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Anatomic fiber post in maxillary central incisor with ovoid-shaped and flared root canal using an indirect technique: A clinical report

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Objective: This clinical report describes treatment sequence and laboratory techniques for indirect anatomic fiber post fabrication in patient with ovoid-shaped and flared root canal.

Materials and Methods: A 32-year old Thai male was indicated for endodontic treatment followed by post, core and crown for his maxillary right central incisor. Flared and ovoid-shaped canal was detected in this tooth and no prefabricated fiber post could satisfactorily adapted to the canal's entire length. Therefore, indirect anatomic fiber post was chosen to be the restorative technique. Impression of the post space and surrounding tooth structure was performed and working model with the canal replica was established. Composite resin was incrementally relined on to the post into the shape of the replicated canal, and the composite core was formed. Anatomic fiber post was transferred into the maxillary right central incisor's canal and fixed with resin cement. Porcelain-fused metal crowns were fabricated and placed onto both maxillary central incisors.

Results: Indirect anatomic fiber post was found to be radiographically adapted to the root canal's entire length, creating a uniform and thin layer of resin cement without any voids detected. The patient was able to function normally and was satisfied with the final results.

Conclusions: Indirect anatomic fiber post is one possible restoration technique to be used in cases of flared and ovoid root canals. This technique ensures good post adaptation to the root canal wall which could be beneficial in terms of reduction in cement layer thickness and reduction in the polymerization shrinkage of the resin cement.

Keywords: anatomic fiber post, composite resin, flared canal, indirect technique, prefabricated fiber post

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Introduction

Restorations of root canal treated teeth with excessive loss of internal structures can be challenging and complicated. These widened and flared canals with thin dentinal wall can be seen in various circumstances. They could be found in necrotic young permanent teeth, dental caries extended into the radicular dentine, recurrent caries into the root dentin around the post, over-preparation and instrumentation of the root canal, internal root resorption, and fusion or germination [1]. Due to the thin dentinal wall, flared root canals are weakened under normal masticatory forces and, therefore, are more susceptible to fractures [1, 2]. Their wide and tapered internal canal morphology also pose risks of creating a bulky luting cement layer, which could generate a potentially weak spot in the restoration and can further complicate the restorative procedures [3].

In addition to the flared canal, elliptical or oval-shaped canal also raised similar difficulties in both endodontic treatment and prosthodontic

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restorations. The high prevalence of oval-shaped canals has been reported in several studies [4-6]. Because of this ovoid intrinsic anatomy, there is a possibility of leaving an un-instrumented area behind during canal disinfection and creating a smear layer after post space preparation. This could lead to lower the accessibility of dentine surface for post cementation and could results in the increased possibility of post dislodgement ,especially in prefabricated fiber post [7].

Several researchers have studied the failure of post-retained restorations, reporting that the most common cause of post-core restoration failure is from the post debonding [8-10]. Debonding was found to occurred mostly in teeth with inadequate ferrule or teeth with excessive cement layer thickness, especially in the coronal region [11]. Therefore, the key to reduce the incidence of post debonding is a good fitting post that creates a thin and uniform cement layer between the post and the canal wall interface.

Post adaptation is an important aspect for successful long-term results of the prosthetic restoration. However, oval-shaped canal or flared canal restoration with post can be complicated, especially with prefabricated fiber post. Prefabricated fiber post does not always resemble the patient's individual root canal anatomy and can adapt to the canal inaccurately. This leads to an excessive space between the post outer surface and the root canal wall, which would be taken up by a bulk of luting cement. Within this thick and non-uniform cement layer, air bubbles could also be easily trapped in the cement-post-dentin interface [12, 13]. This results in a potentially weak area in the restoration which could compromise the long-term prognosis of the restored tooth [13].

Several different techniques have been proposed to minimize this problem, based upon the principles of increasing the canal wall thickness and reducing the luting cement layer thickness. Lui (1994) reported a direct method of canal rehabilitation technique involving intraradicular composite resin polymerization with light-transmitting post. This method uses composite resin as a reinforcing build-up material for the flared and badly damaged root canal treated tooth. With composite resin bonded to the root dentinal surface, this method would both structurally reinforced the weakened canal wall and reduce the cement layer thickness [1]. However, the complete polymerization of composite resin within the canal, especially the apical portion, is concerning. Another direct technique was cited by Clavijo *et al.* (2009), where accessories fiber posts with small diameter were used in addition to the main prefabricated glass fiber post [14]. It was stated that these accessories fiber posts could help with the canal adaptation in oval or flared root canals, thus minimizing the polymerization shrinkage and preventing de-cementation. However, a report suggested no beneficial effect on the retention strength in flared root canals when accessories posts were used, and there is a high chance of having air bubbles trapped inside the cement layer between the posts [15].

Alternatively, the use of anatomic or custom fiber post is also one of the techniques proposed for large, non-circular, and fragile root canals. It is obtained through molding and relining the prefabricated fiber post directly with composite resin, using either direct or indirect technique [16, 17]. This technique was reported to provide a close adaptation of the post to the canal wall and improves the mechanical and retentive properties of the teeth. Additionally, good laboratory results were also found with this technique [14, 18-20]. In the past, cast metal posts have been traditionally used in flared root canal restorations because of the good canal adaptation [1]. However, because of the biomechanical disadvantages that could result in catastrophic root fractures, prefabricated fiber posts have, therefore, gained an increased in

popularity [21]. Prefabricated fiber posts have several favorable mechanical properties that overrule the use of cast metal post. This includes its modulus of elasticity that is similar to the dentin, allowing the post to become a single unit with the tooth and provides adequate stress distribution within the tooth. As a result, prefabricated fiber post could decreases the incidence of catastrophic root fractures [1, 2]. With the composite resin relined for better post adaptation in the root canal, the anatomic fiber post now reduces excessive space, provides close adaptation of post to the canal wall, and enables the formation of thin and homogenous layer of resin cement. This reduction in cement layer thickness further contributes to an increase in fracture resistance and provides favorable conditions for post retention [16]. Therefore, anatomic or custom fiber post appeared to be an effective technique in the restoration of flared or ovoid-shaped root canal.

This clinical report presents treatment sequence and laboratory techniques in the fabrication of indirect anatomic fiber post in maxillary right central incisor with ovoid-shaped and flared root canal. The report will also discuss factors that would determine the success and failure of this indirect anatomic fiber post technique.

Clinical report

A 32-year old Thai male presented to Oral Diagnostic Clinic, Rangsit University, Thailand with chief complaint of having holes between his 2 maxillary central incisors for many years. He reported that the cavities began to develop around 3 years ago, in which there was consistent food impaction between those two teeth. He also experienced some sensitivity upon drinking cold water, the sensitivity resolved by itself without the need for any medications. Clinical examination revealed tooth 11 (maxillary right central incisor) with large and deep soft brown cavitated carious lesion at mesio-incisal area, positive to EPT and airblow, negative to percussion and palpation (figure. 1A and B). Periapical radiograph showed radiolucent area superimposed to the pulp chamber and widening PDL space at the root apex (figure. 1C). During caries removal process, pulpal exposure due to dental caries was detected. Therefore, the diagnosis given was symptomatic irreversible pulpitis with asymptomatic apical periodontitis [22], and the ideal treatment plan was root canal treatment followed by post, core and crown. Tooth 21 (maxillary left central incisor) also revealed large and deep soft brown cavitated carious lesion at mesio-incisal area, positive to EPT, negative to airblow, percussion and palpation (figure. 1A and B). However, the periapical radiograph showed radiolucent area involved only inner third of the dentin and a normal PDL space (figure. 1C). Caries removal showed no signs of pulpal exposure and reasonable thickness of dentin was remained. Therefore, the diagnosis given was asymptomatic reversible pulpitis with normal apical tissues [22], and the treatment plan was composite filling followed by crown.

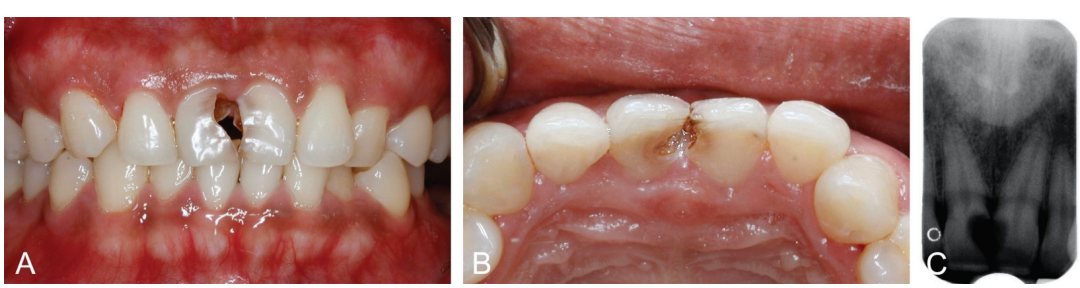

Figure 1 Pre-treatment clinical and radiographic examination of tooth 11 and 21; frontal view when biting (1A), occlusal view (1B) and periapical radiograph (1C)

Upon provisional composite resin restoration on both teeth, it was noticeable that the space for both maxillary central incisors restorations were lost due to long-term cavitation and mesial tooth migration. Interproximal bone height resorption and loss of interdental papilla were also detected between both teeth. Tooth wax-up and space assessment were performed on the study cast, and provisional crowns were fabricated for 11 and 21 teeth using self-cured acrylic resin (UNIFAST Trad; GC America, USA) (Figure. 2A and B).

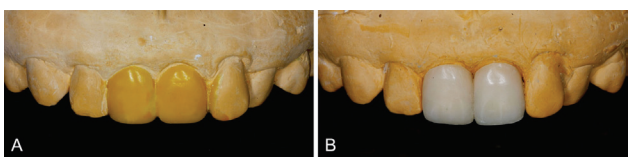

Figure 2 Tooth wax-up and space assessment on study cast (2A) and provisional crowns fabrication using self-cured acrylic resin for tooth 11 and 21 (2B)

After endodontic treatment of tooth 11 was completed and post space preparation was done, preserving 5 mm of apical obturation, prefabricated fiber post was selected and tried in (Figure. 3A-C). Upon cleaning and shaping the root canal of tooth 11, it was noticeable that the canal has an ovoid intrinsic configuration and was relatively flared coronally. Jou et al. (2004) described the "oval" root canal configuration as having a maximal initial horizontal dimension greater than minimal initial horizontal dimension (up to two times more) [23]. Therefore, no prefabricated fiber post size was found to satisfactorily adapt to the canal's entire length. With its slightly coronally flared canal, the larger post diameter would fit to the prepared post space coronally but not apically, and the smaller post diameter would fit to the prepared post space apically but not coronally. Additional post space preparation and the use of larger post diameter could possibly aid in the try-in process. However, because of the circular form of the prefabricated fiber post and the ovoid configuration of the root canal, this mismatch in shape could still lead to an excessive space between the post outer surface and the root canal wall, forming an unwanted bulk of luting cement.

Several methods that could minimize this problem were put into considerations and a decision was made to fabricate an anatomic fiber post using an indirect technique for tooth 11 restoration. Indirect technique was chosen over direct technique due to the concern of saliva contamination, the reduction of the patient's chair time and the errors that could occur during post relining process. Prefabricated fiber post with apical diameter of 0.8 mm and coronal diameter of 1.25 mm was selected for the anatomic post fabrication (D.T. Light-Post® Illusion™ X-RO®, ø 0.5 mm, BISCO, Schaumburg, IL, USA). Upon try-in and radiographic examination, the selected prefabricated fiber post was found to fit perfectly in the apical area, approximate to the gutta-percha interface. However, a noticeable amount of gap between the post and the root canal wall was detected along the middle and coronal portion of the root (Figure. 3C). Therefore, anatomically relining the post with composite resin in these areas for better canal adaptation would be ideal.

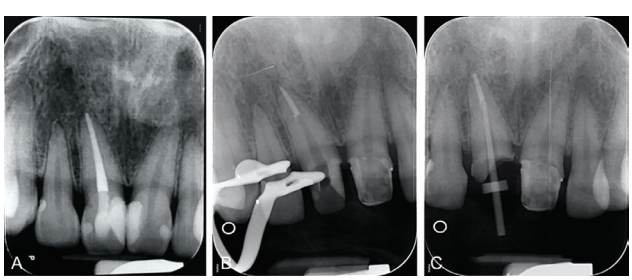

Figure 3 Completion of endodontic treatment on tooth 11 (3A), post space preparation preserving 5 mm apical seal (3B) and try-in of selected prefabricated fiber post, notice considerable amount of gap between the post and the root canal wall (3C)

The method began with an impression of the post space and the surrounding tooth structure using polyether impression material (Impregum™, 3M ESPE), and the working cast was fabricated with Gypsum type IV (Vel-mix stone, Kerr, Chicago, IL, USA). This working cast will serve as a mold of the root canal. In the laboratory process, a thin layer of glycerin gel was applied to the working cast as a separating medium and air thinned. The selected prefabricated fiber post was inserted into the canal replica to verify the measured post length. The surface of prefabricated fiber post was treated with 35% hydrogen peroxide for 5 minutes [24], rinsed with water, and air dried. Silane coupling agent (Monobond® N, Ivoclar Vivadent AG, Schaan, Liechtenstein) was then applied on to the post for 30 seconds and air dried. This was followed by the application of bonding agent (OptiBond™ FL, Kerr, Chicago, IL, USA) to the surface of the post and light-cured using output intensity of 1,100 mW/cm^2 (*Demi*™ Plus LED, Kerr) for 20 seconds. Small portion of A3 dentin-colored composite resin (Filtek™ Z350 XT, 3M ESPE) was placed on to the post surface and adapted into the shape fit for the root canal. The post with composite resin adapted on it was then placed into the canal replica for relining process. After the initial 10 seconds of light polymerization with the relined post inside the canal replica, the post was removed from the canal and light cured for another 40 seconds per side. The post was then reinserted into the canal replica to verify its length and adaptation. The composite resin relining process was repeated incrementally until the whole post length was completely adapted and the composite core was built (Figure. 4A-K).

In a clinical visit, the anatomic fiber post was tried in and was radiographically examined to be successfully adapted. The relined fiber post was cleaned in an ultrasonic cleaner for 5 minutes, rinsed with distilled water and air dried. Post surface was then treated with 37% phosphoric acid for 60 seconds and rinsed with water for cleaning purposes. Self-etching, dual-cure resin cement (Panavia F 2.0, Kuraray Medical Inc., Tokyo, Japan) was handled according to the manufacturer's directions, and the paste was applied on to the post surface. Anatomic fiber post was seated, excess cement was removed, and the remaining cement was light cured for 40 seconds

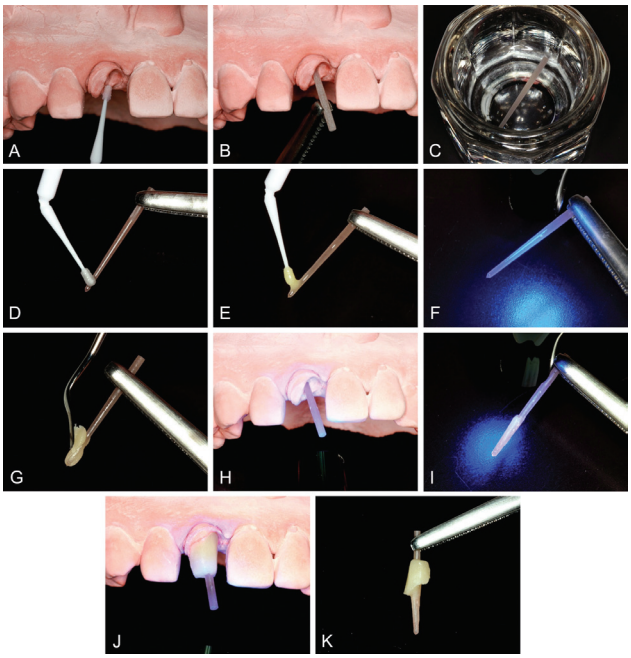

Figure 4 Laboratory process of indirect anatomic post fabrication. Glycerin gel application and air thinned (4A), post length verification with the selected prefabricated fiber post inserted into the canal replica (4B). Post treatment surface with 35% hydrogen peroxide for 5 minutes, rinsed and air dried (4C). Silane coupling agent application and air dried (4D). Application of bonding agent (4E) and light-cured for 20 seconds (4F). Composite resin adaptation onto the post surface to into the shape fit for the canal (4G), placed into the canal replica for the relining process and light cured initially for 10 seconds (4H). Anatomic post removed from the replica canal and light cured for another 40 seconds (4I). Composite resin relining process repeated incrementally until the whole post length was completely adapted and the composite core was built (4J). Final anatomic post (4K).

through the cervical portion of the root. Periapical x-ray was again taken for verifications (Figure. 5C), and final crown preparations for both maxillary central incisors were completed (Figure. 5A). Porcelain fused metal crowns were fabricated for tooth 11 and 21 and were permanently cemented on both teeth using a resin cement (Panavia F2.0, Kuraray Medical Inc., Tokyo, Japan) (Figure. 5B and D).

The patient was scheduled for follow-up visits 1 day, 1 week and 2 weeks after the cementation. The patient was able to function normally, the gingival tissue condition was healthy, and the patient was generally satisfied with the final results (Figure. 5E).

Discussion

Obtaining a well-fitted post in a flared or oval-shaped root canal can be difficult and problematic. Throughout the years, many studies have been attempted to improve the adaptation of post to canal anatomy and have proposed and tested many techniques accordingly.

Figure 5 Final crown preparation (5A) and porcelain fused to metal crown cementation (5B). Periapical radiographic verification revealed tooth 11 with good post adaptation to the canal wall (5C). Periapical radiographic verification of tooth 11 and 21 crown cementation (5D). Outcome of the restorative procedures, the patient was satisfied with the treatment results (5E).

In comparison between different restorative post options in flared canals, several researches have investigated the fractural strength in flared canals using custom cast post, prefabricated fiber post, and composite resin relined anatomic fiber post. Of all the studies, cast posts were found to have the least fracture resistance and highest occurrence of irreparable catastrophic root fractures in flared and weakened root canals [2, 18]. This was due to its rigidity and stiffness which allow them to resist greater amount of force without being distorted. Once the stress reached a critical value, failure of the adhesive system at post-cement-root dentin interface could occur. As a result, the stiff metal post will cause a wedging effect that leads to stress concentration at the interface and root fracture, especially in cases of flared root canal with thin dentinal wall [18].

On the other hand, lower incidence of irreparable catastrophic fractures was displayed in flared root canals that restored with composite resin relined anatomic fiber post, when compared to custom cast post group. The explanation given was that the elastic modulus of dentin (15-25 GPa), fiber posts (30-40 GPa), and composite resin (20 GPa) are in correspondence to each other, resulting in the formation of a biomechanical homogeneity unit. This unit with low modulus of elasticity could also act as shock absorbers which homogenously distribute tension and could also potentially promote the tooth strength [18].

In addition, Coelho *et al*. (2009) research that compared stress distribution between cast metal post and prefabricated fiber post revealed homogeneous distribution of the load along the root and periodontal support in the prefabricated fiber post group. Unlike custom cast post, prefabricated fiber post has a similar modulus of elasticity to dentin in which its flexibility prevents the propagation of microcracks, reduce stress at the interface, and thereby reduce the chance of catastrophic root fractures [25].

Prefabricated fiber post in normal root canal was reported to have a survival percentage after fatigue test of 100%, meaning no fracture was detected. However, the survival percentage decreased to 70% in flared canals restored with only prefabricated fiber post. The highest incidence of irreparable fractures (40%) was also observed in this group. Ferro *et al*. (2016) study further compared the survival percentage of direct anatomic post and indirect anatomic post restored in flared canals. They were both found to have an increased in survival percentage of up to 80% and lower incidence of irreparable fractures (20%) when compared to the prefabricated fiber post only group in flared canals. The explanation given was that direct and indirect anatomic post offer a closer contact between resin cement and the dentinal wall. This decreases the cement layer thickness and increases the homogenous continuality of the resin cement layer. As a result, this will less likely to cause stress to concentrate within one area and, therefore, reduce the risk of root fracture. Furthermore, composite resin surrounding the anatomic post was reported to improve the long-term prognosis of the restoration by reducing the stress concentration at interfaces and uniformly distributes the force which will reduce the occurrence of irreparable fractures [12].

As previously mentioned, one of the most commonly found failures in prefabricated fiber post is the post debonding as a result of inadequate ferrule and excessive thickness of cement layer. Flared or elliptical canal with prefabricated fiber post restoration will most likely to suffer from this event. However, the use of composite resin relined fiber post in flared or elliptical canals can promote closer adaptation of post to the root canal walls. This technique creates a uniform thin cement layer which favors in both long term prognosis and ensuring greater retentive strength. The reduction in thickness of resin cement layer decreases the porosity formed in the cement layer and lessen the polymerization shrinkage and stress occurred at the cement/dentin and cement/post interface [18]. The closer contact between the resin cement and dentinal wall will also increases the frictional retention due to better adaptation of the post to the canal wall and increase in contact area [12]. This is in correlation with Al-Assar *et al*. (2015) study which concluded that composite reinforced anatomic fiber post has significantly higher retention than prefabricated fiber post when restored in flared canals [19]. Additionally, Rocha *et al*. (2017) also revealed an increased in bond strength value in the anatomic fiber post group and the significant reduction in bubbles formation in the cement layer of this group [20].

Throughout the years, several other techniques have been mentioned for the restoration of flared root canals including the use of accessory fiber posts and root canal reinforcement with composite resin. However, various difficulties were reported in those techniques. The thickness of cement layer in the canals restored with accessory posts was not significantly reduced and the likelihood of bubbles trapped inside the cement layer was still high. Root canal reinforcement with composite resin poses risk of inadequate polymerization of composite resin in the deepest regions of the root canal wall. This could be responsible for the lower bond strength value and lower fracture resistance [26].

In this case report, an indirect method was chosen in the fabrication of the anatomic post where post space impression was done, and the anatomic post was made in the laboratory in order to reduce the patient's chair time and errors occurred during post relining. Even though it is a time-consuming option, this method still provides the superior accuracy, mechanical properties [14] and less contamination risk in comparison to the other methods. Alternatively, a direct method of anatomic post fabrication could also be considered as the technique is relatively faster

and no laboratory process is needed [16]. Nevertheless, this technique bears great risk during the relining process as composite resin could get stuck in the canal easily if it was not properly lubricated or if there was any undercut remained.

Therefore, choosing the right case is one of the most important factors that would determine the success of the restorative procedures. As post space impression is needed to be performed in the indirect anatomic post fabrication and the main objective of the procedure is to reduce the space between the post and the canal wall, flared or non-circular shaped canals that are relatively large should only be selected for this procedure. Narrow canals with constricted apical will pose great risk of having the impression material trapped and stuck within those confined area. Additionally, the selected canals for this procedure should not have any undercut remained and no gouging present in any areas above the apical obturation. Furthermore, special caution must be made during the canal impression in this indirect anatomic post fabrication technique. The post space impression must be accurate and must be the exact same dimension as the prepared post canal. Canal's length must be accurately measured in the patient's prepared post space, the post space impression, and the working cast where all length must be the same. To prevent any composite resin from getting stuck inside the canal of the working cast, lubricating the canal walls with glycerin gel was suggested [14, 27]. As a result, proper cleaning and removal of the contaminated glycerin gel on the anatomic post after composite resin relining process must be established. In this case report, the final anatomic fiber post was cleansed by immersion in an ultrasonic cleaner using a general-purpose ultrasonic cleaning solution for 5 minutes and was rinsed in distilled water abundantly to remove any remaining soap [28].

Light transmitting DT Light post which composes of epoxy resin (40%) and quartz fiber (60%) [29], and Methacrylate resin-based composites (Filtek™ Z350 XT, 3M ESPE) were used in this case report as a main core for composite resin application and as a post relining material in the anatomic post fabrication. However, because of the polymerized epoxy resin matrices of the prefabricated fiber post, this results in lack of strong chemical bond between the composite resin (methacrylate-based) and the untreated post surface [30]. This absence in chemical interaction can cause a weakness in the post-to-composite bonds. Removal of the superficial epoxy resin layer through post surface treatment is therefore required for a chemical bond through silanization. Hydrogen peroxide was suggested to be the post surface treatment of choice in order to expose the embedded quartz fibers for silane application. Spaces between each exposed fiber will also provide additional sites for the micromechanical retention composite resin [31]. This was supported by a study involving SEM evaluation which revealed greater impact on post surface modification where greater depth of epoxy resin matrix was removed using hydrogen peroxide, in comparison to methylene chloride. In consequence, a significant increase in shear bond strength between the composite resin and prefabricated fiber was found in this group where hydrogen peroxide was used for post surface treatment and silane was used for chemical retention [32]. In this case report, prefabricated fiber post surface was treated with 35% hydrogen peroxide for 5 minutes prior to silane application. With the concentration of 35% to be readily available in many clinics in a form of tooth bleaching agent, this makes the 35% concentration to be clinically convenient. Even though a study found that treatment with 30% hydrogen peroxide for 10 minutes provided the best push-out bond strength, but the result comparing with 35% hydrogen peroxide for 5 minutes was not statistically different. Therefore, the use of easily accessible 35% concentration with a shorter treatment time of 5 minutes seems to be a better option practically [24].

In this case, A3 dentin-colored composite resin (Filtek™ Z350 XT, 3M ESPE) was selected to be used as the color was slightly different from the patient's dentin so the adaptation of the core part can be easily verified, and the color was not too dark that it would interfere with the esthetics or the light curing polymerization process. In addition, Indirect composite resin could also be one of the material options when an indirect method was chosen in the fabrication of the anatomic post. According to Nandini (2010), various studies showed an elastic modulus of indirect composite resin ranging from 8.5 - 22 GPa. The figure is similar to that of fiber post (about 20 GPa) and of dentin (about 18 GPa). This suggests that using indirect composite resin in anatomic fiber post can promote a relatively uniform pattern of stress distribution, thus dropping the risk of root fracture. However, specific conditions and processing methods are required for the polymerization of indirect composite resin, and more researches are needed to be done for the use of this material in an anatomic fiber post [33].

Although the caries progression is quite deep for tooth 21 and permanent PFM crown was planned as a final restoration, intentional root canal treatment was not performed in this tooth. This is because observations for any signs and symptoms of pulp inflammation had been executed by the means of temporary crown placement for over 2 months prior to the final crown preparation and impression. Along with several periapical radiographs being taken during the period of tooth 11 endodontic and prosthodontic treatment, no signs of pulp inflammation were detected in tooth 21, and the patient denied any pain nor sensitivity experienced. In consequence, PFM crown was fabricated and cemented on tooth 21 without any endodontic treatment required.

In conclusion, anatomic fiber post is one of many treatment options available in the restoration of weakened, non-circular flared canal. Using either direct or indirect technique, the composite resin relined on the prefabricated fiber post will promote a better post adaptation to the canal shape, reduction in cement layer thickness which leads to the reduction of voids and decrease in the polymerization shrinkage of the resin cement.

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