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Case Report

Use of an intraoral scanner and CAD-CAM for simultaneous restoration with a personalized titanium post-core and a zirconia crown

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Abstract: Customized posts-and-cores have been widely used for improved fitness within a prepared post space. However, in comparison to direct restoration, they necessitate an increased number of appointments for patients. A 24-year-old man presented with a maxillary left canine that had fractured due to trauma 10 months previously. For this case, a digital process was used for simultaneous restoration with a personalized titanium post-and-core and a zirconia crown achieved with an intraoral scanner (IOS) and computer-aided design/computer-aided manufacturing (CAD-CAM). This workflow allowed the restoration to be completed in 2 visits, facilitating more effective and predictable treatment, with reduced time and cost for the patient.

Keywords: CAD-CAM, digital impression, intraoral scanner, post and core

Introduction

Teeth with a large amount of missing coronal tissue after endodontic treatment usually require post-and-core restorations to prevent tooth fracture. In clinical practice, the posts can be either prefabricated or customized. Prefabricated fiber posts, which improve the stress distribution of teeth and reduce the risk of catastrophic fracture, have attracted much attention because of their excellent esthetic characteristics and elastic modulus, similar to those of dentine [1]. However, prefabricated posts cannot fully match the shape of the post space, especially in elliptical or flared canals [2]. In contrast, customized posts are suitable for the root canal spaces of most teeth, including single-rooted, premolar or molar teeth. Such customized posts can help teeth with severe structural loss resist torsional stress [2]. Advances in computer-aided design/computer-aided manufacturing (CAD-CAM) have meant that CAD-CAM technology in the field of prosthodontics is no longer limited to crowns. Combination of intraoral scanners (IOS) with CAD-CAM has led to the emergence of a digital technique for fabricating customized posts-and-cores [3]. This technology has several advantages including better efficiency, a reduction of manufacturing time, and standardization of procedures to improve quality. This article introduces an innovative technique based on digital technology using a personalized titanium post-and-core and a zirconia crown.

Case report

A 24-year-old man presented with missing maxillary incisors and a fractured maxillary left canine due to trauma 10 months previously (Fig. 1A). Root canal treatment for the maxillary left canine had been completed, and three implant restorations and four temporary resin crowns had been used for the replacement of teeth 11, 12, 21, and 22. The patient wished to restore his original oral appearance with as few appointments as possible because of his active social life. Most of the canine coronal structure was missing. A periodontal probe was used to measure the remnants of the canine, and 5-mm-high coronal structure and 1-mm-wide root canal orifice was found. The effect of endodontic treatment was evaluated, and cone beam computed tomography (CBCT) (i-CAT, KaVo, Biberach, Germany) revealed no shadow around the periapical area (Fig. 1B). The treatment plan for the involved tooth included simultaneous restoration using a personalized titanium post-and-core and a zirconia crown based on IOS and CAD-CAM.

A post space in tooth 23 was prepared with #4 through #6 post drills (Para Post DRILLS, Coltene/Whaledent Inc., Cuyahoga Falls, OH, USA) (Fig. 2A). The root canal was prepared so as to ensure apical sealing with a 3-5-mm gutta-percha cone. The tooth receiving the zirconia crown was prepared in a minimally invasive way (axial wall reduction: 0.8-1.0 mm; labial surface margin: 0.5 mm subgingival; heavy chamfer edge: 0.8 mm) (Fig. 2B).

Para Post DRILLS#6 (Coltene/Whaledent Inc.) was used as a scan post. An IOS (TRIOS 3D Intraoral scanner, 3Shape, Copenhagen, Denmark) (Fig. 3A) was used to scan the post space without the scan post, and then with the scan post inside the root canal. The scan post was scanned separately and fitted to the post space subsequently (Fig. 3B, C). Gingival retraction cords (Ultrapack#00, Ultradent, South Jordan, UT, USA) had been used to expose the shoulder edge. The intraoral scanning data included the post space, crown preparation, and a full arch digital impression (Fig. 3D).

The imported digital files for optical scanning were converted to a computer-aided design (CAD) software program (Exocad-Dental CAD 3.0, Exocad GmbH, Darmstadt, Germany) and a virtual post-and-core was designed (Fig. 4A). The titanium post-and-core (Titan, R+K CAD-CAM Technologie GmbH, Berlin, Germany) was subsequently milled by computer-aided manufacturing (CAM) (CAD-CAM, R+K CAD-CAM Technologie GmbH) (Fig. 4B). The digital model was printed using a 3D printer (RuiyiDLP1080EA, Han's Laser, Shenzhen, PR China), then the titanium post-and-core was fitted on the model, which was scanned using IOS. The standard tessellation language files obtained from the IOS were imported into the CAD software (Exocad GmbH). Based on the data, a zirconia crown (Multilayer, Aidite, Qinhuangdao, PR China) was designed and milled with a computer-aided manufacture (CAD-CAM) machine (Linggong Ideal Mill 5A, Beijing Baden Technology Co. LTD, Beijing, PR China) (Fig. 4C).

After a fitting and adaptation check to ensure that the sitting position could be completed with minimal force and no adjustment would be required, the surface of the customized post-and-core was cleaned for the subsequent adhesive procedures. Eighth-generation bonding agent (Single Bond Universal, 3M ESPE, St. Paul, MN, USA) was applied inside the canal and on the post-and-core, followed by curing for 20 s. The flowable composite material (Rely X Unicem, 3M ESPE) was injected into the canal, the composite material was applied to the post-and-core, which was then placed inside the canal and curing was performed for 20 s (Fig. 5A). Subsequently, the zirconia crown was fitted, adjusted for occlusion, and cemented using the eighth generation bonding agent (3M ESPE) and resin cement (Rely X Ultimate Clicker, 3M ESPE) in accordance with the manufacturer's instructions to complete the definitive restoration (Fig. 5B).

The patient was satisfied with both the function and esthetics of the restoration, and no signs or symptoms of periapical disease were observed at the 3-month clinical follow-up point.

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Fig. 1 Preoperative situation
(A) intraoral view. (B) cone-beam CT image of the maxillary left canine area

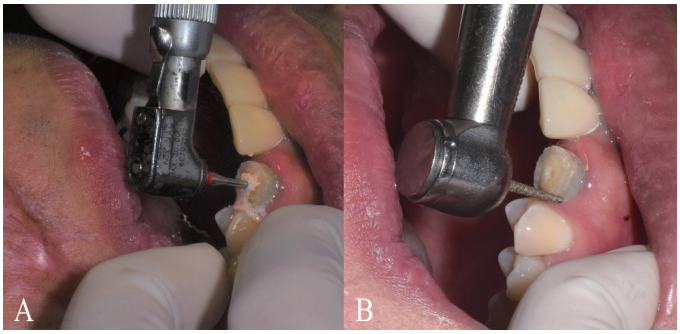

Fig. 2 (A) post-space preparation, (B) tooth preparation

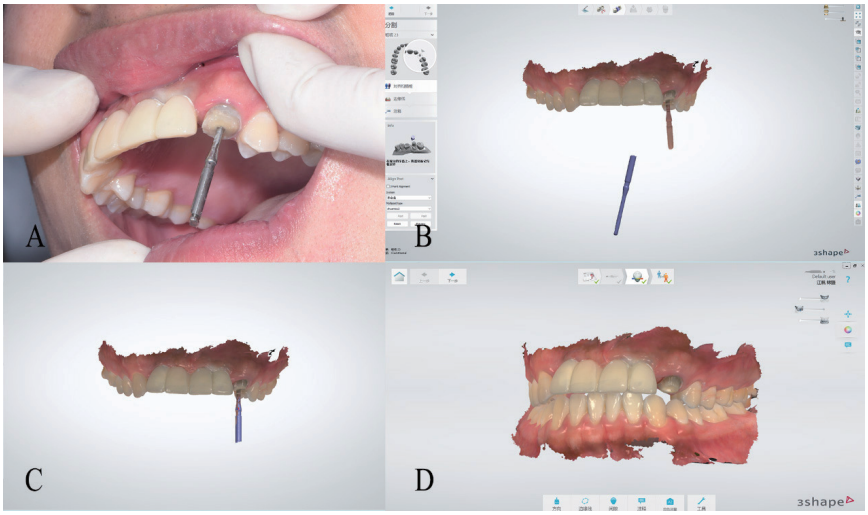

Fig. 3 Intraoral scanning
(A) intraoral view of the scan post inside the root canal, (B, C) software view of the scan post fitted to the post space, (D) software view of the digital impression obtained with the intraoral digital scanner

Discussion

This clinical case illustrates the possibility of using customized posts-and-cores with digital intraoral impression-taking. By using a scan post, data on the post space can be obtained, allowing CAD-CAM to achieve simultaneous restoration with a post-and-core and a crown, thus saving clinical follow-up visits. Although many treatment situations in the field of prosthodontics no longer require post-and-core restorations due to updating of adhesive materials, there is a lack of sufficient tooth structure for fixed restorations in clinical practice, and the use of posts-and-cores is effective [4]. In comparison to prefabricated posts, customized posts-and-cores have been proven to be more adaptable in wide root canals [2]. Moreover, with continuous developments in materials science, restorative materials for customized posts-and-cores are no longer limited to alloys, and various materials such as zirconium dioxide, polyether ether ketone, glass-fiber-reinforced composites, and hybrid ceramic [5,6] can be applied for post-and-core fabrication. Digital technology has also brought about an innovative revolution in the fabrication of posts-and-cores. Currently, however, there is concern about the accuracy of fully digital techniques. Hendi et al. compared the accuracy of conventional and fully digital fabrication techniques and concluded that conventional techniques are superior in this respect. However, the errors inherent to a fully digital approach are within acceptable norms, suggesting that this would be applicable to clinical work [3]. Additionally, in terms of time efficiency and patient preference, digital impressions seem to be preferable to traditional impressions [7]. Dentists have also shown interest in this technology, which means that demand for it may continue to increase. Research has confirmed the ability of the 3Shape Trios scanner to read post-spaces up to 9 mm in depth [8]. However, for root canal post-spaces above 9 mm, due to the relatively shallow depth of field before IOS, as well as the narrow and deep root canal and the small intraoral space, IOS cannot directly obtain digital impressions from within the mouth. In the present case, a drill was utilized as a scan post to scan the post space, similar to the use of scan bodies for obtaining digital impressions in implant dentistry. The teeth were scanned with the scan post inside the canal, allowing IOS even in areas with deep and narrow canals.

Although satisfactory results were achieved in this case, there are limitations to this treatment. Firstly, the post-and-core and crown are designed and fabricated based on optical impressions, so the accuracy of intraoral scanning is affected by environmental lighting conditions [9]. Due to interference from various lights in the dental office, it is difficult to replicate illumination conditions that are ideal. In addition to lighting factors, parameters such as saliva, temperature, and scanning angle may

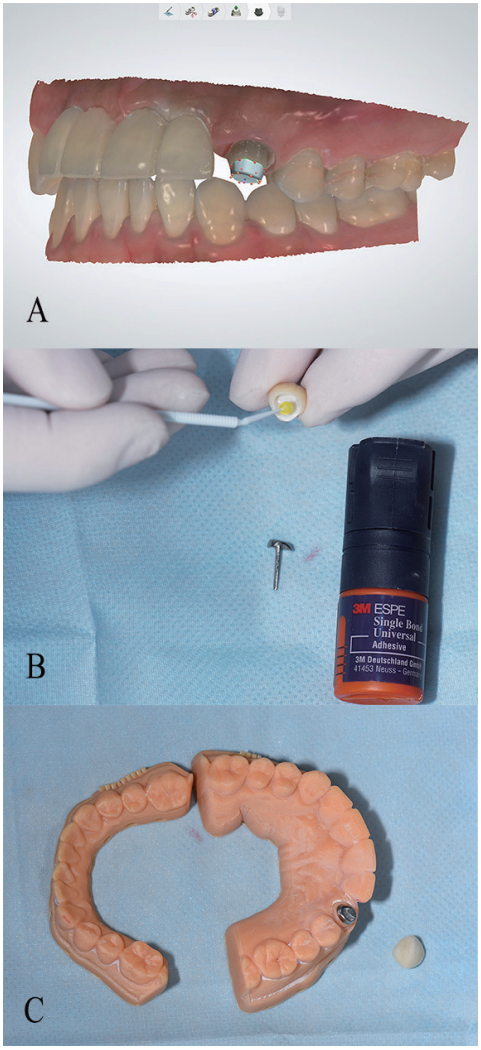

Fig. 4 Computer-aided design and computer-aided manufacturing
(A) software view of the computer-assisted design of the correct post-and-core based on the impression, (B) photograph of the final personalized post-and-core, (C) photograph of the customized titanium post-and-core and zirconia crown

Fig. 5 Definitive restoration
(A) occlusal view of the cemented post-and-core, (B) esthetic result

also affect the results. Secondly, further clinical studies and laboratory data are needed to verify whether different IOS and CAD-CAM systems would affect the optimal adaptation of posts-and-cores. Moreover, it remains to be confirmed whether other materials can achieve good adaptability with a fully digital workflow. Finally, this program requires cooperation among dentists, patients, and dental laboratory technicians. The use of IOS and scan posts requires patients to open their mouths as widely as possible, which may be uncomfortable for patients with temporomandibular joint disorders. Although the number of follow-up visits for patients may be reduced, the time required by dental laboratory technicians is greatly increased due to relatively complex preoperative design and production. For dentists, in comparison to traditional technology, this approach is more expensive in the early stages as IOS and CAD-CAM equipment needs to be purchased, followed by considerable training to master the digital technology proficiently. Therefore, to conduct a realistic cost assessment, it is necessary to carefully weigh the additional expenses of the workflow before deciding whether to apply it.

Currently, many dentists still prefer to use conventional methods. Composite resin and fiber posts are used to build the core and form a suitable tooth preparation. Then, impressions are taken with gingival displacement. The next step is to set the crown. This means that the number of treatments remains the same, the optical impression of the post area is not limited, and the accuracy of the crown is improved. Traditional fiber posts and all-ceramic crowns still play an important role in modern dentistry. However, digital technology continues to make advances, and further improvements are expected to enhance the accuracy and applicability of digital impression technology. A fully digital workflow is expected to improve efficiency, reduce manufacturing time, and standardize procedures to improve quality in the long run.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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Author Contributions

PPC conceived the technique, and ZQZ designed the technique. LL and YYZ completed the workflow. LL and XC wrote the paper. JL reviewed and edited the manuscript. All authors read and approved the final manuscript.

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