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Digital Workflow Optimization for Endocrown Restorations on Root-Treated Teeth

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Abstract **Case Report**

Endocrown restorations have become a popular solution for endodontically treated teeth, offering both functional and esthetic benefits. These restorations are particularly effective for molars due to the larger surface area of the pulp chamber, which enhances retention and stability. This article presents a clinical case of a zirconia endocrown restoration for a highly damaged mandibular molar. Utilizing a fully digital workflow, the preparation, design, and fabrication of the restoration were performed with precision, ensuring minimal tooth structure removal. Zirconia was chosen for its superior mechanical properties, including fracture resistance and durability. The challenges associated with zirconia, such as bonding reliability, were addressed through surface treatments like air abrasion and the use of 10-MDP-based chemical promoters. The patient's outcome was both esthetically pleasing and functionally successful. This case highlights the advantages of integrating digital workflows and advanced materials in modern prosthodontic practice, while also acknowledging the need for careful selection of materials and techniques based on the individual case.
Keywords: Zirconia endocrown, Digital workflow, Endodontically treated teeth, Mandibular molar, Prosthodontic treatment.

INTRODUCTION

Endodontically treated teeth often exhibit structural weaknesses due to the loss of vital pulp tissue, making them more prone to fractures [1]. The extensive removal of dentin during root canal therapy, combined with a lack of moisture in the tooth structure, contributes to a reduced resistance to occlusal forces. As a result, these teeth are more susceptible to fractures, especially in areas with significant coronal damage. Additionally, the weakening of tooth structure after treatment can compromise the long-term prognosis if not adequately restored [2]. The use of intracanal posts may appear necessary [3]. The complications of traditional procedures [4] and the advancements in adhesive techniques have shifted the traditional belief that a devitalized tooth must be restored with a post, core, and crown into innovative techniques and restorations such as the endocrown.

An endocrown is a full ceramic crown bonded to a devitalized tooth, anchored within the pulp chamber and along the cavity margins. This design ensures macromechanical retention (supported by the pulpal walls) and microretention (achieved through adhesive cementation).

This monolithic ceramic adhesive restoration demands precise preparation techniques to meet key biomechanical requirements such as a cervical margin designed as a butt joint and a pulp chamber preparation that avoids extending into the root canals [5]. This approach preserves more of the tooth's structure, enhancing its durability and lifespan. The simplicity and effectiveness of this method align with the philosophy of biointegrated prostheses [6]. While endocrowns have been proven effective for molars where the larger surface area of the pulp chamber allows for better retention and distribution of occlusal forces. However, their use in premolars and anterior teeth remains debated [7].

This paper aims to highlight the advantages of integrating digital workflows and advanced materials in modern prosthodontic practice, while also acknowledging the need for careful selection of materials and techniques based on the individual case.

CASE PRESENTATION

A 21-year-old male presented to the department of fixed prosthodontics at the dental clinic of Monastir to restore his highly damaged first right mandibular molar #46. The clinical examination revealed an extensive glass ionomer restoration. The tooth was asymptomatic.

Figure 1: Endobuccal view of tooth #46 with the glass ionomer filling

After removal of the coronal filling, the quality of the remaining tooth tissue was reassessed. The remaining tooth walls were supragingival. Radiological examination revealed a sufficient endodontic treatment. The pulp chamber was large and deep. The analysis of the tooth anatomy is fundamental to the indication of all sorts of adhesive restorations.

Owing its conservative aspect and esthetic results, the decision of a zirconium endocrown was taken with the patient's consent.

1-Tooth preparation:

Before beginning the preparation, the shade was chosen using the VITA master shade guide, taking into account the neighboring and opposing teeth. The critical areas of focus for the restoration were the cervical margin and the pulp chamber cavity. During the procedure, the root canals were left unshaped and untouched, meaning they were not weakened by any drilling and did not experience the stress typically associated with placing an anchorage.

The cervical margin was prepared using a diamond "wheel" dental bur (green ring) (818040C-FG), which ensures the creation of a flat surface. A reduction of at least 2mm was made on the supporting and guiding cusps to provide sufficient space for the ceramic. The position of the cervical margin determined the volume of space available for the ceramic material.

Figure 2: Reduction of tooth walls using a wheel bur in order to have a flat surface

For the preparation of the pulp chamber cavity, a cylindrical-conical dental bur (green ring) (848 018F-FG) was used. The bur's taper is 3.5°, resulting in an overall stump angle of 7°. These measurements correspond to Jorgensen's recommendations for a minimum stump size, which promotes retention and stabilization [8].

Figure 3: Occlusal and lateral view of the preparation (butt margin)

2-Digital Impression

The first step in the digital workflow was to capture a digital impression of the patient's oral cavity. This was done using an intraoral scanner, which captured highly accurate 3D images of the existing dentition, the prepared tooth and surrounding soft tissues. An impression of the antagonist dentition and the patient’s occlusion were taken. The digital impressions were then imported into specialized software for planning.

Figure 4: Digital impression of the antagonist

Figure 5: Digital impression of the preparation

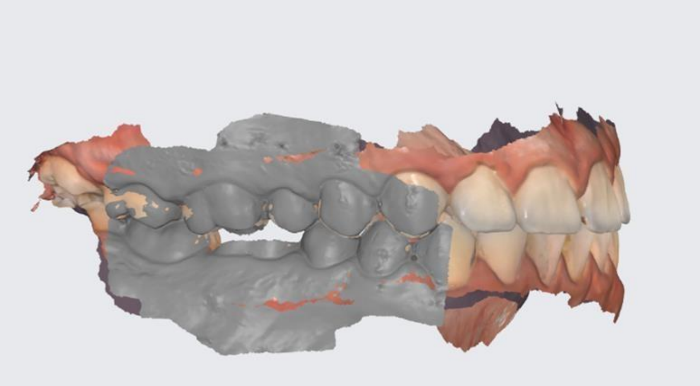

Figure 6: Digital impression of the occlusion

3-Conception of the final restoration

Using the STL file issued from the digital impression, the laboratory technician outlined the limits of the preparation and removed the undercuts. The endocrown was then conceptualized.

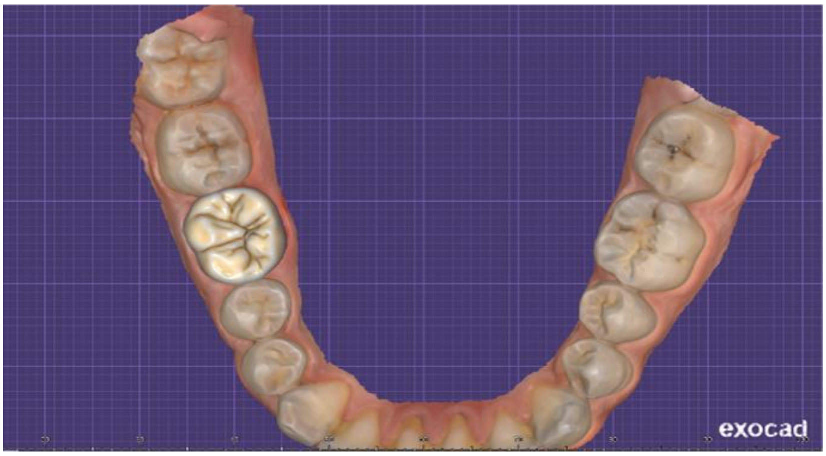

Figure 7: Occlusal view of the final endocrown design

4-Fabrication and placement of the final restoration:

The final restoration shape was transferred to a milling machine. The endocrown was milled into a zirconium block using a high precision CAD/CAM technology.

The endocrown was tried in after sintering and checked for the marginal fit, shade, shape and occlusion. The static occlusion was controlled to check the bilateral distribution of the contacts at Maximum Intercuspation. Dynamic occlusion was controlled to ensure the absence of interferences.

Figure 8: Clinical try in of the endocrown

The cementation was programmed in the following appointment after staining and glazing.

Figure 9: Staining of the endocrown

Figure 10: Glazing furnace

Figure 11: Final restoration

Figure 12: Occlusal and lateral view of the final endocrown cemented

Regular recalls were programmed during which oral hygiene maintenance and gingival margins stability were evaluated. The patient was satisfied with both esthetic and functional outcome.

DISCUSSION

Various materials, including lithium disilicate glass-ceramic, zirconia, zirconiareinforced lithium silicate glass-ceramic, and resin composites, have been employed in the fabrication of endocrowns [7, 9, 10]. The choice of material plays a crucial role in determining the performance and long-term success of the restoration, particularly in enhancing fracture resistance [8].

In our case, we used a multi-layered, pre-shaded zirconia discs that combine 3Y (3 mol% yttria) and 4Y (4 mol% yttria) zirconia in a seamless gradient that are ideal for endocrown restorations due to their balanced properties. This disc offers a gradient of Chroma (color intensity), strength, translucency, and toughness, which are crucial for both functional and esthetic dental restorations. The 3Y zirconia provides the necessary strength and toughness to withstand occlusal forces in load-bearing areas, while the 4Y zirconia offers enhanced translucency and esthetic appeal in more visible areas. This combination ensures that the endocrown restoration not only matches the natural appearance of the tooth but also maintains the structural integrity required for long-term durability [11].

Zirconia, in particular, is widely used due to its exceptional mechanical properties [12]. Studies have shown that zirconia endocrowns offer superior durability and load-bearing capacity, making them ideal for situations where long-term strength is critical. With high flexural strength and excellent wear resistance, zirconia ensures the longevity of the restoration while minimizing wear on the opposing dentition, as it strikes a balance between rigidity and durability. These properties make zirconia an optimal choice for endocrown restorations, especially in cases involving bruxism or heavy occlusal forces [13, 14].

However, due to its acid-resistant polycrystalline structure and lack of amorphous silica, zirconia cannot be treated with conventional etching methods. This makes its retention in partial coverage restorations, such as endocrowns, less reliable compared to other ceramics. In fact, debonding is commonly cited as the leading cause of failure in zirconia endocrown restorations [15, 16]. To address this, a combination of mechanical and chemical treatments can significantly improve the bond strength between zirconia and the tooth. Techniques such as air abrasion with alumina particles and laser irradiation are commonly used to create surface irregularities. When these methods are combined with chemical promoters like 10-MDP-based products, they have been shown to enhance bonding effectiveness [17].

In our case, for bonding, we utilized air abrasion (sandblasting) with Al_2O_3 particles, which is the most common and effective surface treatment method for improving adhesion to zirconia [18, 19].

The introduction of a fully digital workflow also contributed to the success of the restoration. Digital scanning has emerged as a reliable alternative to conventional impression techniques for fabricating fixed restorations. However, evidence on its ability to achieve optimal marginal accuracy in endocrowns remains limited. Some studies indicate that digital scanning and conventional impressions result in crowns with comparable marginal adaptation [20].

In our case, we opted for a fully digital workflow due to its numerous advantages. Digital impressions provide superior accuracy, a better cost-benefit ratio, and enhanced patient comfort by eliminating the discomfort of traditional impressions, such as nausea and bad taste. Furthermore, digital workflows streamline the treatment process by facilitating the easy sharing of patient data between dental professionals and laboratories, ensuring a more efficient and precise restoration process [21].

In summary, combining zirconia's superior mechanical properties with the efficiency of a digital workflow allows for a durable, aesthetic, and patientfriendly approach to endocrown restorations.

CONCLUSION

Although surface treatments have been developed to improve bonding strength in zirconia restorations, the predictability of zirconia bonding remains less reliable compared to other materials. Achieving consistent and durable bonds with zirconia necessitates meticulous technique and precise surface preparation.

Conversely, while the digital workflow provides several benefits, including enhanced efficiency and patient comfort, it also has limitations such as overmilling, undermargination, and marginal chipping. The conventional workflow, on the other hand, frequently results in superior clinical outcomes and can help reduce errors associated with digital methods. Therefore, it is essential for clinicians to thoughtfully evaluate and select the most appropriate fabrication techniques and materials based on the specific needs of each case.

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