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Restoring an Extremely Destructed Tooth with Flared Root Canal Walls: A Case Report

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ABSTRACT

Reconstructing severely damaged teeth has always presented a challenge when the remaining crown structure is limited, often requiring retention from the root canal using intracanal posts. However, the real challenge is when the root canal walls are also weak, and there is a high risk of vertical root fracture due to the wedging forces of a rigid post. This case report presents a tooth with extremely flared (0.3mm) root canal walls, successfully restored with a newly introduced polymer made of polyether ether ketone (PEEK), with one-year follow-up. Due to its close elastic modulus to dentin, capacity to bond effectively to tooth structure, shock-absorbing properties, and thereby facilitating favorable stress distribution, utilizing this material for an intracanal post has the potential to mitigate the risk of fractures often associated with cast metal posts. It combines the good fitness of cast posts with the low modulus of elasticity and optical properties of prefabricated fiber posts.

Keywords: Tooth Nonvital; Polyetheretherketone; Post and Core Technique; Conservative Treatment

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INTRODUCTION

Endodontic treatment makes teeth more susceptible to fracture than vital teeth. The remaining dentin thickness is a crucial factor in this regard. In addition, in some cases, a compromise of the root structure might be attributed to immature development, dental caries, over-instrumentation of the root canal, a previously placed restoration using a very large dowel and core, and internal root resorption [1]. Although different treatment modalities have been described for rehabilitating these flared root canals, treatment is always challenging for clinicians [2]. Traditionally, intracanal posts are used for restoring these severely damaged teeth to provide retention and support for the final crown. There are two types of posts, prefabricated and custom-fabricated. The former can be commercially purchased with various shapes, sizes, and materials, while the latter are fabricated through casting. [1]. The preservationists advocate a minimum of 1 mm of sound dentin around the entire dowel surface [3]. In addition, a custom-made post might help preserve tooth structure, with a better adaptation to root canal space [4].

A tooth-colored, custom-made post might have the advantages of both previously discussed treatment options and combine the excellent fitness of casting posts with the optical properties of prefabricated fiber posts. Recently, biocompatible high-performance polymers [Bio-HPP] of polyether ether ketone (PEEK) have been marketed as new dental materials. These polymers are advocated as alternatives for metal and glass ceramics since they exhibit good fracture resistance, more favorable stress distribution, and proper shock-absorbing ability. As an organic thermoplastic polymer in the poly aryl ether ketone (PAEK) family, PEEK is considered a high-performance polymer, mainly serving as an implantation material because it exhibits favorable features and biocompatibility in various fields of medicine. Furthermore, it has been established in orthopedics as a biocompatible alternative material for titanium in the long term. In the dental area, the main application of the PAEK family in dentistry is a temporary implant abutment. In addition, it has found applications as dental clasps and frameworks in removable partial dentures [5].

As a post-and-core material, PEEK should be adequately investigated clinically. A finite element analysis showed that PEEK exhibits higher fracture resistance as a post-and-core material compared to metal and fiberglass post-and-core systems. This material has a favorable stress distribution at the intraradicular surface, reducing the potential of root fracture [5]. Given these favorable findings, this clinical case report describes the clinical and laboratory procedures for a newly introduced PEEK post-and-core and the relevant composite resin build-up, with a one-year follow-up.

CASE REPORT

A 30-year-old female patient was referred from the Endodontics Department for the restoration of the lower left lateral incisor (tooth #32 in the ISO system or tooth #23 in the universal numbering system). The patient had a low socioeconomic status, poor oral hygiene, and several carious lesions. The clinical crown was lost approximately to the level of the gingiva (Figure 1). Radiographic examination showed the over-instrumentation of the root canal, resulting in flared and extremely weak dentinal walls (Figure 2). All the treatment options were explained to the patient, including extraction of the tooth and placement of an implant-supported restoration, or restoring the tooth with resin composite and intra-canal post. Rehabilitation was undertaken with post-and-core and composite build-up based on the patient's choice. Informed consent was obtained.

After removing the temporary restorative material, a gingivectomy was carried out to half the depth of the gingival sulcus (1mm) using a tissue trimmer ceramic bur (CSTT, Ceramic Burs FG, Dia-Tessin, Vanetti SA) (Figure 1). Afterward, gutta-percha was removed, followed by conservative root canal preparation using a bur with a non-cutting end (i.e., Gates-Glidden and Peeso reamer). These instruments cut and remove gutta-percha rather than the dentin of the canal wall [1]. Since the dentinal wall was very thin in the middle third of the root (approximately 0.3mm in the mid-mesial portion of the root (Figure 2)), gutta-percha removal was limited to this level due to the risk of root perforation. In the same session, all the preparation angles were rounded, and the Duralay resin pattern was made for post-and-core.

In the laboratory, the post-and-core resin pattern was sprued and waxed onto a special muffle former and filled with investment material. After a setting time of 25 minutes, the muffle was placed into the preheated

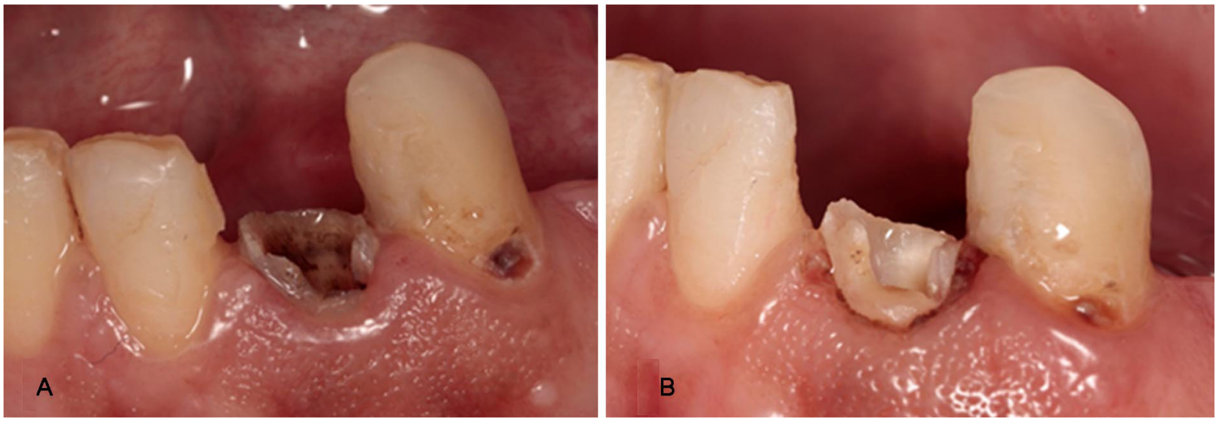

Fig. 1. (A) Initial clinical view showing severe loss of clinical crown. (B) The outcome of gingivectomy with a tissue trimmer bur

preheating furnace at 850°C - 900°C for 45 minutes. Then the temperature was lowered slowly (max. 8°C/minute) to the required melting temperature (400°C) of the PEEK material (BioHPP for2press, Bredent, UK), and the melting reservoir of the muffle was filled with BioHPP for2press in accordance with the wax weight of the model and was placed back into the calibrated preheating furnace at a temperature of 400°C (melting time:20 minutes). The press procedure was completed automatically. Devesting pliers were used to remove the investment material. Investment material residue was removed with a fine sandblasting unit (110μ aluminium oxide, at a pressure of 2.5bar). The distance between the nozzle of the sandblasting unit and the objects should be at least 3cm. Otherwise, the polymer will be heated selectively and damaged. Then, tungsten carbide burs were used to achieve the desired shape (Figure 3).

In the next session, after removing the temporary restorative material, the tooth was cleaned with an endosonic ultrasound cleaner (Figure 4). After testing and adjustments, the PEEK post-and-core was cleaned in an ultrasonic ethanol bath, air abraded, and cemented with resin-modified glass-ionomer (RMGI) (GC Fuji II LC, GC America) [6] under rubber dam isolation (Figure 5). The adhesive resin (Clearfil SE Bond, Kuraray, Japan) was applied to all the dentin surfaces before cementation to enhance the bond strength of RMGI to dentin [7, 8]. The tooth crown was restored with composite resin A2 shade (Aelite All-Purpose Body and Aelite Aesthetic Enamel, BISCO Dental Products, IL, USA) after the bonding process (GPB; GC Corp, Tokyo, Japan) and masking the PEEK color by tinting (Creative Color®Tints, Light Brown, Cosmedent, Chicago, IL). Figure 6 shows the outcome of the restorative procedure at the end of the session. After one year, the restoration was intact and satisfying without any symptoms.

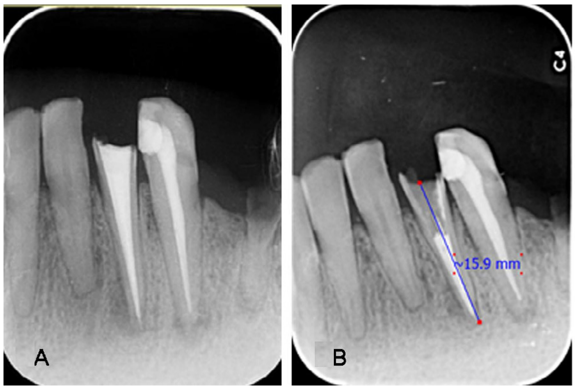

Fig. 2. (A) Initial radiograph showing flared root canal space with thin dentinal walls. (B) Radiographic view at the stage of gutta-percha removal. Note the extremely thin dentinal wall in the mid-mesial portion of the root (approximately 0.3mm)

DISCUSSION

The present case was amenable to prepare a PEEK esthetic post-and-core and composite build-up for management of a tooth with loss of crown structure. Due to the endodontic treatment and over-instrumentation, the root canal was flared with extremely thin radicular dentin (approximately 0.3mm in the middle third of the root). No study was found regarding the management of such cases. Therefore, a custom-made post that was well-fitted to the canal shape and has an elastic modulus similar to dentin was used, which may reduce the possibility of catastrophic fractures by better distribution of stresses in the root dentinal walls.

For decades, the rigid gold cast post was the gold standard for the management of teeth with considerable loss of crown structure. It has several disadvantages. First, they compromised the esthetic 'shine-through phenomenon'. They also demonstrated an increased risk of root fracture due to the marked difference in the modulus of elasticity between metal posts (95.0GPa for gold and 110.0GPa for titanium) compared to dentin (18.6GPa), which amplifies the coronal wedging forces at the already

Fig. 3. Post and core made of PEEK material

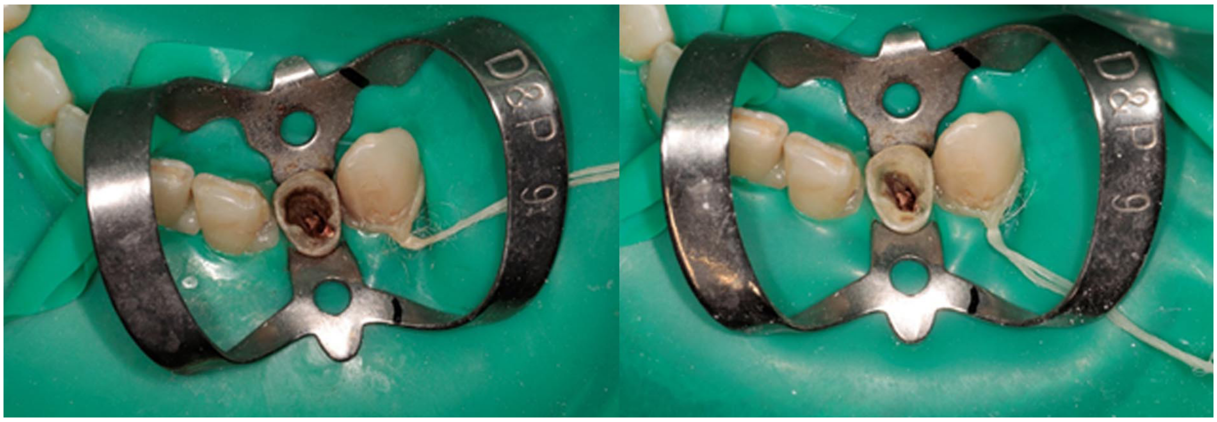

Fig. 4. Occlusal view before (Left) and after (Right) ultrasonic cleaning. Note that the remaining gutta-percha in the narrow channel in the distobuccal portion of the root canal was not completely removed due to the risk of root perforation

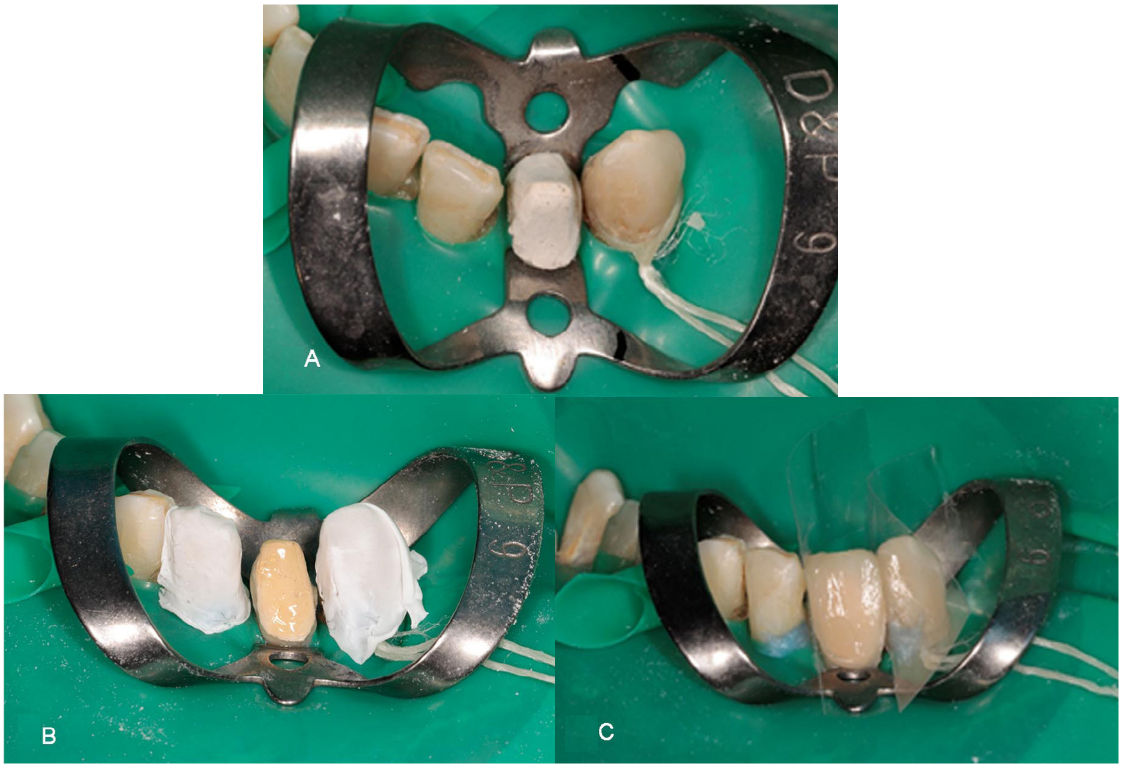

Fig. 5. (A) Cementation of polyether ether ketone post and core (B) Tint was applied with a brush (C) Composite resin placement

Fig. 6. Final view of the restoration on the lower left lateral incisor

weakened root [1, 5]. PEEK has a lower elastic modulus (5.1GPa); therefore, it is expected to cause less stress to the remaining dentinal walls [9]. The gold post does not bond to the tooth structure and needs to be cemented, which also puts the tooth at an increased risk of root fracture. A full coverage crown is needed when restoring a tooth with a gold post and core, while in the presented case, the remaining tooth structure was not enough for achieving the ferrule effect.

Prefabricated fiber-posts have a lower elastic modulus (45.7–53.8GPa) than metallic posts; however, these values are still around three times higher than the elastic modulus of dentin [5]. Moreover, these prefabricated posts do not fit perfectly into the irregular internal anatomy of the root canal. The "anatomic post" technique suggests to reline the fiber posts with a highly filled composite resin when the canal is wider than the largest prefabricated fiber post [10, 11]. In flared root canals, most failures of the fiber posts happen at the coronal portion of the post or cervical third of the root even when it is relined with resin composite [12]. However, the fracture resistance of PEEK post and core is higher than the customized fiber post [13], and it has a more favorable elastic modulus [9].

When the coronal root canal orifice is wider than the largest prefabricated fiber post, another solution might be using "accessory posts" to fill in the discrepancies around the principal glass fiber post and the root canal walls. However, the cement layer thickness does not decrease significantly since there are still empty spaces between the accessory posts and the root canal walls. As a result, the resin cement layer might still harbor large voids [14], decreasing the efficacy of this technique [15].

Prefabricated zirconia posts are also available. Covering zirconia posts with lithium disilicate glass-ceramic (e.max), i.e., the 'pressed ceramic' core technique, has been used for core build-up over prefabricated zirconia posts for higher fracture resistance [4].

PEEK material has several advantages including low elastic modulus, proper mechanical strength, favorable shock-absorbing ability, low hardness and suitable wear behavior, good marginal fit, and biocompatibility [16]. It has acceptable fracture resistance even for use in implant-supported FPDs in the posterior region [17] or endocrowns [18, 19]. According to the manufacturer (Cendres+M´etaux, Milano, Italia), PEEK's compressive strength (246MPa) is similar to that of dentin (297MPa) [5]. However, its modulus of elasticity (5.1GPa) is lower than that of dentin (18.6GPa). The fabrication process is simple, including milling and heat-pressing methods. The pressed technique results in higher accuracy [20, 21], while CAD-CAM milled FPDs showed higher resistance to fracture than those pressed from PEEK-pellets [22]. All these features have made PEEK a promising dental material for custom-made intraradicular dental post-and-core systems. Though, PEEK transfers higher stresses to the interfacial area of the material and restorative crown than other materials due to its flexibility, increasing the odds of debonding and crown failure in PEEK post-and-core systems compared to rigid post-and-core systems [5].

Zoidis et al. successfully used a PEEK post and core with a lithium-disilicate crown for a maxillary lateral incisor. In this case, the root canal walls were not weakened and the remaining crown structure was enough for achieving an ideal ferrule [9]. In contrast to Zoidis, in our case, the tooth structure was severely lost; hence, there was not enough structure for achieving an ideal ferrule, therefore, composite resin was used to build up the tooth. Furthermore, the canal walls were extremely weakened, which increases the possibility of root fracture.

The use of resin cement is important when bonding a BioHPP RBFDP as it provides a bond strength of 25Mpa, which is sufficient for effective bonding and allows for conservative tooth preparations without the need for retentive elements [23]. When comparing PEEK posts with different surface treatments, those with silica-coating, salinization, or sandblasting exhibit higher microtensile bond strengths (average MPa: 18.09 and 16.25, respectively) compared to conventional fiberglass posts (average MPa: 14.93, $p<0.05$). Additionally, the choice of resin cement also plays a critical role in increasing the bond strength of PEEK posts. The highest microtensile bond strength was related to PEEK posts were treated with a silica coating and silane treatment and bonded with RelyX U200 (average: 22.22MPa). compared to G-CEM LinkAce, Multilink Speed, and PANAVIA F2.0 [24]. One in-vitro study showed that glass-ionomer cement (Fuji Plus) exhibited better bond strength than resin cement (RelyX Unicem) with BioHPP and dentin [6].

CONCLUSIONS

According to a successful one-year follow-up presented here, when the dentinal walls of the root canal are thin and the risk of vertical root fracture is high, a custom-made post made of polyether ether ketone (PEEK) polymer seems to be preferred due to the similarity of elastic modulus to dentin, ability to bond to the tooth structure, and shock-absorbing ability. Therefore, favorable stress distribution leads to a reduced chance of catastrophic fracture of the tooth. In addition, it may minimize the risk of fractures commonly observed with cast metal posts. It combines the good fitness of cast posts with the low modulus of elasticity and optical properties of prefabricated fiber posts.

CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Öztürk C, Polat S, Tunçdemir M, Gönüldaş F, Şeker E. Evaluation of the fracture resistance of root filled thin walled teeth restored with different post systems. Biomed J. 2019 Feb;42(1):53-58.
2. Braz R, Mergulhão VA, Oliveira LR, Alves MS, Canto CA. Flared Roots Reinforced With Bulk-fill Flowable Composite - Case Report. Oper Dent. 2018 May/Jun;43(3):225-231.
3. Lloyd PM, Palik JF. The philosophies of dowel diameter preparation: a literature review. J Prosthet Dent. 1993 Jan;69(1):32-6. doi: 10.1016/0022-3913(93)90236-h.
4. S Soundar SI, Suneetha TJ, Angelo MC, Kovoor LC. Analysis of fracture resistance of endodontically treated teeth restored with different post and core system of variable diameters: an in vitro study. J Indian Prosthodont Soc. 2014 Jun;14(2):144-50.
5. Lee KS, Shin JH, Kim JE, Kim JH, Lee WC, Shin SW, et al. Biomechanical Evaluation of a Tooth Restored with High Performance Polymer PEKK Post-Core System: A 3D Finite Element Analysis. Biomed Res Int. 2017;2017:1373127.
6. Yousry MA, Hussein SA, Al Abbassy FH. Evaluation of shear bond strength of high-performance polymers to its resin veneering and to dentin (In vitro study). Alex Dent J. 2018 Aug 1;43(2):62-8.
7. Saad A, Inoue G, Nikaido T, Abdou AMA, Sayed M, Burrow MF, et al. Effect of dentin contamination with two hemostatic agents on bond strength of resin-modified glass ionomer cement with different conditioning. Dent Mater J. 2019 Mar 31;38(2):257-263.
8. Poggio C, Beltrami R, Scribante A, Colombo M, Lombardini M. Effects of dentin surface treatments on shear bond strength of glass-ionomer cements. Ann Stomatol (Roma). 2014 Mar 31;5(1):15-22.
9. Zoidis P. The Use of Modified Polyetheretherketone Post and Core for an Esthetic Lithium Disilicate Anterior Ceramic Restoration: A Clinical Report. Int J Prosthodont. 2021 Jan-Feb;34(1):120-125.
10. Sary S B, Samah M S, Walid A AZ. Effect of restoration technique on resistance to fracture of endodontically treated anterior teeth with flared root canals. J Biomed Res. 2019 Apr 22;33(2):131-138.
11. Boksman L, Hepburn AB, Kogan E, Friedman M, de Rijk W. Fiber post techniques for anatomical root variations. Dent Today. 2011 May;30(5):104, 106-11.
12. 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 Jun;57(3):153-60.
13. AbdElmohsen NA, Zohdy MM, Abdelsattar GA, Wahsh MM. Fracture resistance of different post-core systems restoring mandibular premolars. Mansoura J Dent. 2021; 8(4): 6-11.
14. Grandini S, Goracci C, Monticelli F, Borracchini A, Ferrari M. SEM evaluation of the cement layer thickness after luting two different posts. J Adhes Dent. 2005 Autumn;7(3):235-40.
15. 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 Jun;16(3):267-76.
16. Reda R, Zanza A, Galli M, De Biase A, Testarelli L, Di Nardo D. Applications and clinical behavior of biohpp in prosthetic dentistry: A short review. J Compos Sci. 2022 Mar 14;6(3):90.
17. Jin HY, Teng MH, Wang ZJ, Li X, Liang JY, Wang WX, et al. Comparative evaluation of BioHPP and titanium as a framework veneered with composite resin for implant-supported fixed dental prostheses. J Prosthet Dent. 2019 Oct;122(4):383-388.
18. El-Hosary AM, Al-Zordk W, Abdelkader A, Ghazy M. Influence of material type and preparation

depth on the fracture resistance of endocrown restoration. Egyptian Dent J. 2022 Jan 1;68(1):597-605.

19. Leon S, Salah I, Halim C. Fracture resistance of endodontically treated premolars restored with lithium disilicate crowns retained with fiber posts compared to lithium disilicate and PEEK endocrowns (An in vitro study). Egyptian Dent J. 2022 Oct 1;68(4):3587-607.

20. Lalama M, Rocha MG, O'Neill E, Zoidis P. Polyetheretherketone (PEEK) Post and Core Restorations: A 3D Accuracy Analysis between Heat-Pressed and CAD-CAM Fabrication Methods. J Prosthodont. 2022 Jul;31(6):537-542. doi: 10.1111/jopr.13452. Epub 2021 Dec 3.

21. Naddar S, Hamdy I, Taymour M. Evaluation of The Internal Fit of Pressable Versus CAD/CAM Peek Post and Core Using Scanning Electron Microscope: An in Vitro Study. Egyptian Dent J. 2022 Oct 1;68(4):3671-82.

22. Stawarczyk B, Eichberger M, Uhrenbacher J, Wimmer T, Edelhoff D, Schmidlin PR. Three-unit reinforced polyetheretherketone composite FDPs: influence of fabrication method on load-bearing capacity and failure types. Dent Mater J. 2015;34(1):7-12.

23. Andrikopoulou E, Zoidis P, Artopoulou II, Doukoudakis A. Modified PEEK Resin Bonded Fixed Dental Prosthesis for a Young Cleft Lip and Palate Patient. J Esthet Restor Dent. 2016 Jul;28(4):201-7.

24. Song CH, Choi JW, Jeon YC, Jeong CM, Lee SH, Kang ES, et al. Comparison of the Microtensile Bond Strength of a Polyetherketoneketone (PEKK) Tooth Post Cemented with Various Surface Treatments and Various Resin Cements. Materials (Basel). 2018 May 29;11(6):916.