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# Fabrication of Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) post and core using indirect digitalisation technique

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## Abstract

The advancement of digital technology in dentistry signifies an opportunity for the clinician to explore novel techniques in fabricating post and core. Conventional custom-made post and core is constructed in the laboratory with very limited material either gold, nickel-chromium or cobalt-chromium. Apart from higher modulus elasticity compared to dentin, the colour of the conventional custom-made post and core was also unaesthetic making it inferior to be used with all ceramic crown. This article describes post and core fabrication technique using computer-aided design and computer-aided manufacturing (CAD/CAM) technology with acrylic resin pattern build-up and indirect digitalisation method. The same procedure for custom-made metal post and core was adopted in this case to capture the anatomical shape of the root canal before digital technology was incorporated in the fabrication of post and core manufacture using CAD/CAM. With the CAD/CAM approach, an increased in quality, productivity, workflow efficiency and consistency of prosthetic rehabilitation may be obtained. It also enables clinicians to fabricate post and core using tooth colour material with better physical properties and improved mechanical qualities to achieve the best result in restoring endodontically treated teeth.

***Keywords:*** *computer-aided design, computer-aided manufacturing, core, post*

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## Introduction

Custom-made cast post is indicated when there is extensive loss of tooth structure, wide, non-circular or extremely tapered canal (Soares *et al*., 2014; Pang *et al*., 2019). The main advantage is that it can be tailor-made to the shapes of the root canal, however, the choice of substrate material is limited. Gold, cobalt-chromium (Co-Cr) and nickel-chromium (Ni-Cr) are mainly the material of choice for the fabrication of custom-made post and core (Fraga *et al*., 1998; Martinez-Insua *et al*., 1998; Khaledi *et al*., 2015). However, due to the different modulus of elasticity between post material and dentin, they tend to produce excessive functional stress leading to the root fracture. (Fraga *et al*., 1998; Akkayan & Gülmez, 2002). Ideally, the material for post and core should have comparable physical and mechanical properties of dentin such as optical properties, comprehensive strength, tensile strength, and thermal expansion

coefficient (Manhart, 2009; Gonzaga & Correr, 2017; Machado *et al*., 2017). Computer-aided design/computer-aided manufacturing (CAD/CAM) offers new technique and a wide range of tooth-colour materials for the fabrication of custom-made post and core. Previous studies had reported diversities of materials in fabricating the CAD/CAM post and core namely ceramic (zirconia, leucite-reinforced ceramics or lithium disilicate) (Awad & Marghalani, 2007; Sipahi *et al*., 2011 Eid *et al*., 2019a; Eid *et al*., 2019b; Oguz *et al*., 2019), resin (Spina *et al*., 2018; Oguz *et al*., 2019) or experimental block of customized glass-fiber reinforced (Tsintsadze *et al*., 2017; Garcia *et al*., 2018; Tsintsadze *et al*., 2018). These materials have the advantage of similar optical properties as well as comparable modulus elasticity with the natural teeth. Furthermore, the monobloc effect of CAD/CAM post and core may lower the likelihood of failure as it combines into a single unit (Vinothkumar *et al*., 2011).

The fabrication of CAD/CAM post and core can be divided into direct digitalisation using scan post and indirect digitalisation using an impression of the post space with a resin pattern, gypsum material, or poly-vinyl siloxane (PVS) impression (Hamid & Ahmad, 2022). Although direct digitisation is desirable as it allows the clinician to quickly identify and rectify the preparation margin, reducing clinical and laboratory procedures, the system was not readily available in Malaysia at the moment. In addition, a previous study also showed that the current system can only capture canal post lengths of 10 mm or less (Kalyoncuoğlu *et al*., 2015). Thus, this paper aimed to describe the indirect digitalisation technique of impression of post canal space using resin pattern for post and core fabrication using CAD/CAM technology utilising the available CAD/CAM machine.

## Technical Report Methods

### Tooth preparation prior to fabrication of CAD/CAM post and core

After completion of endodontic obturation for the maxillary central incisor, the gutta percha was removed with a low-speed Gates-Glidden instruments up to the size 3 (Dentsply Sirona, USA). Post space preparation was performed using ParaPost® XP™ drills (Coltène Whaledent, Germany) in conventional sequences, leaving 5mm of gutta percha as apical seal (Mattison *et al*., 1984). Root canal were lubricated with petroleum jelly before application of autopolymerizing acrylic resin (GC Pattern Resin; GC Corp, America) on the ParaPost® XP™ plastic lab burnout post (Coltène Whaledent, Germany) with a brush and the post was placed into the canal and core was build-up. The core was refined into desired incisor shape of 4 mm height using diamond rotary cutting tools (Figure 1). Crown preparation was completed with 2-mm ferrule as crown finish line (Morgano & Brackett, 1999; Bittner *et al*., 2010)

### Scanning and designing procedure of CAD/CAM post and core

The resin pattern was sent to the laboratory for the digitalisation process. The incisal portion of the resin pattern was attached to a putty silicone base. Then, an optical scan of the resin pattern was obtained using an intraoral scanner (Aoralscan 3, Shining 3D Scanner, China). The optical scan was processed within a CAD design software (Ceramill Match; Amann Girrbach, Austria) utilising the inlay set-up mode as there was no proprietary post and core design mode within the software.

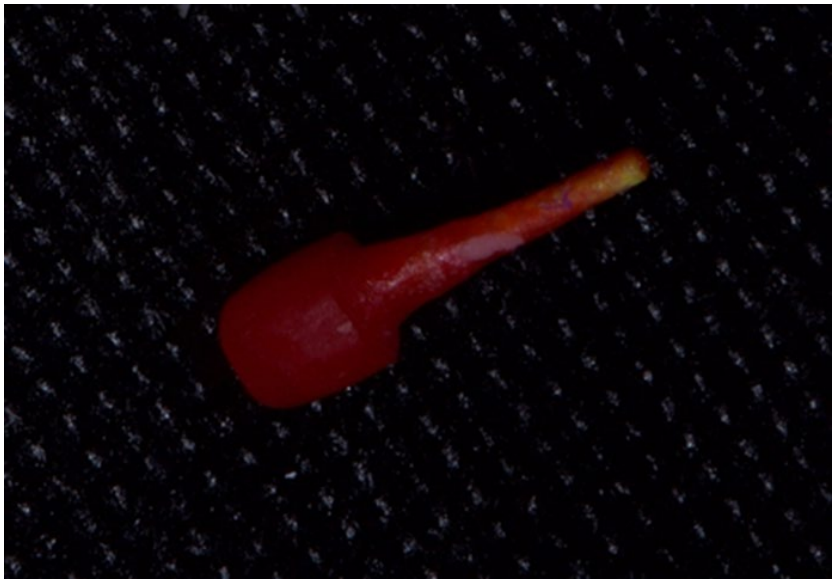

Figure 1. Post and core fabricated using acrylic resin pattern

## Milling procedure of CAD/CAM post and core

Following the completion of scanning and designing process (Figure 2a and Figure 2b), the milling was done using 5-axis milling machine (Ceramil Motion 2, Amann Girrbach, Austria). In the present study, the clinician manipulated the digital file to make the milling with a 14-mm CAD-CAM polymer-infiltrated ceramic-network Vita Enamic® block (VITA Zahnfabrik, Germany) permissible. The digital file of the post and core was angulated to give a 2-mm sprue, 4-mm core height and 9-mm post length to fit in the Vita Enamic® block. The post length was longer in this case because of the use of the central incisor tooth (Figure 3). The maximum post length would be 8-mm if no angulation was applied for milling of a 14-mm Vita Enamic® block. A completed post and core was milled with the sprue connection using a rotary diamond RFID cutting bur size 1.8, 1.4, 1.0 and 0.4 (Amann Girrbach, Austria) under cooling. After milling, the post and core was placed into the post space to evaluate the fit by using the silicone disclosing agent (Fit Checker Advanced Blue; GC America) to assess the fitting. Any interferences were relieved using a finishing diamond rotary cutting instrument in a high-speed handpiece before the cementation process. Figure 4 showed the comparison of milled post and core (left) and resin pattern (right).

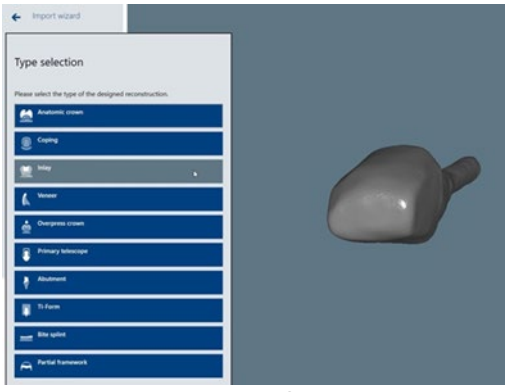


Figure 2a

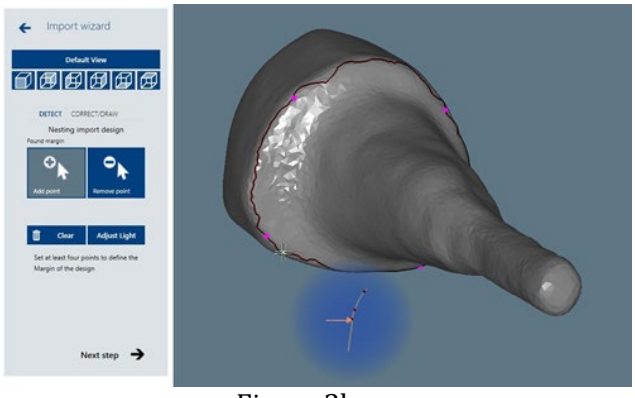


Figure 2b

Figure 2a. An inlay set up was chosen in the CAD software; Figure 2b. Core margin was marked.

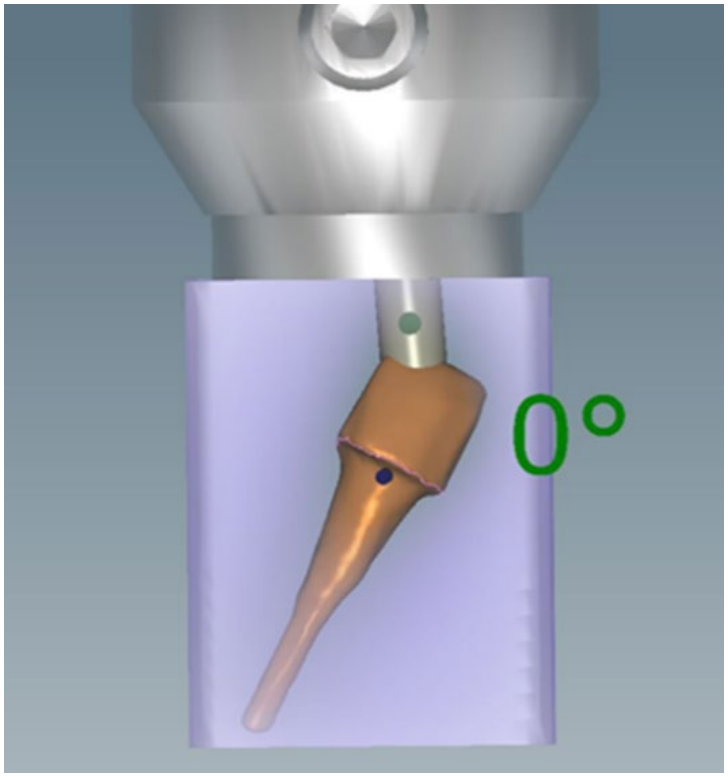


Figure 3. The digital file of the post and core has been angulated to make a 13-mm post and core fit in the 14-mm Vita Enamic® block for milling process

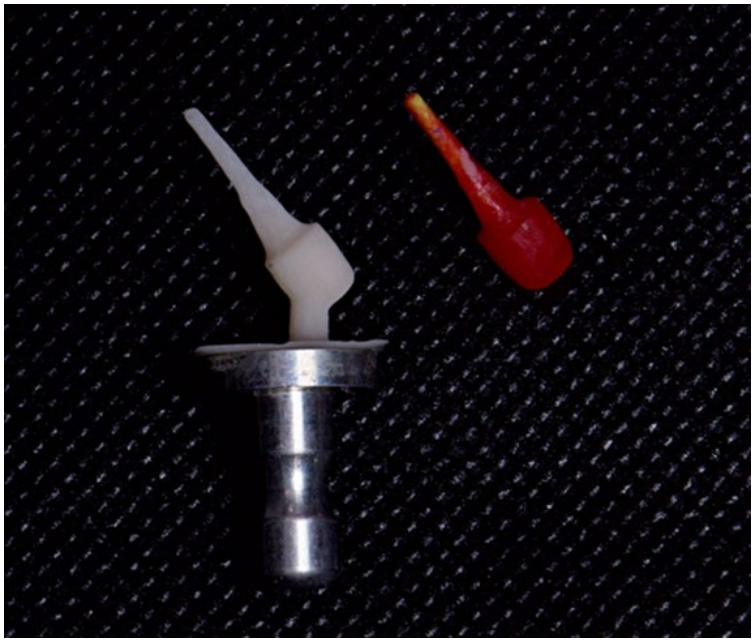

Figure 4. Comparison of milled (right) and pattern resin (left) of post and core

## Discussion

It is important to understand and use appropriate material for the construction of post and core to ensure a positive treatment outcome. To date, no CAD/CAM material blocks are indicated specifically for the fabrication of post and core. Nevertheless, most case reports and *in vitro* studies used tooth-coloured materials that had a comparable modulus of elasticity to dentin. The combination of positive properties of both ceramic and composite materials in this hybrid ceramic block offer optimum performance with a modulus of elasticity that is close to the human dentin which allows uniform stress distribution along the post structure especially during mastication (Pontius & Hutter, 2002; Ausiello *et al*., 2004). A post with high rigidity and higher modulus of elasticity than the dentin might exhibit higher stress distribution throughout the post and root structures which can promote post separation and unfavourable root fracture (Fokkinga *et al*., 2006). Evaluation of tooth preparation prior to scanning and milling of CAD/CAM post and core is extremely important. The clinician must make sure that absence of acute angle on the junction of post surface and apical surface of the core to reduce any risk of fracture during milling process. A round internal line angle on the post structure was recommended (Awad & Marghalani, 2007; Streacker & Geissberger, 2007).

3Shape (Trios,Denmark) is the only fully digital option that available in the market with a special scan post to scan depth of post and core restorations while most of the CAD/CAM systems available in the market are focused on the extracoronal restorations (3Shape, 2013). There are variety of shapes and lengths of scan posts available, which can be employed intraorally or extraorally in a dental laboratory. Two intraoral scans (one of the prepared tooth and another one with the scan post inserted in the prepared canal) are needed for a CAD software to construct the final post and core restoration. Different size and shape of the root canal require different type of scan post; thus, this will add an additional step and is not a cost-effective process as clinicians need to buy the entire scan post system depending on the clinical cases. The fitting of the scan post is very important as it can lead to inaccuracies of the final restoration especially on the apical part (Kanduti *et al*., 2021). Nevertheless, although the system had been in the market since 2013, the clinical evidence on the effectiveness of the scan post is still scarce. Several studies stated that direct digitalisation process was faster as it can eliminate conventional process (Yuzbasioglu *et al*., 2014; Ting-shu & Jian, 2015), but current available Chairside Economical Restoration of Esthetic Ceramics (CEREC) system had indicated that post and core length must be either 10 mm or less if direct digitalisation technique was opted. This is due to unreliable scanning procedure causing incomplete volume reading in narrow post space area which will limit the usage especially for longer root canals. (Pinto *et al.*, 2017).

The presented technique eliminates the need for a scan post in the CAD component and uses the available CAD/CAM system available (Aoralscan 3, Shining 3D Scanner, China) to scan the CAD/CAM post and core. The impression of post space using acrylic resin build-up eliminates the length issue depicted in the direct digitalisation scanning process. However, it is important to note that most of the available length of CAD/CAM block are either 12-mm or 14-mm (Shofu, 2017; Zahnfabrik,, 2021). This can be further explained by the need 2-mm sprue, with core height of 4 to 5-mm leaving only 7 to 8-mm of block material left for the post length. As presented in this case, the CAD/CAM block was angulated to achieve post and core milling of 15-mm in length. Thus, further improvement on inventing a longer block dimensions or production of a disk form will be beneficial in such situation.

The present study utilized the five-axis milling machine that was set to a high-quality; slow speed technique which took around 30 minutes to complete the milling process of the post and core. It is important to note that, the milling of a post and core system requires a slower, low-stress machining approach due to their fine shape, which demands an approach to minimise

vibrations, inaccuracy, and failure of the machining process (Alghazzawi, 2016; Libonati *et al*., 2020).

## Conclusion

This article presents a scanning technique for post and core of indirect digitalisation technique using impression of post space with acrylic resin build-up. Acrylic resin build-up aids in reproducing accurate canal anatomy and detailed length prior to the digital fabrication process.

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