

Influence of Glass Fiber Post Design and Luting Cements on Ease of Post Removal and Fracture Strength of Endodontically Retreated Teeth: An *In Vitro* Study

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ABSTRACT **Aims and Objectives:** The aim of this study was to evaluate the time needed to remove two types of glass fiber posts cemented with two different cements and removed with two different techniques and to evaluate the fracture strength of teeth after post removal. **Materials and Methods:** Root canal treatment was completed in 80 extracted single-rooted premolars and the teeth were decoronated. Following canal preparation, the roots were coated with polysiloxane impression material and embedded in acrylic resin cubes. The specimens were randomly divided into eight experimental groups ($n = 10$) based on the type of fiber post inserted: Reforpost (R) or Contec Blanco (C); luting cement: Multilink-N/self-etch (M) or G-Cem/self-adhesive (G); technique of removal: Peeso reamer (P); or ultrasonic (U). The posts were removed with respective technique under magnification and the time (in seconds) of post removal was determined. Following post removal, the fracture strength of the specimens was determined using a universal testing machine. The mode of failure was also determined. Data were analyzed by three-way analysis of variance (ANOVA), one-way ANOVA, Tukey's *post hoc* test, *t* test, and correlation. Chi-square analysis was performed to compare the failure mode. Statistical significance was set at $P < 0.05$. **Results:** The post and cement types had an influence in post removal time ($P < 0.05$). There was no role of post or cement types on the fracture strength of teeth after post removal with either technique ($P > 0.05$). A weak negative correlation was found between the post removal time and fracture resistance for both Peeso reamer ($r = -0.373$) and ultrasonic ($r = -0.177$) techniques. Both techniques of post removal produced a majority of favorable failures ($P > 0.05$). **Conclusion:** The type of post and luting cement plays a significant role in ease of post removal by Peeso reamer or ultrasonic technique. Post-removal technique had no effect on the fracture strength of teeth. Parallel serrated fiber post luted with self-etch resin cements was difficult to remove as compared with parallel smooth surface post luted with self-etch or self-adhesive resin cement.

KEYWORDS: Carbide bur, endodontic retreatment, glass-fiber post, self-adhesive resin cement, self-etch resin cement, ultrasonics

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INTRODUCTION

The restoration of endodontically treated teeth with excessive coronal destruction often requires a post and core system.^[1] In recent years, nonmetallic

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prefabricated fiber post systems consisting of inorganic carbon, glass, or quartz fibers embedded in an epoxy or methacrylic matrix are widely used as an alternative to metal posts.^[2] Various types of glass are used to produce prefabricated glass fiber posts such as electric glass, high-resistance or quartz fiber glass, and glass with silica fibers and oxides.^[3] Prefabricated glass fiber posts are popular due to their superior aesthetics and mechanical properties similar to dentine, which minimizes root fractures.^[3,4]

On occasion, a fiber post needs to be removed to facilitate nonsurgical retreatment due to reasons such as endodontic treatment failure, to improve design, mechanics or aesthetics, or when the post system fractures.^[5-7]

Many devices and techniques have been advocated for fiber post removal. However, fiber post removal is still a challenge as the clinician is confronted with a post of unknown brand.^[6] In addition to this, the resin cements with improved dentine bonding make post removal, especially with ultrasonic, less effective.^[8] Hence, a considerable amount of radicular dentine can be lost during retreatment, especially in teeth restored with fiber post.^[1,9] Although studies have evaluated the influence of post or cement types on bond strength or fracture resistance after post placement,^[3,10-13] only few studies have evaluated the influence of fiber post and cement type on ease of removal (time) or fracture resistance after post removal.^[1,8,9,14] Due to the ease of manipulation, self-adhesive resin cements are advocated for fiber post cementation as compared with regular self-etch adhesive technique, which is a sensitive as well as time-consuming procedure.^[13]

A literature search revealed no studies evaluating the influence of post designs (serrated versus smooth) and resin cements (Multilink-N/self-etch versus G-Cem/Self-adhesive) on post-removal techniques (Peeso versus ultrasonic). Hence, the objective of this *in vitro* study was to evaluate the time needed to remove two types of glass fiber posts cemented with two different cements and removed with two different techniques and to evaluate the fracture strength (FS) of teeth after post removal. In addition, the mode of failure after fracture was also determined. The null hypothesis tested was that the glass fiber post design and luting cement have no influence on post removal time and FS.

MATERIALS AND METHODS

This *in vitro* study was conducted at the Department of Conservative Dentistry and Endodontics after approval from the Institutional Ethics Committee. Informed consent was obtained for the use of human extracted teeth for research (IEC protocol no. 24/2018).

The sample size for this study was determined based on previous studies^[1,3,14] using a power analysis program (G*Power Version 3.1.9.6, universitat kiel, Germany), which was determined to be 80 with a 0.5% confidence interval. A total of 80 extracted single-rooted human mandibular first premolar teeth of similar root diameter and length were selected. The inclusion criteria of the study included intact teeth with mature apex and single canal, whereas the exclusion criteria of the study were teeth with restoration, caries, cracks/fracture, developmental defects, resorption (internal or external), and calcification. The teeth were cleaned with an ultrasonic scaler and stored in distilled water. Digital radiographs taken in two planes, that is, buccolingual and mesiodistal (Visualix, Gendex/Dentsply, Milan, Italy), were used to confirm single canal of the tooth. The teeth were decoronated at 2 mm above the proximal cemento–enamel junction (CEJ) under water cooling using a diamond disc (NTI Diamond Disc. Kavo Kerr, CA, USA). Digital Caliper (Digimatic Calipers, Mitsutoyo, Tokyo, Japan) was used to make all teeth measure 14 mm from apex to the coronal reference.

CANAL PREPARATION

The working length was visually determined under $\times 10$ magnification (OPMI PICO; Carl Zeiss, Oberkochen, Germany) by passively placing a size 15 K-file (Mani, INC. Tochigi, Japan) into the canal until it reached the apical foramen and subtracting 0.5 mm from the measured length.

The canals were prepared using ProTaper Gold Rotary instruments (Dentsply Maillefer, Ballaigues, Switzerland) to apical size F3 and irrigated with 1% sodium hypochlorite (NaOCl; Prime Dental Products Pvt Ltd, Thane, India) and 17% ethylene diamine tetraacetic acid (RC Help, Prime Dental Products Pvt Ltd). After the final irrigation with distilled water, the canals were dried using absorbent points (Dentsply Maillefer) and cone fit with F3 size gutta-percha (Dentsply Maillefer) was confirmed. Using a K-file, the apical one-third of the canal was coated with an epoxy-resin-based root canal sealer (AH Plus; Dentsply-DeTrey, Konstanz, Germany). The apical 4 mm of the selected master cone was cut with a scalpel, coated with the sealer and placed apically in the canal using a warm endodontic plugger (sectional obturation). A plain cotton pellet was placed in the canal and a noneugenol temporary filling (Cavit, 3M ESPE AG, Seefeld, Germany) was used to seal the coronal portion. The teeth were stored in 100% humidity for 7 days at 37°C to ensure setting of the sealer.

PERIODONTAL LIGAMENT SIMULATION

The method of periodontal ligament simulation was similar to a previous study. The roots were immersed

into hot liquid wax (Deepti Dental Products of India Pvt Ltd, Ratnagiri, India) 2mm below the facial CEJ. Standardized aluminum tubes (12.20mm × 12.20mm × 29mm) were prepared and the tooth mounted parallel to the long axis of the tube using acrylic resin (Deepti Dental Products of India Pvt Ltd). After polymerization of the acrylic resin, the wax was removed from the roots by using a scalpel and immersing the roots in a hot water bath (55°C) for 2min. Injection type polyvinyl siloxane impression material (GC Flexceed, GC Asia, Singapore) was lined into acrylic resin alveolus using a mixing tip from the dispenser gun and the tooth was reinserted into the resin block. This technique facilitated a uniform 0.2–0.3mm thickness of the material to simulate the periodontal ligament. The specimens were stored at 37°C for 24h.

POST-SPACE PREPARATION AND CEMENTATION

The specimens were randomly assigned to eight groups (n = 10) according to the type of post placed (Reforpost [R] or Contec Blanco [C]), cement used (G-Cem [G] or Multilink-N [M]) and the technique of post removal (Peeso reamer [P] or ultrasonics [U]) as depicted in Figure 1. The materials used in the study are described in Table 1.

Reforpost (Angelus Reforpost Glass Fiber, Londrina–PR–Brazil): The post space was prepared using size 2 Peeso reamer (Mani) 4mm short of tooth length. Any residual sealer on the canal wall was also removed with the Peeso reamer. Before luting, excess post length was cut using high-speed diamond disc (NTI Diamond Disc, Kavo Kerr) under water-cooling. For luting with Multilink-N (Ivoclar Vivadent AG, Schaan/Liechtenstein), the primer A + B were mixed in the ratio of 1:1 and applied on the canal wall for 30s and air dried. The post surface was wiped with

alcohol and Monobond was applied and air dried for 60s. The elongated tip supplied by the manufacturer was used for dispensing of cement into the post-space and the post was inserted into canal immediately to full depth. The post was pressed under a finger for 10s and excess cement was removed with a brush and light-cured (Bluephase C8, Ivoclar-Vivadent, Schaan, Liechtenstein) for 20s. For luting with G-Cem (GC Corporation, Tokyo, Japan), the post surface was wiped with alcohol and Monobond was applied and air-dried for 60s. G-Cem capsule was activated and mixed in capsule mixer for 10s. The elongated tip was used for dispensing the cement into the post space and the post was inserted immediately and held under pressure for 10s. Excess cement was removed with a brush and after 4min it was light cured for 20s.

Contec Blanco post (E. Hahnenkratt GmbH, Benzstrasse, Germany): Same steps were followed as for Reforpost; however, the post space was prepared with the dedicated drill provided in the kit. Flowable resin composite (Tetric N-Flow, Ivoclar-Vivadent, Schaan/Liechtenstein) was used to seal the coronal orifice in order to prevent the post contact with the storage medium.

Before and after the post placement, a radiograph was taken to confirm the position of the post in the canal [Figure 2A]. The teeth were stored in individual vials containing saline until post removal.

POST-REMOVAL PROCEDURE

After 2 days of storage at room temperature, the post-removal procedure was carried out under dental operating microscope (OPMI PICO, Carl Zeiss) at ×10 magnification by an experienced operator who was not blinded to the type of post being removed. However,

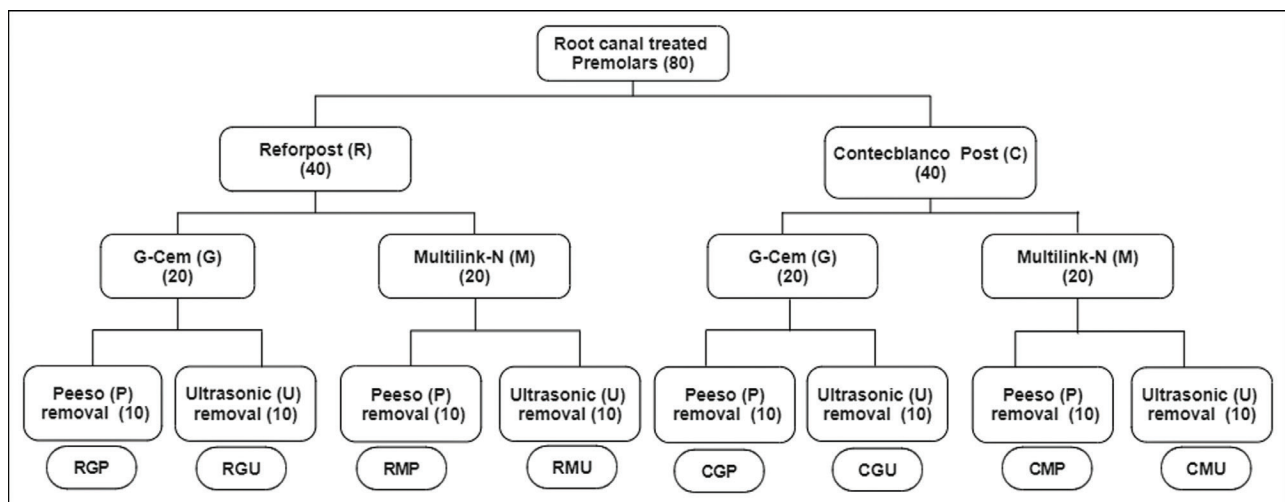


Figure 1: Flow diagram of grouping based on post type, cement type, and removal technique

Table 1: Materials used in the study

Material	Description
Angelus Reforpost Glass Fiber (Londrina, PR, Brazil) Diameter 1.3 mm LOT 101491	<ul style="list-style-type: none"> • Composition: Glass fiber 80%, pigmented resin (Bis-GMA) 19%, and stainless steel filament 1%. • Shape: parallel, serrated, and radiopaque.
Hahnenkratt Contec Blanco Glass Fiber Post (E. Hahnenkratt GmbH, Benzstrasse, Germany) Diameter 1.3 mm LOT 38547	<ul style="list-style-type: none"> • Composition: HT glass fibers • Shape: Cylindrical and a conical apical part, radiopaque, and micro-retentive surface
G-CEM Capsules (GC Corporation) (self-adhesive luting cement) LOT 2002031	<ul style="list-style-type: none"> • Powder: fluoro-alumino-silicate glass, initiator, and pigments • Liquid: dimethacrylate + UDMA+ acidic resins such as phosphoric acid ester monomer + water
Multilink-N (Ivoclar Vivadent AG FL-9494 Schaan/ Liechtenstein) (self-etch adhesive luting cement) LOT W44613	<ul style="list-style-type: none"> • Dimethacrylate and HEMA, barium glass filler and silicon dioxide filler, ytterbium trifluoride, catalyst and stabilizers and pigments; Primer A: Aqueous solution of initiators; Primer B: HEMA, phosphonic acid, and methacrylate monomers • Monobond-S-3-ethacryloxypropyltrimethoxysilane, ethyl alcohol, and distilled water
Round Carbide bur (SS White Burs) Peeso reamers (Mani, INC. Tochigi, Japan) Ultrasonic tip (Dentsply Maillefer, Ballaignes, Switzerland)	<ul style="list-style-type: none"> • 2FGSL (friction grip surgical length): diameter: 0.0630" and length 1.004" • #2 • Start X #3

Bis-GMA = bisphenol A glycidyl methacrylate, HEMA = 2-hydroxyethyl methacrylate, HT = high tenacity, UDMA - urethane dimethacrylate

the operator was blinded regarding the type of cement used for luting the post. One operator performed both procedures of post removal. The specimens were allotted for post removal using a simple randomization method.

Peeso technique

A water-cooled long neck round carbide bur (0.0630" diameter, SS White Burs, Lakewood, New Jersey; Figure 2B) was used to remove the flowable composite covering the fiber post, followed by a #2 Peeso reamer to penetrate the post at low speed without water-cooling [Figure 2C].

Ultrasonic technique

A water-cooled long neck round carbide bur (0.0630" diameter, SS White Burs) was used to remove the flowable composite covering the fiber post and continued apically to worn down until about one-third of the canal length to create adequate space for the placement of ultrasonic

tip to contact the tooth-post bonding interface. Fiber post was removed without water spray using an ultrasonic handpiece (Suprasson P5 Booster, Satelec Acteon, Merignac, France) fitted with a #3 Start-X Ultrasonic tip (Dentsply Maillefer) set to maximum power. The tip was used for post dislodgement by breaking the bonding interface and vibrate out the post [Figure 2D]. During post removal, the aluminum tubes with embedded teeth were held by hand on a flat hard surface.

Post removal time

The time (in seconds) starting from using the first bur mounted on the drill until the apical gutta-percha was first seen in the canal was recorded using a digital stopwatch [Figure 2E and F].

FS determination

Each specimen was mounted using a customized jig and was positioned in the mounting device aligned at a 45° angle with respect to the long axis of the tooth.

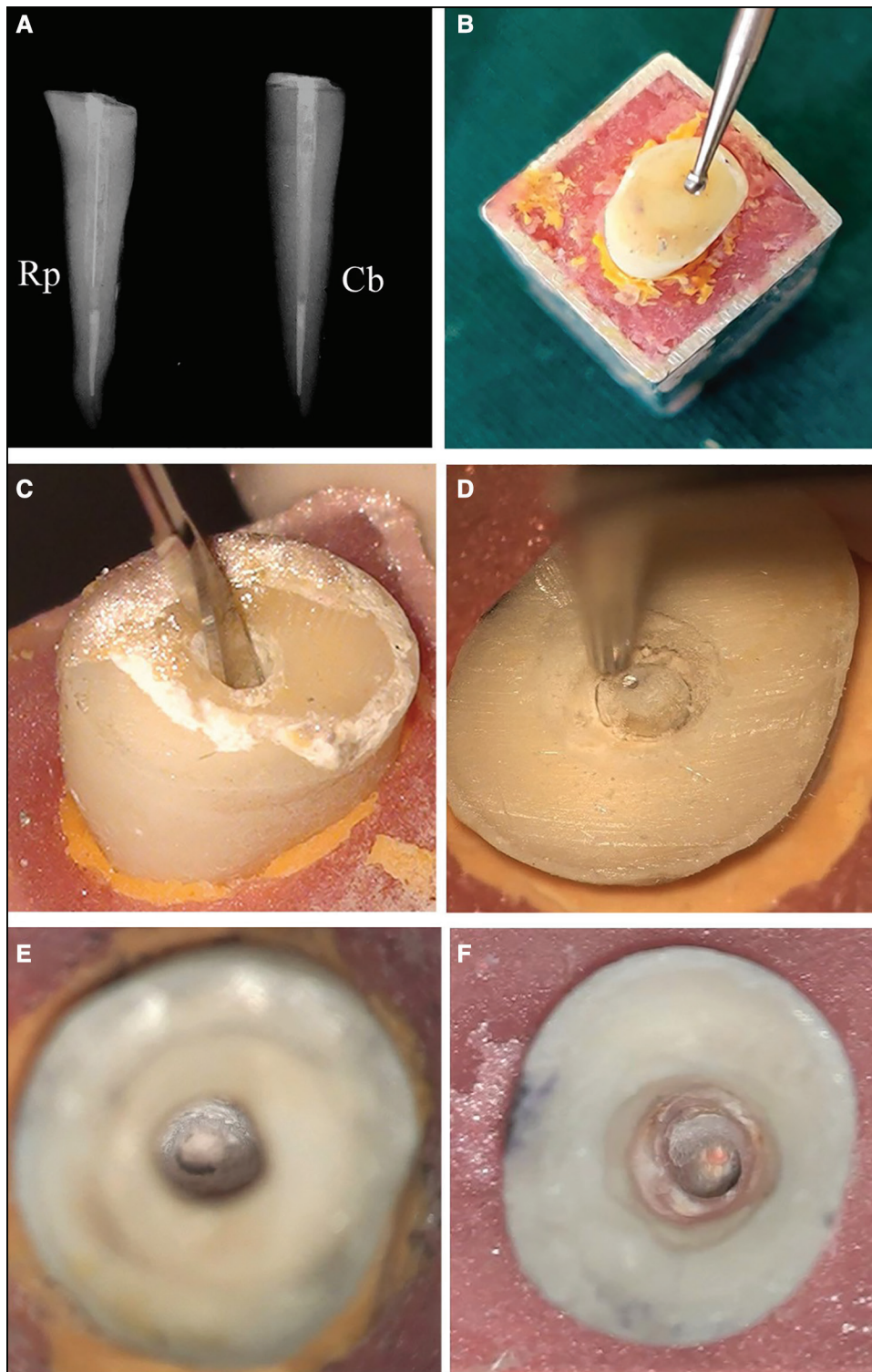


Figure 2: (A) Radiograph confirming (Rp) Reforpost and (Cb) Contec Blanco post position. (B) Surgical length round carbide bur. (C) # 2 Peeso reamer for post removal. (D) #3 Start-X Ultrasonic tip for post removal. (E) Apical gutta-percha seen after post removal using Peeso reamer. (F) Apical gutta-percha seen after ultrasonic removal

A universal testing machine (BISS, ITW, UT-04-0050, Bengaluru, India) was used to apply a constant load using a 3-mm-diameter steel pin with a crosshead speed of 0.5 mm/min until failure [Figure 3]. The peak load to

fracture was recorded in newton (N) and the modes of failure were visually examined under a dental operating microscope at a magnification of 16× (OPMI PICO, Carl Zeiss). The fracture lines extending till the cervical

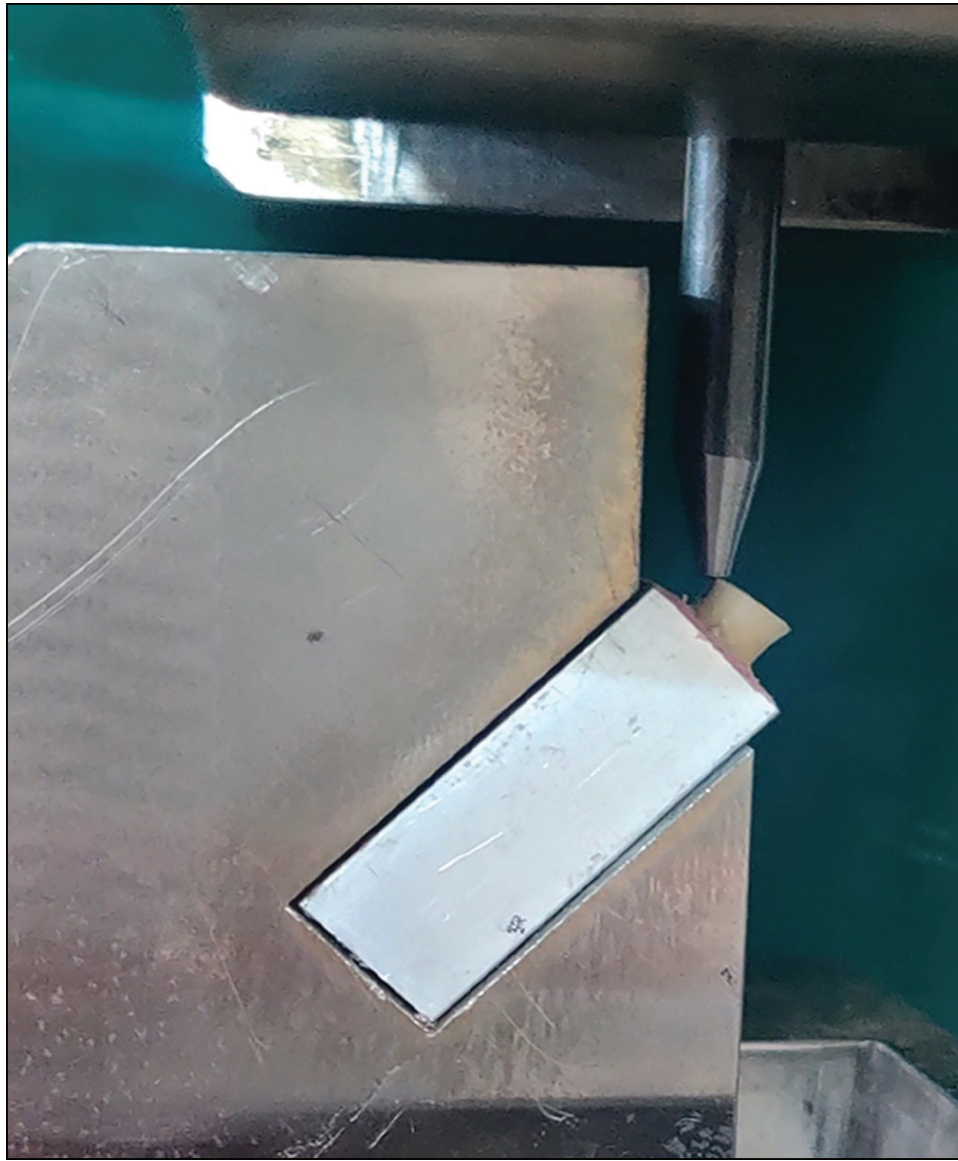


Figure 3: Specimen in universal testing machine

third only were categorized as favorable, whereas those extending to the middle or apical third were categorized as unfavorable.

STATISTICAL ANALYSIS

Data were analyzed for normality using the Shapiro–Wilk test, which showed the normal distribution of the data. Three-way analysis of variance (ANOVA) was used to analyze the interaction between post type, cement type, and the post-removal technique for post removal time and FS (dependent variable). One-way ANOVA and Tukey *post hoc* test were used to compare the Peeso and ultrasonic technique, and *t* test was used to compare the respective groups for Peeso and ultrasonic technique. A correlation test was performed between post removal time and FS. The mode of failure of specimens was analyzed using the chi-square test. The

level of statistical significance was set at $P < 0.05$. All statistical analyses were performed using the Statistical Package for Social Sciences, version 21.0 (IBM SPSS, Chicago, Illinois) for Windows.

RESULTS

Mean (standard deviation) of post removal times (in seconds) and FS (in newton) are presented in Tables 2 and 3, respectively.

- (i) Post removal time: Based on a three-way ANOVA, statistically significant differences were observed while comparing the factors post type, cement type, and the technique of removal ($P < 0.05$). Maximum time was needed for the removal of Reforpost luted with multilink-N using Peeso or ultrasonic technique ($P < 0.05$); however, removal

Table 2: Mean (standard deviation) of post removal time by Peeso and ultrasonic technique

Post	Cement	Post-removal technique		<i>t</i> Test P Value
		Peeso (n = 10)	Ultrasonic (n = 10)	
Reforpost	G-Cem	536.10 ^{Aa} (209.00)	978.50 ^{Ab} (448.62)	<0.05
	Multilink-N	1051.60 ^{Ba} (382.28)	1488.10 ^{Bb} (412.42)	<0.05
Contec Blanco	G-Cem	362.90 ^{Aa} (97.93)	576.40 ^{Aa} (357.39)	>0.05
	Multilink-N	593.50 ^{Aa} (174.15)	702.80 ^{Aa} (135.69)	>0.05
ANOVA		F = 15.037 P < 0.05	F = 12.633 P < 0.05	
		Tukey HSD	Tukey HSD	

ANOVA = analysis of variance, HSD = honestly significant difference

Capital letter superscripts indicate comparison within Peeso or ultrasonic removal technique (one-way ANOVA, significance $P < 0.05$)

Small letter superscripts indicate comparison between Peeso and ultrasonic techniques for respective post and cement (*t* test, $P < 0.05$)

Table 3: Mean (standard deviation) of fracture strength (newton) after post-removal

Post	Cement	Post removal technique		<i>t</i> Test P Value
		Peeso (n = 10)	Ultrasonic (n = 10)	
Reforpost	G-Cem	489.700 (148.14) ^{Aa}	394.00 (75.36) ^{Aa}	>0.05
	Multilink-N	453.90 (262.80) ^{Ab}	345.00 (82.79) ^{Ab}	>0.05
Contec Blanco	G-Cem	550.50 (153.77) ^{Ac}	570.70 (226.94) ^{Bc}	>0.05
	Multilink-N	356.30 (102.70) ^{Ad}	350.80 (139.03) ^{Ad}	>0.05
ANOVA		F = 2.112 P > 0.05	F = 5.390 P < 0.05	
		Tukey HSD	Tukey HSD	

ANOVA = analysis of variance, HSD = honestly significant difference

Capital letter superscripts indicate comparison within Peeso or ultrasonic removal technique (one-way ANOVA, significance $P < 0.05$)

Small letter superscripts indicate comparison between Peeso and ultrasonic techniques for respective post and cement (*t* test, $P < 0.05$)

time for Contec Blanco post was not affected by cement or removal technique ($P > 0.05$).

- (ii) FS: Based on a three-way ANOVA, no statistically significant differences were observed while comparing the factors post type, cement type, and the technique of removal ($P > 0.05$). However, with the ultrasonic technique (one-way ANOVA), Contec Blanco post cemented with G-Cem offered the highest FS ($P < 0.05$). No statistically significant difference was observed in FS values between Peeso and ultrasonic technique ($P > 0.05$).
- (iii) Correlation: A weak negative correlation was found between the post removal time and FS for both Peeso ($r = -0.373$) and ultrasonic ($r = -0.177$) techniques [Figure 4].
- (iv) Mode of failure: Based on the chi-square test, a majority of fractures were favorable for Peeso technique and not ultrasonic post removal. However, this was not statistically significant ($P > 0.05$) [Figure 5].

DISCUSSION

During endodontic retreatment, quick and safe post removal without compromising the mechanical properties of the teeth is an important consideration,

which depends on various factors such as post-removal system, post type, nature of the luting cement, and operator experience.^[7,9]

The null hypothesis tested in this study was that the glass fiber post type and luting cement have no influence on post removal time and FS. The results indicate that the glass fiber post removal time was influenced by the post type, cement type, and removal technique; however, the FS of teeth after post removal by any technique was not influenced by the post or cement type. Hence, the null hypothesis was partly accepted.

Mandibular premolars were selected in this study as they are most susceptible to root fracture and used in previous studies.^[13] To mimic clinical conditions, NaOCl was used for canal irrigation. Although NaOCl is reported to compromise bond strengths of the adhesive systems to canal dentine, Nova *et al.*^[15] observed that NaOCl irrigation did not decrease the bond strength of self-etch or self-adhesive resin cement to a nonacceptable clinical level. Resin-based sealer and sectional obturation was performed in this study to avoid the interference with the resin luting of the post. Posts of similar length and dimensions were placed in the root canal according to the manufacturer's instructions. To enable accurate *in vitro*

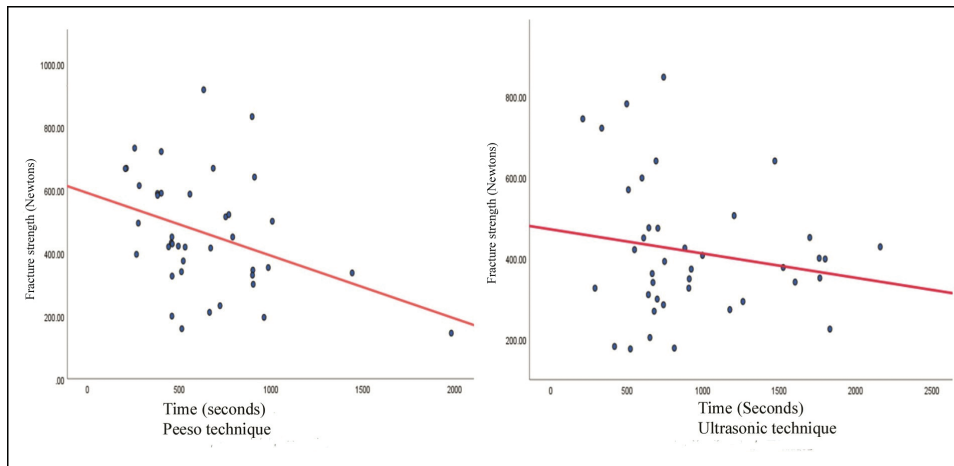


Figure 4: Scatter plot: Correlation between the fracture strength (FS) and time with Peeso ($r = -0.373$) and ultrasonic post-removal technique ($r = -0.177$)

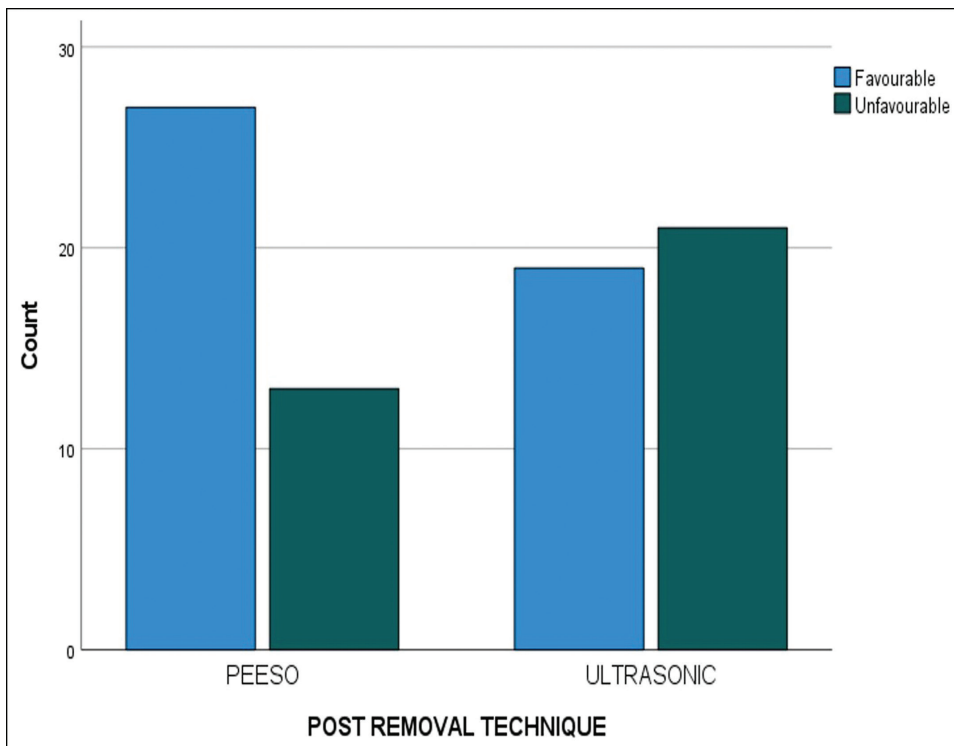


Figure 5: Bar graph: Fracture mode after Peeso (favorable 67.5%, unfavorable 32.5%) and ultrasonic post-removal technique (favorable 47.5%, unfavorable 52.5%). ($P > 0.05$)

replication of oral environment, periodontal ligament simulation was done in this study as in previous studies.^[6,12] In both fiber posts, silane application was carried out to promote adhesion between the post and the resin cement.^[16] However, Sahafi *et al.*^[17] concluded application of silane did not always have a positive effect on retention.

All post-removal procedures were performed by one experienced operator to avoid bias.^[7] A 45° angulation of the specimen was used during specimen loading to

simulate the occlusal contact and characteristics of loading for determining the FS.^[7,12,18]

Reforpost removal time was longer as compared with Contec Blanco, which could be attributed to its parallel and serrated design.^[12,17,18] Although Sayed reported that the central metal filament can cause slippage with the removal instrument,^[19] Novais *et al.*^[4] reported that the mechanical properties of metal filament-reinforced glass fiber post were similar to those of a regular glass fiber post.

With regard to post retention, it has been stated that the dislocation resistance of posts luted with cement is derived from (a) micromechanical interlocking, (b) chemical bonding, and (c) sliding friction. Hence, any factor influencing these parameters could influence the pull-out bond strength of the fiber post.^[15] Pirani *et al.*^[2] concluded that clinical success associated with bonded fiber posts is probably due predominantly to frictional retention. These finding would impact the ease of post removal. According to Goracci *et al.*^[16] other factors that could affect post retention include dentine moisture, the debris produced due to canal preparation and the traces of obturating materials, all of which can directly affect the preparation of dentine and resin adhesive infiltration during the luting procedure.

According to Kremeier *et al.*^[10] the selection of post type may be more important for bond strength than luting material. This study compared the influence of self-etch (Multilink-N) and self-adhesive (G-Cem) resin cements on the ease of post removal. It was found that posts cemented with Multilink-N were difficult to remove. This could be attributed to the difference in the adhesive mechanism and the bond strength to dentine.^[15,20,21]

One of the important causes of cement failure includes the interfacial gaps (discontinuity) in the bonded posts, which is commonly attributed to resin shrinkage because the strength of polymerization contraction often exceeds dentine adhesiveness. This according to Pirani *et al.*^[2] is due to the problem of low compliance in endodontics. Mazzoni *et al.*^[22] found a significant reduction in retention and an increase in the interfacial gap for posts luted with self-adhesive cements as compared with etch-and-rinse cement after thermocycling. Mazzitelli *et al.*^[11] reported an increase in bond strength of G-Cem after thermal aging. As this study did not do thermal aging, the bond strength may have been compromised, resulting in easy post removal.

Bitter *et al.*^[23] evaluated the bonding of various resin cements to dentine and found that self-adhesive resin cement, which showed the formation of a hybrid layer and resin tags only sporadically, had the highest bond strengths. Another reason for easy removal of G-Cem luted posts is the scarce interaction of the adhesive to the substrate due to high viscosity of the resin cement.^[24]

Balbosh *et al.*^[25] recommended roughening of post space to increase the retention of post while using self-etch or self-adhesive cements, which causes micro-mechanical grooves formations where the cement could flow and establish a stronger union. In this study, Reforpost surface had serrations and Contec Blanco had smooth

surface, whereas the canal wall was smooth in all teeth. Hence, this explains the ease of Contec Blanco post removal irrespective of the cement type. Samran *et al.*^[13] reported that additional dentine conditioning step in adhesive cement (total etch) achieved greater bond strength than self-adhesive cement due to formation of a dentine-post monobloc system and this was a determining factor for fracture resistance. Similarly, Zicari *et al.*^[24] found that self-etching 10-methacryloyloxydecyl dihydrogen phosphate-based cements presented the highest push-out bond strength as compared with self-adhesive cements.

The close adaptation of the post and the improvement in radicular dentine bonding make safe post removal challenging.^[7,15] It has been suggested that the use of ultrasonic devices promotes a safe and simple removal while reducing operating time.^[5,7,26] However, while using ultrasonics, the viscoelastic nature of resin cement dampens vibrations and adsorbs ultrasonic energy transmitted to the post. Also, conductance of vibration forces within a post is proportional to the square root of the modulus of elasticity of the post material. So, a fiber post, which has a lower elastic modulus as compared with stainless steel or titanium, transmits vibration energy less effectively.^[26]

In this study, it was found that Reforpost removal was more time-consuming with ultrasonic and the reason could be attributed to the difference in the modulus of elasticity between the post and the presence of metallic filament in the post.^[4]

To increase the action of ultrasonic on the resin cement and to allow post visualization during post removal, water spray was not used in this study.^[14,27] According to Garrido *et al.*^[27] the absence of cooling allows the ultrasound to generate mainly thermal energy instead of mechanical energy, which is responsible for its efficiency. However, it should be remembered that absence of water spray could generate significant heat generation in post and cement, affecting the force required to remove post.

According to Soares *et al.*,^[8] resin cements require a longer vibration time as compared with conventional cements. However, Feiz *et al.*^[28] found there was no significant difference between removal force of self-etch and self-adhesive resin cements using ultrasonics. In this study, Reforpost post luted with multilink was difficult to remove as compared with G-Cem ($P < 0.05$); however, this was not true for Contec Blanco post. Aydemir *et al.*^[1] reported a mean time of 12.70 min and Abe *et al.*^[14] reported a mean time of 10.24 min for fiber post removal using ultrasonic technique. Buoncristiani

et al.^[26] have reported the post removal time could range from 6 to 41.2 min. In this study, the post removal time with ultrasonics ranged from 9.6 to 11.7 min for Contec Blanco and 16.3–24.8 min for Reforpost. The difference in the removal time in this study and other study could be attributed to difference in the type of post, luting cement, ultrasonic tip design and the generator used.^[9,14,15,29]

The reason for lower fracture resistance in teeth after ultrasonic post removal could be attributed to heat production, dentinal microcrack formation, or excessive removal of dentine.^[1] Hence, studies have compared ultrasonic and other techniques like Largo drills and diamond or carbide burs.^[1,5,14,29]

In our study, long neck carbide bur and Peeso reamer were used for post-removal and similar techniques have been reported in the literature.^[6,14] Accordingly, the time of post removal in this study ranged from 8.93–17.51 min (Reforpost) to 6.03–9.8 min (Contec Blanco). These findings are in accordance with previous studies, in which the time of post removal ranged from 3.1 to 16.46 min.^[6,14] Scotti *et al.*^[7] showed the better removal of fiber post by a Profile file combined with a Largo drill than ultrasonic technique. Gesi *et al.*^[29] found that diamond bur combined with a Largo bur was able to remove fiber posts faster when compared with specific removal kits; however, the study concluded that removal time was not affected by type of post.

In this study, regardless of the type of cement, post removal time with Peeso technique was less than the ultrasonic technique, which was statistically significant for Reforpost ($P < 0.05$) and not significant for Contec Blanco post. Lindemann *et al.*^[5] concluded that the removal kits were faster, albeit less effective than the combination of diamond bur and ultrasonic insert.

Although the FS of teeth after post removal with Peeso technique was higher than ultrasonic, there was no statistically significant difference between them and these findings are in agreement with those obtained by the study of Alsafrá *et al.*^[9]

A weak negative correlation between the post removal time and FS was found which indicated, as the post removal time increased, the FS of the teeth decreased. The ultrasonic technique resulted in more unfavorable fracture as compared with Peeso technique, irrespective of the type of the post or the cement. This could be attributed to excess removal of dentine and heat generated during ultrasonic instrumentation.

Major limitations of the study are static loading of specimens for FS determination and absence of thermal aging. Also, the study did not evaluate the role of other post designs like tapered post (smooth or serrated) on

the study parameters. Hence, the results from this study cannot be directly applied in clinical situation and further studies are needed to confirm the findings.

CONCLUSION

Within the limitations of this *in vitro* study, it can be concluded that the post type and cement type influenced the time of the fiber post removal by Peeso or ultrasonic technique; however, these factors do not influence the FS after post removal. Parallel serrated post and/or use of self-etch resin cements was associated with difficulty in post removal as compared with parallel smooth surface post or use of self-adhesive resin cements.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHORS CONTRIBUTIONS

Prerna Priya Krishnarayan: Concepts, design, data acquisition, literature search, manuscript preparation; Paras Mull Gehlot: Concepts, design, Literature search, data analysis, manuscript preparation, manuscript editing, manuscript review.

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

Approval from the Institutional Ethics Committee (JSSDCH IEC) and informed consent was obtained for the use of human extracted teeth for research (IEC protocol no. 24/2018).

PATIENT DECLARATION OF CONSENT

Not applicable.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

1. Aydemir S, Arukaslan G, Sarıdağ S, Kaya-Büyükbayram I, Yıldıran Y. Comparing fracture resistance and the time required for two different fiber post removal systems. *J Prosthodont* 2018;27:771-4.
2. Pirani C, Chersoni S, Foschi F, Piana G, Loushine RJ, Tay FR, *et al.* Does hybridization of intraradicular dentin really improve fiber post retention in endodontically treated teeth? *J Endod* 2005;31:891-4.
3. De Matos LMR, Oliveira LP, Silva AM, Silva JKA, Silva ML. Resistance to fracture of endodontically treated teeth: Influence of the post systems and cements. *Dent Res J (Isfahan)* 2020;17:417-23.
4. Novais VR, Quagliatto PS, Bona AD, Correr-Sobrinho L, Soares CJ. Flexural modulus, flexural strength, and stiffness of fiber-reinforced posts. *Indian J Dent Res* 2009;20:277-81.

5. Lindemann M, Yaman P, Dennison JB, Herrero AA. Comparison of the efficiency and effectiveness of various techniques for removal of fiber posts. *J Endod* 2005;31:520-2.
6. Anderson GC, Perdigão J, Hodges JS, Bowles WR. Efficiency and effectiveness of fiber post removal using 3 techniques. *Quintessence Int* 2007;38:663-70.
7. Scotti N, Bergantin E, Alovisei M, Pasqualini D, Berutti E. Evaluation of a simplified fiber post removal system. *J Endod* 2013;39:1431-4.
8. Soares JA, Brito-Júnior M, Fonseca DR, Melo AF, Santos SM, Sotomayor NC, *et al.* Influence of luting agents on time required for cast post removal by ultrasound: An *in vitro* study. *J Appl Oral Sci* 2009;17:145-9.
9. Alsafra S, Yassin O, Mohammad Y. Effect of three glass fiber post removal techniques on the amount of removed root dentin: An *in vitro* study. *Saudi Endod J* 2021;11:240-5.
10. Kremeier K, Fasen L, Klaiber B, Hofmann N. Influence of endodontic post type (glass fiber, quartz fiber or gold) and luting material on push-out bond strength to dentin *in vitro*. *Dent Mater* 2008;24:660-6.
11. Mazzitelli C, Monticelli F, Toledano M, Ferrari M, Osorio R. Effect of thermal cycling on the bond strength of self-adhesive cements to fiber posts. *Clin Oral Investig* 2012;16:909-15.
12. Jayasenthil A, Solomon-Sathish E, Venkatalakshmi-Aparna P, Balagopal S. Fracture resistance of tooth restored with four glass fiber post systems of varying surface geometries: An *in vitro* study. *J Clin Exp Dent* 2016;8:e44-8.
13. Samran A, Najjar MO, Samran A, Al-Akhali M, Al-Maweri SA, Özcan M. Influence of different post luting cements on the fracture strength of endodontically treated teeth: An *in vitro* study. *Eur Endod J* 2018;3:113-7.
14. Abe FC, Bueno CE, De Martin AS, Davini F, Cunha RS. Efficiency and effectiveness evaluation of three glass fiber post removal techniques using dental structure wear assessment method. *Indian J Dent Res* 2014;25:576-9.
15. Nova V, Karygianni L, Altenburger MJ, Wolkewitz M, Kielbassa AM, Wrbas KT. Pull-out bond strength of a fibre-reinforced composite post system luted with self-adhesive resin cements. *J Dent* 2013;41:1020-6.
16. Goracci C, Ferrari M. Current perspectives on post systems: A literature review. *Aust Dent J* 2011;56:77-83.
17. Sahafi A, Peutzfeldt A, Asmussen E, Gotfredsen K. Retention and failure morphology of prefabricated posts. *Int J Prosthodont* 2004;17:307-12.
18. Teixeira EC, Teixeira FB, Piasick JR, Thompson JY. An *in vitro* assessment of prefabricated fiber post systems. *J Am Dent Assoc* 2006;137:1006-12.
19. Sayed NM. Influence of post and drill design on removal of fiber posts in maxillary molars. *Egypt Dent J* 2015;61:2309-20.
20. Available from: <https://www.gcindidental.com/products/luting-lining/g-cem/2021>. [Last accessed on January 28, 2021].
21. Multilink N. Brochure; 2020. Available from: <https://www.ivoclarvivadent.in/enin/p/all/adhesive-luting-composite/multilink-N>. [Last accessed on December 24, 2020].
22. Mazzoni A, Marchesi G, Cadenaro M, Mazzotti G, Di Lenarda R, Ferrari M, *et al.* Push-out stress for fibre posts luted using different adhesive strategies. *Eur J Oral Sci* 2009;117:447-53.
23. Bitter K, Paris S, Pfuertner C, Neumann K, Kielbassa AM. Morphological and bond strength evaluation of different resin cements to root dentin. *Eur J Oral Sci* 2009;117:326-33.
24. Zicari F, Couthino E, De Munck J, Poitevin A, Scotti R, Naert I, *et al.* Bonding effectiveness and sealing ability of fiber-post bonding. *Dent Mater* 2008;24:967-77.
25. Balbosh A, Ludwig K, Kern M. Comparison of titanium dowel retention using four different luting agents. *J Prosthet Dent* 2005;94:227-33.
26. Buoncristiani J, Seto BG, Caputo AA. Evaluation of ultrasonic and sonic instruments for intraradicular post removal. *J Endod* 1994;20:486-9.
27. Garrido AD, Fonseca TS, Alfredo E, Silva-Sousa YT, Sousa-Neto MD. Influence of ultrasound, with and without water spray cooling, on removal of posts cemented with resin or zinc phosphate cements. *J Endod* 2004;30:173-6.
28. Feiz A, Barekatin B, Naseri R, Zarezadeh H, Askari N, Nasiri S. The influence of ultrasound on removal of prefabricated metal post cemented with different resin cements. *Dent Res J (Isfahan)* 2013;10:760-3.
29. Gesi A, Magnolfi S, Goracci C, Ferrari M. Comparison of two techniques for removing fiber posts. *J Endod* 2003;29:580-2.