have a high coefficient of thermal expansion, which can contribute to inaccuracies in the final denture. The potential for expansion and contraction of the wax material may lead to distortions in the impression, affecting the precision of the prosthesis [32-34].

The disadvantages of using mouth-temperature wax impressions for removable partial dentures include issues related to time consumption, tissue displacement, and the material's thermal properties, which can impact the accuracy and quality of the final prosthesis [35-38].

Fit problems, differences in design parameters, and material selection can all lead to inadequate retention in CAD/CAM detachable dentures. This emphasizes the significance of accuracy in fabrication procedures and material selection for the best possible retention and functionality of dental prostheses.

When it comes to removable dentures, the benefits of utilizing various impression materials include better fit and precision, adaptability, stability in dimensions, simplicity of usage, and increased patient comfort throughout the dental process. All of these advantages

work together to successfully fabricate superior removable dentures that are customized to meet the demands of each patient.

*To improve the accuracy of CAD/CAM removable dentures, several strategies can be implemented based on:*

*Enhance Fit Parameters* Ensuring precise fit parameters during the design and fabrication process of CAD/CAM removable dentures is crucial. This includes meticulous attention to detail in capturing digital impressions and optimizing the design to achieve an accurate fit.

*Optimize Material Selection* Selecting high-quality materials suitable for CAD/CAM fabrication can significantly impact the accuracy of removable dentures. Utilizing materials with excellent properties in terms of strength, durability, and biocompatibility can enhance the overall accuracy and performance of the prostheses. [39].

*Refine Fabrication Techniques* Continuous refinement of CAD/CAM fabrication techniques, including rapid prototyping methods, can contribute to improving the accuracy of removable dentures. Staying updated with technological advancements and best practices in digital dentistry can lead to more precise outcomes.

*Quality Control Measures* Implementing stringent quality control measures throughout the CAD/CAM workflow is essential for ensuring the accuracy of removable dentures. Regular checks, validations, and adjustments during the design and manufacturing stages can help maintain high standards of accuracy.(Fig.2)

By focusing on enhancing fit parameters, optimizing material selection, refining fabrication techniques, and implementing quality control measures, the accuracy of CAD/CAM removable dentures can be significantly improved, leading to better-fitting, more precise dental prostheses for patients.

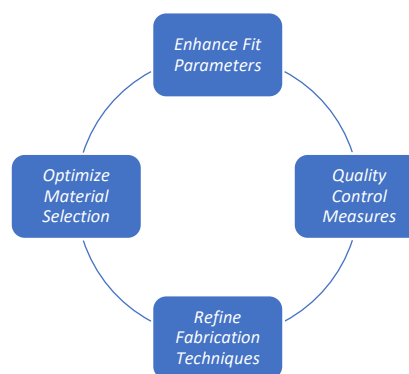


Fig.2 Several strategies to improve the accuracy of CAD/CAM removable dentures

The latest advancements in technology for fixed dentures include the use of Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) systems in the production of high-strength zirconia fixed partial dentures (FPDs). These CAD/CAM systems allow for milling of zirconia-based restorations, offering improved strength and durability compared to traditional materials.

Some studies CAD/CAM (lithium disilicate and zirconia) based and conventional full crowns and FPDs found that CAD/CAM restorations act as a favorable alternative to conventional methods. However, little is known about their intermediate and persistent clinical performance. The study assessed the clinical performance in terms of biological, technical, and esthetic aspects and the survival and success ratios for single full crowns (SFCs) and FPDs. [40,45].

CAD/CAM technology has also been applied in the fabrication of dental implant-supported crowns and bridges, as well as removable or fixed dentures. The use of CAD/CAM systems allows for increased speed, convenience, and simplicity in the design, creation, and insertion processes, making possible restorations and appliances that would otherwise be infeasible.

The latest advancements in technology for fixed dentures involve the use of CAD/CAM systems in the production of high-strength zirconia-based restorations, offering improved strength, durability, and accuracy compared to traditional methods. These advancements have led to the development of dental implant-supported crowns and bridges, as well as removable or fixed dentures, providing patients with more comfortable and aesthetically pleasing dental solutions.

*What are the advantages of using CAD/CAM for fixed partial dentures*

1. *Precision and Accuracy:* CAD/CAM technology allows for precise and accurate design and manufacturing of fixed partial dentures, ensuring a better fit and improved functionality for patients.
2. *Efficiency:* The digital workflow of CAD/CAM systems streamlines the process of creating fixed partial dentures, reducing the time required for fabrication and delivery. This efficiency benefits both dental professionals and patients by saving time and reducing the number of appointments needed. [15-17].
3. *Customization:* CAD/CAM technology enables the customization of fixed partial dentures to meet the specific needs and preferences of individual patients. This customization ensures a more comfortable fit and better aesthetic results.
4. *Reduced Errors:* The use of CAD/CAM systems minimizes human errors that can occur during the traditional manual fabrication process. This reduction in errors leads to improved quality and consistency in the production of fixed partial dentures.
5. *Cost-Effectiveness:* While the initial investment in CAD/CAM technology may be significant, the long-term benefits include reduced labor costs, fewer remakes, and improved overall efficiency, making it a cost-effective solution for producing fixed partial dentures.(Fig.3)

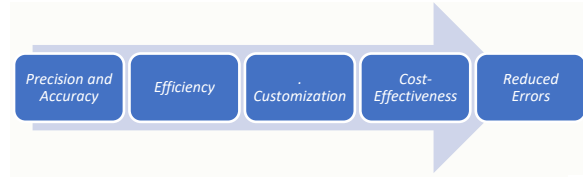


Fig.3 The advantages of using CAD/CAM for fixed partial dentures

*The accuracy of CAD/CAM fixed partial dentures is comparable to traditional methods*, as shown in a study comparing the fit of dentures fabricated by traditional techniques versus CAD/CAM technology. However, the introduction of technology has revolutionized the field of dentistry, including the manufacturing processes for removable complete dentures and clinical protocols, with CAD/CAM technology offering benefits in terms of precision, efficiency, and customization. [41-46].

CAD/CAM technology involves taking a virtual impression by means of an Intraoral Scanner, enabling digital reproduction of the patient's oral cavity, and then creating a virtual model of the prosthesis (CAD), which is fabricated by milling with CAM. While there is still some reservation about the extensive acquisition of fornices digitally, many operators currently use the traditional elastomer impression method for this step[45-47].

A study comparing the clinical time required and costs incurred for the fabrication of removable complete dentures using traditional and digital methods found that the conventional protocol requires longer clinical times than those needed in the digital protocol, and overall costs are significantly higher for the conventional protocol than for the digital prosthesis protocol.

*The factors that affect the accuracy of CAD/CAM fixed partial dentures include:*

1. *Manufacturing Method:* The method used for manufacturing the fixed partial dentures, whether through CAD/CAM technology or traditional methods, can impact the accuracy of the



final restoration. CAD/CAM systems offer precise digital design and milling processes that contribute to better accuracy compared to conventional manual techniques.

2. Fabrication Technique: The fabrication technique employed in CAD/CAM systems, such as the scanning, design, and manufacturing processes, plays a crucial role in determining the accuracy of fixed partial dentures. Proper calibration and execution of these steps are essential for achieving optimal accuracy in the final restoration. [3-6].

3. Material Selection: The choice of materials used in CAD/CAM systems for fixed partial dentures can influence accuracy. Different materials may have varying properties that affect the fit and longevity of the restoration. Factors like the type of alloy or ceramic used can impact the accuracy of the final prosthesis.

4. Scanning Accuracy: The accuracy of the digital scanning process, which captures the patient's oral anatomy to create a virtual model, is critical for ensuring the precision of CAD/CAM fixed partial dentures. High-quality scans with detailed information contribute to the accuracy of the final restoration.

5. Milling Precision: The milling process in CAD/CAM systems, whether using three-axis or five-axis machines, can affect the accuracy of fixed partial dentures. The level of precision in milling the restoration from the chosen material influences the fit and quality of the final prosthesis. [8-11].

Factors such as the manufacturing method, fabrication technique, material selection, scanning accuracy, and milling precision all play a significant role in determining the accuracy of CAD/CAM fixed partial dentures. Attention to these factors is essential to ensure the successful creation of precise and well-fitting dental restorations.

## CONCLUSION

Cutting-edge innovations in the production of removable dentures include digital denture procedures, 3D printing developments, and CAD/CAM technology. These technologies are all geared toward improving prosthodontics' precision, efficiency, patient results, and overall quality. With so many digital and traditional procedures available, one of the major oral concerns is oral rehabilitation. Although digital approaches are perceived to offer numerous benefits, an analysis of them reveals the existence of significant drawbacks.

Better patient outcomes and satisfaction in removable prosthodontics are all facilitated by the benefits of CAD/CAM systems for dentures, which include increased fabrication efficiency, better retention, digital archiving capabilities, improved material properties, and superior mechanical characteristics.

The patient's comfort, a decrease in material usage, the avoidance of changing the impression material prior to model casting, efficiency in denture production, and adherence to denture-making principles by regaining the stomatognathic system's functions are all examples of the benefits of the digital removable denture workflow.

The benefits of using digital techniques, such as the patient's comfort, fewer procedures, precise stage placement, minimal material consumption, elimination of some procedures repetition, and a favorable cost-effectiveness ratio are driving up demand for their use.

The advantages of using CAD/CAM for fixed partial dentures include precision, efficiency, customization, reduced errors, and cost-effectiveness, ultimately leading to better outcomes for both dental professionals and patients.

CAD/CAM technology offers a more precise, efficient, and accurate method for creating fixed and removable partial dentures compared to traditional

manual methods, leading to better-fitting restorations and improved patient outcomes.

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