OSR
ORAL SCIENCES REPORTS

Review Article

Received: October 28, 2024
Revised: November 22, 2024
Accepted: December 13, 2024

Corresponding Author:
Tarin Piangsuk, Department of Restorative Dentistry and Periodontics, Faculty of Dentistry, Chiang Mai University, Chiang Mai 50200, Thailand
E-mail: tarin.p@cmu.ac.th

Oral Sci Rep. 2025; 46(1): 5-12

Management of Flared Root Canal with Anatomical Post and Core Using Conventional and Digital Technique: A Literature Review

Pattamaporn Buranasatja[1], Nopawong Luevitoonvechakij[2], Tarin Piangsuk[2]

[1]Graduate Student, Department of Restorative Dentistry and Periodontics, Faculty of Dentistry, Chiang Mai University, Thailand
[2]Department of Restorative Dentistry and Periodontics, Faculty of Dentistry, Chiang Mai University, Thailand

Abstract

Endodontically treated teeth often requires internal retainers and cores to support the final restoration due to significant structural damage. Nevertheless, the discrepancy between the size of the root canal space and the diameter of the post is an important clinical consideration, especially in cases of flared or widened root canals. Even though cast metal post and cores can adapt well to remaining root structure, they present a high elastic modulus which can lead to irreparable root fractures. Conversely, bonding prefabricated glass-fiber posts to flared root canals results in thick resin cement layers, increasing the possibility of structural discontinuities and potentially creating a weak spot in the restoration.

Anatomic post is one of the techniques involving the reconstruction of flared root canals by lining glass-fiber posts with resin composite to match the shape of the flared post space. However, multiple interfaces are created when several materials are used.

The computer-aided design/computer-aided manufacture (CAD/CAM) process can be applied to the production of individually, anatomically fitted, and monolithic posts. Eliminating the need for multiple materials and reducing the number of interfaces in the cemented structure. Both of these technique approaches are highly effective in reducing the amount of luting cement required, enhancing mechanical properties of the restoration and reducing chances of irreparable fracture.

The aim of this literature review is to provide general information, methods for making post and core, mechanical properties, and discuss the efficacy of anatomic fiber post and CAD/CAM customized post and core in flared canals.

Keywords: anatomical post, CAD/CAM post and core, flared root canal

Introduction

Root canal treated teeth often have significant loss of tooth structure, increasing the risk of fracture. Therefore, they are commonly restored with indirect restoration to strengthen the structure, such as crowns and onlays. In some occasions, root canal treated teeth may have flared root canals, which tend to have less strength than normal teeth. Teeth with slightly flared root canals have a higher percentage of circumference in the cervical area larger than the largest prefabricated post, which is around 25-50 percent.[1] Whereas teeth with very flared root canals have more circumference in the cervical area than the largest size of prefabricated post, which is around 50 percent or more. The causes of this flared root canal can result from several factors such as tooth decay, childhood accidents[2], excessive post preparation[3], improperly root canal treatment[4], abnormalities in growth such as tooth germination, and fused root canals.[4] The amount of remaining tooth structure affects the strength of the tooth.[5] Minimal remaining root canal dentin increases the risk of fracture, even with normal chewing forces, therefore, requires additional treatment such as post and core.[6]

Using only a prefabricated post for a flared shape of the root canal, often results in a thick cement layer, which is weak and typically develops air bubbles. This creates a weak point in the restorative material due to stress from shrinkage during polymerization, leading to potential fracture lines and reduced bond strength of the post to the root canal.[7]

Therefore, various methods have been proposed to treat teeth with flared root canals. One of these methods includes anatomical post, which was introduced by Grandini and colleagues in 2003.[8] This method involves using resin composite material to reinforce a glass fiber post, mimicking the shape of the root canal. This approach can reduce the amount of cement and minimize shrinkage during polymerization compared to using cement alone.[6,8-12] Additionally, other methods were proposed which include using accessory posts to fill the space between the main post and the root canal wall.[5,6,12] However, research suggests that using accessory posts does not improve retention in flared root canals and may still lead to air bubbles in the cement. Another method involves intraradicular reinforcement by using resin composite to reinforce the root canal wall.[13] This method increases the thickness of the wall, but it can be challenging to achieve complete polymerization, especially at the root apex.[4,10]

When comparing the fracture resistance of tooth with flared root canals restored with different methods, it has been found that anatomical posts, accessory posts, and intraradicular reinforcement did not significantly differ in fracture resistance.[6,7] However, some studies have shown that anatomical posts provide higher fracture resistance compared to the use of accessory posts.[5,12] Regarding bond strength, anatomical posts, accessory posts, and intraradicular reinforcement did not significantly differ statistically, but they exhibited higher bond strength compared to using prefabricated posts alone.[7] Additionally, when studying stress distribution in teeth with flared root canals restored using various methods, it was found that anatomical posts distributes forces within the post and generates less stress around the root compared to reconstruction using accessory posts and intraradicular rehabilitation.[14] Therefore, considering the mechanical properties, restoring flared canal with anatomical posts represents another interesting option.

Various methods have been employed to fabricate anatomical posts and cores, including the use of digital dentistry. Therefore, the objective of this study is to explore data and methods for using anatomical posts in various situations and to compare the properties of anatomical posts in each types of fabrication.

Materials and Methods

The PubMed (MEDLINE) database was the main resource for gathering the most relevant and current information on anatomical posts and CAD/CAM posts. The search focused on studies published in English from 2000, when research on anatomical posts began, through 2023. Supplementary research was gathered via Google Scholar and targeted searches. The most significant article, along with selected studies, is included in the references.

Literature review

Conventional fabrication of anatomical post and core

There are two methods to fabricate anatomical posts and cores using fiber-reinforced prefabricated posts: the direct technique and the indirect technique.

Direct technique

After removing the gutta percha to prepare the space for the post according to the planned length, a selected prefabricated post is tried in. Then, the prefabricated post is removed, cleaned, and the surface is prepared by applying a silane coupling agent, left for 30 seconds, blown dry, and then an adhesive is applied and light-cured for 20 seconds.

A water-soluble lubricating agent is applied in the root canal to prevent resin composite from adhering to the canal walls. Packable resin composite is then molded around the prefabricated post, and the post is inserted into the root canal. Light curing is done for 10 seconds to initiate preliminary resin composite curing. After this, the post with the resin composite base is removed from the root canal, and a complete curing is achieved through additional curing. Resin composite is then incrementally added layer by layer until the entire length of the post is filled. Finally, the post is shaped appropriately, and additional light curing is performed.

After obtaining the anatomical post, the surface of the post is prepared by applying 37% phosphoric acid for 30 seconds, followed by rinsing with water and drying with air. Next, an adhesive is applied, and then cement is placed into the root canal. Once the post is inserted, excess cement is removed using a small micro brush. After the anatomical post is securely placed, shaping of the core can be performed to prepare for the subsequent crown restoration (Figures 1 and 2).[15] Rubber dam application is advisable for this technique to reduce chance of contamination. However, due to specific condition of the patient a rubber dam was not used in this patient.

Indirect technique

An indirect fabrication technique of anatomical post is very similar to direct technique. However, the procedure is done on master model which comes from root canal impression (Figure 3). When compare between the two techniques it was found that direct technique can reduce laboratory process but has the disadvantages of a risk of resin composite locked in the root canal. On the other hand, the indirect technique can reduce chair time, improve accuracy, and decrease the risk of contamination.[5] Both methods of fabricating anatomical posts result in fracture resistance close to that of metal posts and cores, making them effective alternatives for restoring teeth with flared root canals.[5] However, the anatomical posts using resin composite with glass fiber reinforcement often leads to significant material interfaces due to the use of multiple materials. This method involves several fabrication steps and requires the skills of dentists or dental technicians to ensure that the final piece fits well within the root canal, which may affect long-term success.[7]

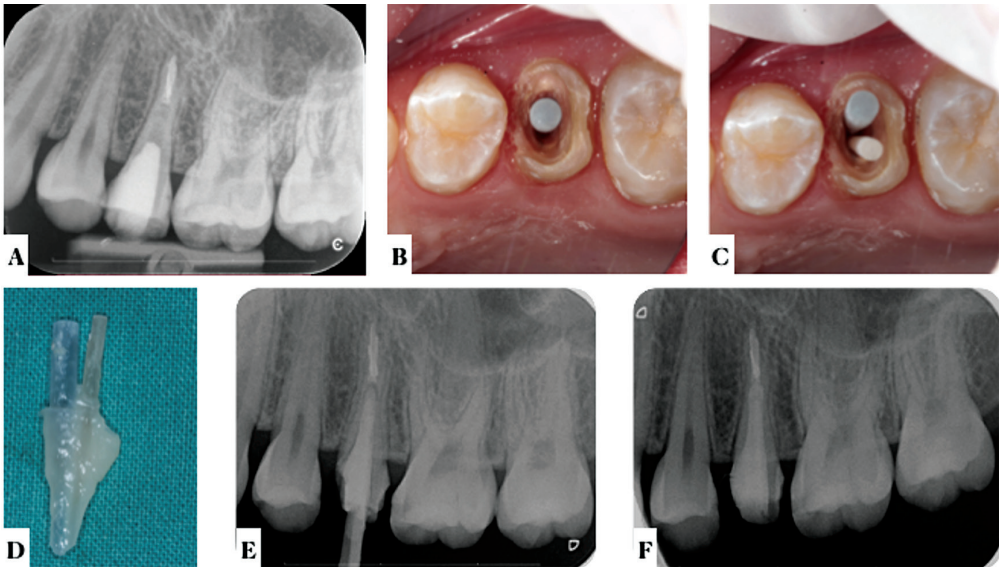

Figure 1: Clinical case for using direct technique to fabricate anatomical post and core. (A), Pre-operative radiograph: (B), Largest prefabricated post was tried-in: (C), A smaller prefabricated post was used as an additional post: (D), Composite resin was applied onto the posts: (E), Radiograph of pre-cementation of anatomical post: (F), Post-operative radiograph.

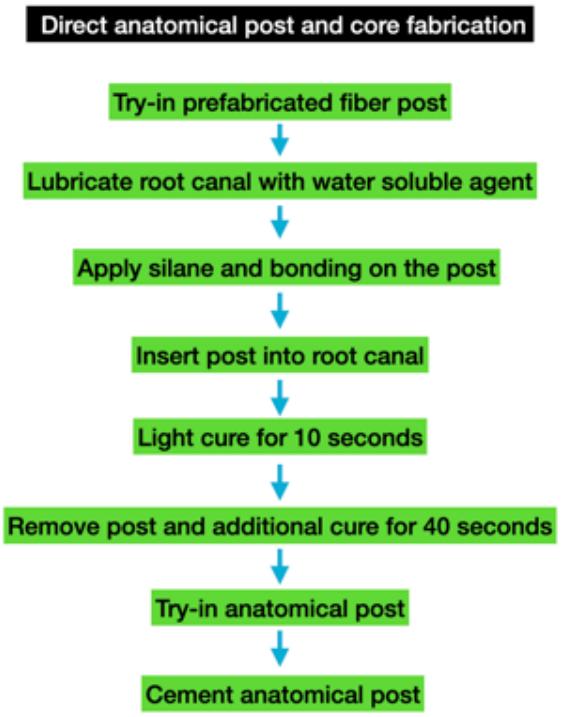

Figure 2: Summary of clinical workflow for direct anatomical post and core fabrication.

Digital fabrication technique for anatomical post and core

The use of computer-aided design and manufacturing in dentistry is another effective option for treating teeth with flared root canals due to its ability to create customized root canal models. This allows the post to fit well and adapt to the root canal. Additionally, using a single material to manufacture post and core reduces material contact surfaces and minimizes shrinkage due to polymerization.[16] CAD/CAM technology enhances the adaptation of the dental post to the root canal and reduces the thickness of the cement layer.[17] Other advantages of CAD/CAM systems include producing precise pieces, reducing errors from human work that may lead to mechanical failures, and the ability to use various types of materials.[18]

There are two ways of using CAD/CAM to fabricate anatomical posts which are fully digital and half digital.[19]

Fully digital technique

Fully digital technique involves using an intraoral scanner to scan the prepared root canal. After removing gutta percha to prepare the space for the post as planned, the intraoral scanner captures images of the coronal structure and the prepared root canal. The system processes these scans into a 3D image, which is then used for computer-aided design to design the post and core. Subsequently, the designed post and core are manufactured using milling or 3D printing machine. Once the post is fabricated, it is tried in the root canal. After fitting, the surface of the post and core is cleaned and prepared based on the chosen material. Adhesive is applied in the root canal, on the post, and the core. Cement is injected and cured according to the manufacturer's instructions. Finally, the core is shaped for subsequent crown placement (Figures 4 and 5).[20] Similar to direct anatomical post technique, rubber dam application is recommended. However, it may interfere with the scanning process like in this particular case. Therefore, the rubber dam was removed and scanning process was repeated without a rubber dam.

An alternative to directly scanning of root canal is to use Scan post™ (3shape; Copenhaegen, Denmark). The Scan post has its extension into root canal and the scan region similar to scan body used for implant restorations. Once it is scanned the CAD software then calculates length and position of the root canal which is then

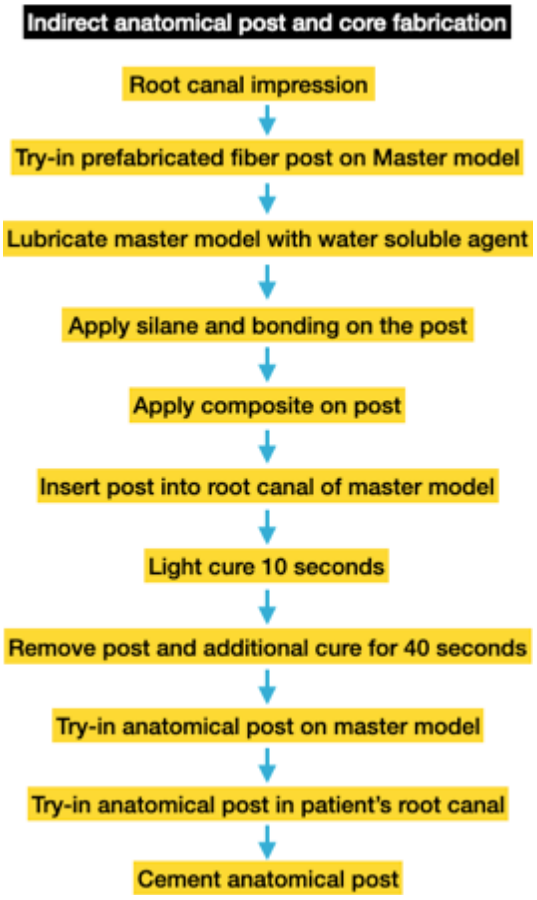

Figure 3: Summary of clinical workflow for indirect anatomical post and core fabrication.

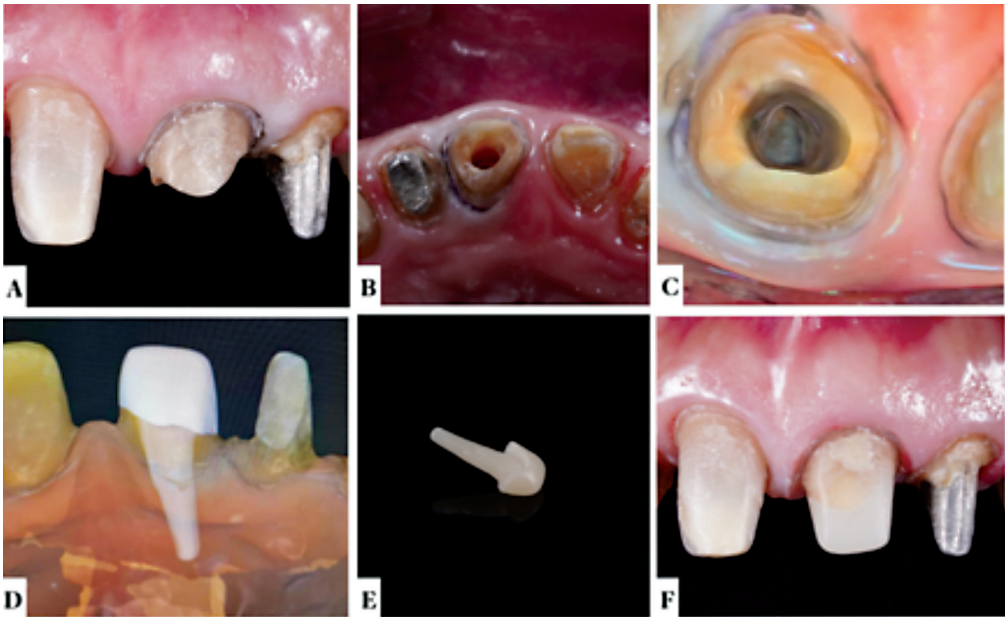

Figure 4: Clinical case for using fully digital technique to fabricate anatomical post and core. (A), Pre-operative anterior view of tooth: (B), Pre-operative occlusal view of tooth: (C), Occlusal view of 3D image from scanner: (D), Design of anatomical post: (E), Anatomical post milled from milling machine: (F), Anatomical post cemented into tooth.

used for designed. A study has shown that the accuracy of scanned root canal is similar with or without using Scan post™. Therefore, it can be used if direct scanning is prohibited.[21]

Half digital technique

Another alternative to direct root canal scanning is half digital technique which utilizes extraoral scanner to scan root canal impression[22], wax, resin or polyvinylsiloxane[23] pattern to fabricate definitive post and core.

Half digital technique involving root canal impression

For this technique, a root canal impression is performed using polyvinylsiloxane. After the impression is made, a scanner is used to digitize it. CAD software is then used to design the post and core accordingly. After that, the material of choice can be selected and fabricated using a milling machine or 3D printer (Figures 6 and 7).[24]

Half digital technique involving direct resin pattern fabrication

In this technique, wax, acrylic resin, or polyvinylsiloxane is used to replicate the shape of the root canal, and the core is also created using a resin pattern. An oral scanner is then used to scan the post and core. CAD software is subsequently used to design them, after which the desired material is selected and fabricated using a milling machine or 3D printer.[24]

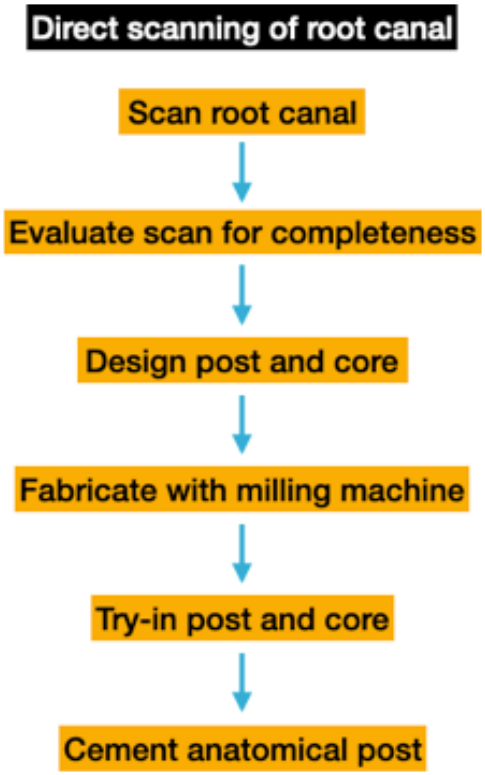

Figure 5: Summary of clinical workflow for fully digital technique.

When considering the advantages of fully digital technique, it is evident that factors causing inaccuracies in post and core fabrication, such as the use of impression materials, gypsum, or acrylic resin, can be eliminated.

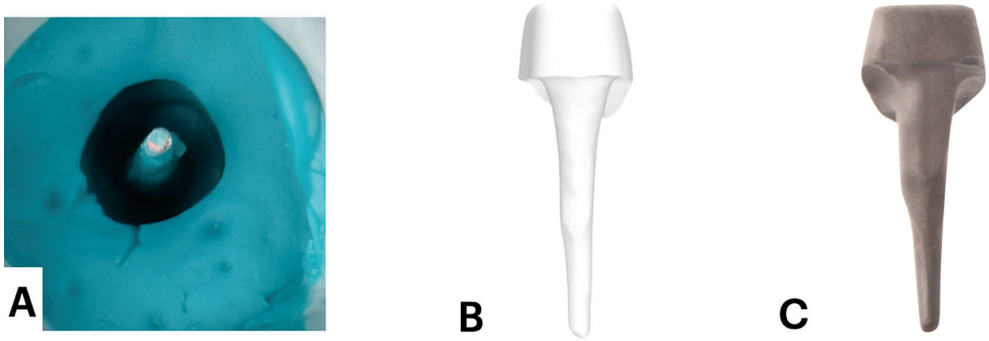

Figure 6: Clinical case for using half digital technique involving root canal impression to fabricate anatomical post and core. (A), Root canal impression: (B), STL file designed in software: (C), Post and core milled from a milling machine.

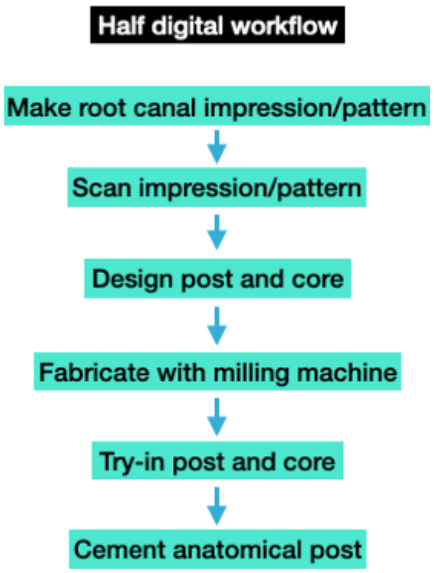

Figure 7: Summary of clinical workflow for half digital technique.

This approach also reduces chairside working time and minimizes laboratory procedures.[23] It was also shown in a study that using fully digital workflow to fabricate metal post and core was more accurate compared to half-digital workflow.[19] However, if the post space is particularly long, the intraoral scanner scan depth may not be enough. Additionally, in teeth with a small or narrow root canal opening, using the intraoral scanner directly may not capture all the details needed.[25] It was also found that the shape of the root canal affects the scanner's trueness. Specifically, if the post space is less than 14 millimeters in length and the root canal opening has a diameter of more than 2.2 millimeters, the intraoral scanner's accuracy was comparable to conventional impression techniques.[26] It is also recommended that, if root canal is longer than 10 mm, half digital technique or Scan post™ should be considered.[25]

Half digital technique involving polyvinylsiloxane pattern fabrication

In this technique, polyvinylsiloxane was directly injected into the root canal, and a rigid metal wire was inserted to form the post and core pattern. The core was created by overfilling the material on the prepared coronal part. Once the material had set, the excess was shaped into the ideal tooth preparation form using a diamond bur. The pattern was then removed, inspected for defects, and scanned. The scanned pattern was utilized to design and mill a wax post and core, which was subsequently cast into a custom metal post and core.[23]

The material used to fabricate post and core with milling machine includes metal, ceramic, and composite materials. However, the flared root canal is weaker, therefore, material with similar modulus of elasticity to dentin should be used.[27] It was found that composite material such as polymer infiltrated ceramic (PINC) had similar fracture resistance compared to metal and zirconia when cemented into root canal. It also showed more favorable failure mode as it was considered reparable.[28] Another composite material created for post and core is fiber glass reinforced composite (Fiber CAD post&core; Angelus, Londrina PR, Brazil) which has similar modulus of elasticity as dentin but offer high flexural strength due to its unidirectional glass fiber reinforcement. A study has shown that using fiber-reinforced composite fabricated with CAD/CAM has higher fracture resistance than conventional anatomical posts and cores when cemented into the root canal. It also demonstrated that the fracture resistance of this material is similar to that of custom metal posts and cores.[29] This result is also shown in another study where fiber-reinforced composite fabricated with CAD/CAM exhibited a higher fracture load than

glass-reinforced fiber posts and anatomical posts in flared root canals.[30] It has been concluded that anatomical posts fabricated using CAD/CAM systems have high precision and fit closely with the root canal, they provide high frictional retention. Additionally, the thin layer of cement allows the post to adhere well to the root canal. Furthermore, the fabrication of anatomical posts through milling creates a single piece (monolayer) for both the post and core, which enhances fracture resistance and improves stress distribution compared to traditional methods.[30]

The thickness of the cement layer is an important factor affecting bond strength, as cement has lower strength than fiber posts. The greater the thickness of the cement layer, the more it contributes to the volume of voids and gaps within the cement and the shrinkage that occurs during the polymerization process. As a result, the bond strength between root canal and post decrease.[30,31] The better adaptation of digitally fabricated post and core results in thinner cement layer thus increase bond strength. A study has shown that pushout bond strength of CAD/CAM fabricated glass fiber post was similar to anatomical post but significantly higher than prefabricated glass reinforced fiber post.[31] Moreover, the amount of cement gap found in CAD/CAM fabricated glass fiber post is less compared to anatomical post and prefabricated glass reinforced fiber post.

Conclusions

Digitally fabricated posts and cores showed promising results compared to conventional methods when restoring flared root canals. This technique can simplify difficult procedures by improving adaptation and bond strength between the root canal and anatomical post, thereby increasing fracture resistance.

References

1. Seckler IN dSBC, Kato AS, Pinheiro SL, Lima DA, de Souza DF. Impact of mechanical load of three post and core systems: CAD/CAM-fabricated glassfiber, prefabricated glassfiber customized with composite resin, and cast metal posts and cores. Cons Dent Endod J. 2020; 5(2):36-41.
2. Boksman L, Hepburn AB, Kogan E, Friedman M, de Rijk W. Fiber post techniques for anatomical root variations. Dent Today. 2011;30(5):104,106-11.
3. Gopal S, Irodi S, Mehta D, Subramanya S, Govindaraju VK. Fracture resistance of endodontically treated roots restored with fiber posts using different resin cements- an *in vitro* study. J Clin Diagn Res. 2017;11(2):Zc52-zc5.
4. Haji-Hassani N, Bakhshi M, Shahabi S. Frequency of iatrogenic errors through root canal treatment procedure in 1335 charts of dental patients. J Int Oral Health. 2015;7 (Suppl 1):14-7.
5. Tait CM, Ricketts DN, Higgins AJ. Weakened anterior roots–intraradicular rehabilitation. Br Dent J. 2005;198 (10):609-17.
6. Clavijo VG, Reis JM, Kabbach W, Silva AL, Oliveira Junior OB, Andrade MF. Fracture strength of flared bovine roots restored with different intraradicular posts. J Appl Oral Sci. 2009;17(6):574-8.
7. Bonfante G, Kaizer OB, Pegoraro LF, do Valle AL. Fracture strength of teeth with flared root canals restored with glass fibre posts. Int Dent J. 2007;57(3):153-60.
8. Gomes GM, Rezende EC, Gomes OM, Gomes JC, Loguercio AD, Reis A. Influence of the resin cement thickness on bond strength and gap formation of fiber posts bonded to root dentin. J Adhes Dent. 2014;16(1):71-8.
9. Grandini S, Sapio S, Simonetti M. Use of anatomic post and core for reconstructing an endodontically treated tooth: a case report. J Adhes Dent. 2003;5(3):243-7.
10. Macedo VC, Faria e Silva AL, Martins LR. Effect of cement type, relining procedure, and length of cementation on pull-out bond strength of fiber posts. J Endod. 2010;36(9):1543-6.
11. Gomes GM, Gomes OM, Gomes JC, Loguercio AD, Calixto AL, Reis A. Evaluation of different restorative techniques for filling flared root canals: fracture resistance and bond strength after mechanical fatigue. J Adhes Dent. 2014;16(3):267-76.
12. Barcellos RR, Correia DP, Farina AP, Mesquita MF, Ferraz CC, Cecchin D. Fracture resistance of endodontically treated teeth restored with intra-radicular post: the effects of post system and dentine thickness. J Biomech. 2013;46(15):2572-7.
13. Silva GR, Santos-Filho PC, Simamoto-Júnior PC, Martins LR, Mota AS, Soares CJ. Effect of post type and restorative techniques on the strain and fracture resistance of flared incisor roots. Braz Dent J. 2011;22(3):230-7.
14. Li Q, Xu B, Wang Y, Cai Y. Effects of auxiliary fiber posts on endodontically treated teeth with flared canals. Oper Dent. 2011;36(4):380-9.
15. Belli S, Eraslan Ö, Eraslan O, Eskitaşcıoğlu G. Effect of restoration technique on stress distribution in roots with flared canals: an FEA study. J Adhes Dent. 2014;16(2): 185-91.
16. Alto RV SG, Santos GO, Noronha J. Tips: customized glass fiber posts. Angelus. 2016:1-5.
17. Ruschel GH, Gomes É A, Silva-Sousa YT, Pinelli RGP, Sousa-Neto MD, Pereira GKR, Spazzin AO. Mechanical properties and superficial characterization of a milled CAD-CAM glass fiber post. J Mech Behav Biomed Mater. 2018;82:187-92.
18. Falcão Spina DR, da Costa RG, Correr GM, Rached RN.

Scanning of root canal impression for the fabrication of a resin CAD-CAM-customized post-and-core. J Prosthet Dent. 2018;120(2):242-5.
19. Ramos Júnior S, Felizardo KR, Guiraldo RD, Berger SB, Ramos NBP, Assis ACM de, *et al.* CAD-CAM endodontic posts: literature review. Res Soc Dev. 2021;10(1):1-7.
20. Hendi AR, Moharrami M, Siadat H, Hajmiragha H, Alikhasi M. The effect of conventional, half-digital, and full-digital fabrication techniques on the retention and apical gap of post and core restorations. J Prosthet Dent. 2019;121(2):364.
21. Libonati A, Di Taranto V, Gallusi G, Montemurro E, Campanella V. CAD/CAM customized glass fiber post and core with digital intraoral impression: a case report. Clin Cosmet Investig Dent. 2020;12:17-24.
22. Leven R, Schmidt A, Binder R, Kampschulte M, Vogler J, Wöstmann B, Schlenz MA. Accuracy of digital impression taking with intraoral scanners and fabrication of CAD/CAM posts and cores in a fully digital workflow. Materials (Basel). 2022;15(12):4199.
23. Piangsuk T, Dawson DV, El-Kerdani T, Lindquist TJ. The accuracy of post and core fabricated with digital technology. J Prosthodont. 2023;32(3):221-6.
24. Farah RI, Aloraini AS, Al-Haj Ali SN. Fabrication of custom post-and-core using a directly fabricated silicone pattern and digital workflow. J Prosthodont. 2020;29(7):631-5.
25. Piangsuk T, Henprasert P, Boonsiriphant P, Lindquist TJ. The accuracy comparison of 3D-printed post and core using castable resin and castable wax resin. J Prosthodont. 2023;32(6):540-5.
26. Al-Qarni FD. Customized post and cores fabricated with CAD/CAM technology: a literature review. Int J Gen Med. 2022;15:4771-9.
27. Elter B, Diker B, Tak Ö. The trueness of an intraoral scanner in scanning different post space depths. J Dent. 2022;127:104352.
28. Gehrcke V, de Oliviera M, Aarestrup F, do Prado M, de Lima CO, Campos CN. Fracture strength of flared root canals restored with different post systems. Eur Endod J. 2017;2(1):1-5.
29. Alkhatri R, Saleh ARM, Kheder W. Evaluating fracture resistance and failure modes of root filled teeth restored with CAD/CAM-fabricated post and core. Clin Cosmet Investig Dent. 2019;11:349-55.
30. Taques LV, Chidoski JC, Ávila BO, Jitumori RT, Gomes JC, Gomes GM. Evaluation of bond strength and fracture load of teeth with flared root canals restored with prefabricated, anatomical, and computer-aided design and computer-aided manufacturing fiber posts. Oper Dent. 2023;48(5):524-37.
31. Gama M, Balbinot GS, Ferreira GC, Mota EG, Leitune V, Collares FM. CAD/CAM milled glass fiber posts: adaptation and mechanical behavior in flared root canals. Oper Dent. 2021;46(4):438-47.