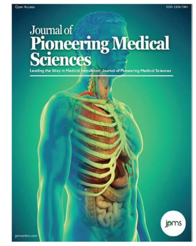

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Comparative Study of Retention of Customized and Conventional Fiber Posts - In vitro study

Osama Ahmed Qutub[1], Saja Abdullah Mannaa[2], Hunaida Khaled Tayeb[3], Abdulrahman Jafar Alhaddad[4], Abdulelah Binmahfooz[5], Ghadeer I. Basunbul[6], Sameer Alghamdi[7], Othman S. Alsulaimani[8], Shatha Abdulrahman Alshali[9], Samar Hatem Abuzinadah[10], Osamah Alsulimani[11], Haneen Abdullah Aljuieed[12], Duaa Youssef Wazgar[13], Moatz Billah Bashar AlReffaie[14], Abeer Ahmed AlSahafi[15], Nawaf Mohammed Althobaiti[16], Abdulaziz Saleh Baatiyah[17] and Ferass Yasser Bahassan[18]

[1-9]Oral and Maxillofacial Prosthodontics Department, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia
[10]Restorative Dentistry Department, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia
[11]Oral Diagnostic Sciences Department, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia
[12]Department of Dental, National Guard Primary Healthcare Center Makkah, Saudi Arabia
[13]Pediatric Dentistry, Hera General Hospital, Makkah, Ministry of Health, Saudi Arabia
[14,16-18]Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia
[15]Faculty of Dentistry, Batterjee Medical College, Jeddah, Saudi Arabia

Author Designation: [1,2,4,5,6,7,9,10,13]Consultant of Prosthodontics, [3,8,11]Assistant Professor, [12]General Dentist, [14,15]Researcher

*Corresponding author: Abdulrahman Jafar Alhaddad (e-mail: aalhaddad@kau.edu.sa).

Abstract: **Background/ Aim:** The continuous development in dental materials and the increased awareness of preserving natural dentition have driven techniques to enhance the treatment of endodontically treated teeth. Prefabricated fiber reinforced (FRC) posts became popular due to their superior aesthetics, adhesive bonding, and modulus of elasticity similar to dentine, which reduces stress concentration and root fracture. Their main limitation is the required canal reshaping to fit the circular post, causing loss of intact dentine and poorer adaptation in roots with elliptical morphology, leading to increased cement thickness and risk of debonding. To avoid unnecessary dentine removal, customized FRC posts were introduced by adding composite resin to the prefabricated post and polymerizing it in situ to replicate the canal anatomy. The aim of this study was to compare the retention of customized and conventional FRC posts. **Method:** Twenty-extracted single rooted human teeth were decoronated, endodontically treated, and post spaces were prepared at equal lengths. Specimens were divided into 2 groups (n = 10), based on the post system used: G1 prefabricated fiber posts (GC), and G2 customized fiber posts using composite. Self-adhesive resin cement was used to cement both post systems. After cementation, the specimens were stored in saline for a duration of 30 days. Pull-out test parallel to the longitudinal axis of the post was carried out using Instron Universal Testing Machine. Data were analyzed using Student *t*-test ($\alpha = 0.05$) and the coefficient of variance as the ratio of standard deviation to the mean. **Results:** The mean pull-out retention strength was 58.54±2.47 N for the prefabricated fiber posts, and 156.02±2.27 N for the customised fiber posts ($p<0.05$). **Conclusions:** The composite customized fiber posts exhibited significantly higher retention forces compared to the prefabricated fiber posts.

Key Words: Prefabricated Fiber Post, Customized Fiber Post, Retention, Pull-Out Test

INTRODUCTION

The continuous development in dental materials, in addition to the increased global awareness of oral health and preserving natural dentition, has steered the wheel for the development of techniques to enhance the treatment of endodontically treated teeth. With the introduction of the original metal posts, followed by the development of the more aesthetic fiber reinforced posts [1]. The popularity of the prefabricated fiber reinforced (FRC) post system, as a favored treatment modality for restoring endodontically treated teeth, can be surely attributed to its superior aesthetics, the utilization of adhesive bonding techniques, and the close resemblance between the modulus of elasticity of the FRC posts and that of dentine (25–57 GPa) [2–4]. The intrinsic flexibility of these posts minimizes the risk of stress concentration within the root canal [5], a major contributing factor for root fracture [6].

In most cases, the main drawback of FRC posts is the inevitable need for some form of canal reshaping, using a drill corresponding to the size of the used post, to allow the seating of the prefabricated posts. This will inadvertently lead to loss of intact dentine from the root canal, with the apical part of the canal being most affected. The cross section of these prefabricated FRC is circular, while over 25% of teeth roots tend to have an elliptical morphology when viewed in cross-section [7].

The process of cleaning and shaping root canals during endodontic treatment results in removal of some dentine from the canal walls, which when combined with some canal modification to fit a prefabricated post, would result in less adaptation of the post to the canal walls and increased thickness of the cement used. Consequently, predisposing the restoration to debonding [8,9].

To evade unnecessary removal of intact radicular dentine, customized FRC posts were introduced. This tailored post system is made via the addition of composite resin to the prefabricated post surface and polymerizing the composite in situ, to make an impression of the interior of the root canal. This innovative method overcomes some of the major problems associated with prefabricated posts, as the generated customized post closely adapts to the root canal walls [10–13].

Both post systems implement similar cementation protocol following manufacturer's instructions for the selected luting cement. There is still a gap in the literature on how the customized FRC posts are performing when compared to prefabricated FRC posts. Therefore, the aim of this study was to compare the retention of customised and conventional FRC posts. The study hypothesized that customized FRC posts would demonstrate retention to the root canal comparable to that obtained with conventional FRC posts.

Aim of the Study

The aim of this study is to compare the differences in retention capacity between customised and conventional FRC posts in teeth with a single canal.

METHODS

Study Design

The study protocol was reviewed and approved by the Ethics committee at King Abdulaziz University faulty of Dentistry Jeddah, Saudi Arabia. For the purpose of this study, a total of 20 intact, straight, single-rooted extracted human premolars exhibiting similar root diameters and lengths were selected. Specimens were randomly split into two groups (n = 10), First group (G1) was assigned to Prefabricated FRC post, and the second group (G2) assigned for customised FRC post.

Specimen Preparation

The roots of the teeth were scraped using universal curettes to remove all attached soft tissues or calculus. The teeth were immersed in 0.05 sodium hypochlorite solution for one hour to ensure adequate disinfection, then rinsed using saline before testing. The teeth were decapitated at coronal level, just above the cemento-enamel junction, using high-speed handpiece and tapered diamond bur with constant water irrigation. The root length of all tested teeth was standardised to 14 mm. Following calibration of the technique by an endodontist, the root canal treatment was carried out for all tested teeth using step -back hand instrumentation protocol utilising ProTaper Universal rotary files. 5 ml of 2.5% NaOCl solution was used for irrigation which was followed by the application of 17% EDTA for 1 minute before rinsing the canal systems with copious amount of 0.9% saline, to ensure thorough elimination of inorganic debris. Sterile RECIPROC paper points corresponding to the master cone size were used to dry the canals. Next, obturation of the canals using gutta percha points (RECIPROC Gutta-Percha; VDW GmbH) and sealer (AH Plus; Dentsply Sirona) was completed using lateral condensation technique. Excess gutta percha was then removed using a heated plugger at level 1 mm coronal to the CEJ. Finally, the canal orifice was sealed using glass ionomer (GC Fuji IX GP Capsules; GC). The samples were immersed in water and stored at room temperature for a duration of 1 week, to allow complete polymerisation of the sealer. In both groups, the basic post space was prepared following the same process. This involved the removal of gutta percha from the coronal 2/3 of the canal using sizes 2 and 3 Gates Glidden drill (G180.204.110; Komet, Gebr, Brasseler GmbH) leaving 4 mm of gutta percha for apical seal. Both investigated groups used the same post size, fiber post size 2 with diameter 0.80 mm and 19 mm total length. Specimens G1 were further prepared to receive the prefabricated post using standardized fiber post drill (colour code: yellow), the prefabricated post was tried in to verify accurate fit, and the canal was flushed with saline and dried using sterile paper points. In G2, prefabricated FRC post was customised to fit the root canal using the composite reline method or 'core build down method' described in previous literature [8,14] as shown in Figure 1.

A thin layer of water-soluble gel (KY Gel, Johnson & Johnson) acting as a separating medium was applied to the interior of the canal to facilitate post removal [15]. The prefabricated FRC post was first coated with 37% phosphoric acid gel (USA Prime-Dent) for twenty seconds, then rinsed off with water using a three-way syringe, and finally gently air-dried. The bonding agent was applied to the post surface (Scotch Bond™ Universal Adhesive, 3M ESPE) and light cured. A hybrid composite material was layered onto the post surface (3M™ Filtek™ Z250 XT Nano Hybrid Universal Restorative), which was then seated and held in place by applying medium finger pressure to replicate the canal morphology [8,16].

Initial polymerization of the post–composite assembly was carried out by applying light curing for 5–10 seconds. The assembly was then removed from the canal and subjected to further light curing for 20–40 seconds to ensure complete polymerization [17]. The customized post was rinsed with water to remove any traces of the separating medium.

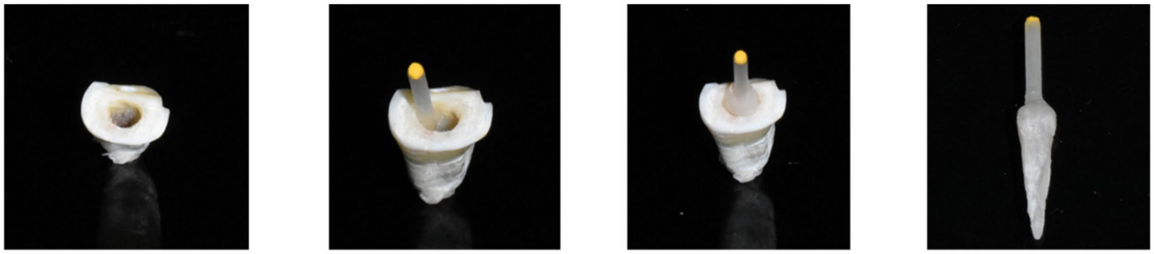

Figure 1: Customisation of Prefabricated FRC Post using Composite

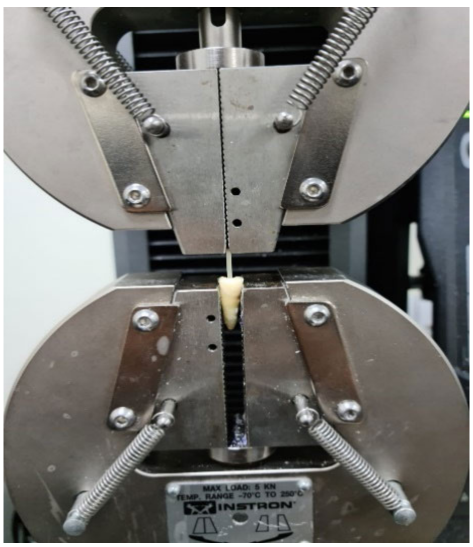

Figure 2: Pull-Out Test on Instron Universal Testing Machine

In both groups of specimens, the same cementation protocol using dual-cure resin cement, following the manufacturer's guidelines, was used [18,19]. The canals were etched using 37% phosphoric acid gel (USA Prime-Dent) for twenty seconds and rinsed using a syringe containing 5 mL distilled water, then gently dried using a three-way syringe. The bonding agent (Scotch Bond™ Universal Adhesive, 3M ESPE) was applied inside the canal using a syringe, followed by air dispersion to remove excess material, and then light-cured for twenty seconds. The posts were held in place with moderate pressure while light curing was carried out for 20 seconds using a light-emitting diode polymerizing unit (Bluephase; Ivoclar Vivadent AG) at low power with an intensity of 800 mW/cm².

Specimens were stored in water at room temperature for a total duration of 30 days before further testing.

Pull-Out Strength

Retention strength of each group (n = 10) was measured by pull-out-test using Instron universal testing machine (Instron 9644) as shown in Figure 2. The pulling forces were applied parallel to the long axis of the tested specimen in Instron universal testing machine for axial pull-out at 0.5 mm/min speed until debonding of the post. Maximum force (N) was recorded Figure 2.

Statistical Analysis

Data were analysed using the student *t*-test ($\alpha = 0.05$). The mean, standard deviation (SD), 95% confidence intervals (CI), and coefficient of variation (CV) were calculated. Pooled standard deviation and Cohen's d were calculated to evaluate the standardised measure of the effect size:

$$d = \frac{\text{Mean difference}}{SD_{pooled}}$$

RESULTS

None of the specimens failed during testing. The pull-out force values (N) were recorded for each specimen as shown in Figure 3. The mean, standard deviation (SD), 95% confidence intervals (CI), and coefficient of variation (CV) for both post systems are summarised in Table 1. Data were analysed using the student *t*-test ($\alpha = 0.05$). statistical analysis revealed that customised FRC posts exhibited higher pull-out retention values (mean±SD: 156.02±2.27 N; 95% CI: 154.40–157.64 N) compared with conventional prefabricated FRC posts (58.54±2.47 N; 95% CI: 56.77–60.31 N) the observed difference was statistically significant ($P< 0.05$). The mean difference between groups was 97.48 N (95% CI: 95.25–99.71 N), indicating a large and clinically true improvement in retention values when customised posts were used.

Statistical analysis using a two-sample Student's t-test, confirmed that the type of post significantly influenced pull-out retention ($t \approx 91.89$; degree of freedom df = 18; $p<0.001$). The pooled standard deviation was approximately 2.37, yielding a Cohen's d of 41.09. The calculation of Cohen's d gives an insight to the great effect that the choice of post has on the resulting retention values. The coefficient of variation was lower for customised posts, indicating that the use of customised FRC posts would have more predictable performance in comparison to prefabricated posts.

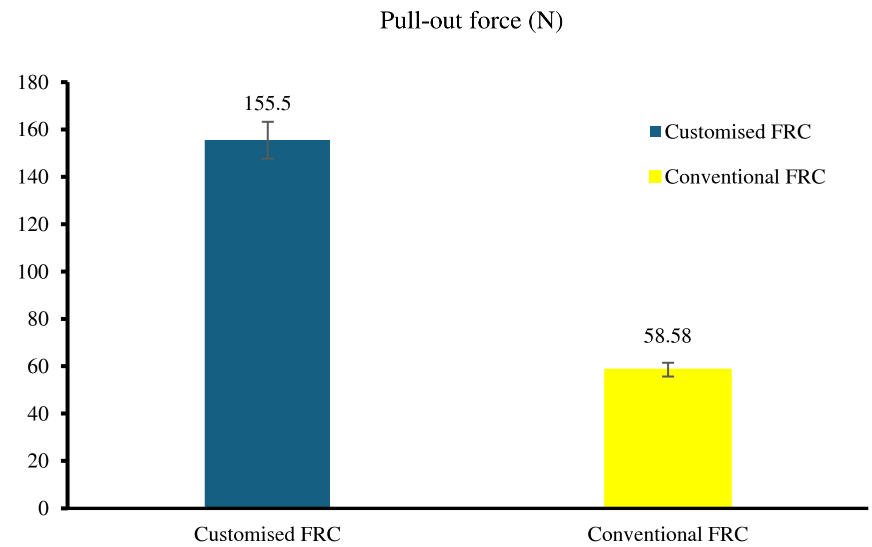

Figure 3: Pull-Out Force Values for Prefabricated Conventional FRC and Customised FRC

Table 1: Mean Values, Standard Deviation, Standard Error, and Coefficients of Variance for Pull-Out Strength for Each FRC Post Systems

Post System	N	Mean Pull-Out Force (Newton) ±SD	SE	CV%	95% CI (N)
Customized FRC (G1)	10	156.02 ±2.27	0.71	1.46	154.40–157.64
Conventional FRC (G2)	10	58.54 ±2.47	0.78	4.22	56.77–60.31

SE: Standard deviation, SE: Standard error, CV: Coefficient of variance, CI: Confidence interval

DISCUSSION

The clinical performance of endodontically treated teeth using prefabricated FRC posts has been the focus of many dental researchers. The general consensus indicates that the main mode of failure of this type of restoration is debonding of the post from the canal. Thus, attaining maximum post retention using modified cementation or post alteration techniques is considered a goal in successful dental practice [20–22].

The present study compared the retention performance of customized fiber-reinforced composite (FRC) posts with that of conventional prefabricated FRC posts in single-rooted teeth using an axial pull-out test. The null hypothesis was rejected, as the results revealed that the choice of post system significantly affects retention values. Customized posts in group 1 showed significantly higher mean retention values in the pull-out test (156.02±2.27 N) when compared to their prefabricated counterparts (58.54±2.47 N) ($p < 0.001$). The calculated mean difference between samples in G1 and G2 was 97.48 N, and the 95% confidence interval was narrow (CI: 95.25–99.71 N). These findings suggest that post customization results in a true average improvement in retention values in the range of 95–100 N.

Deviations of the root canal cross section from the ideal circular shape of prefabricated posts would inadvertently affect adaptation to the canal wall and necessitate additional removal of dentine to allow fitting. This consequently increases the thickness of the cement layer, which is unfavorable, as stress concentration during function may lead to debonding [7,18].

To overcome these challenges without increasing clinical complexity, chairside techniques to reline prefabricated FRC posts were introduced. Relining with composite allows intimate adaptation to canal irregularities, minimizing the thickness of the cement layer. Controlling these factors is key to enhanced mechanical interlocking and adhesive performance [8,15,17]. The enhanced retention observed with the customized post technique in this study is attributed to the close adaptation of the post to anatomical variations of the root canal. The increased friction created by this adaptation is a predominant factor in the success of restoring endodontically treated teeth [23].

This improvement aligns with current understanding that thin, uniform cement layers and intimate post adaptation reduce interfacial voids, minimize polymerization stress, and enhance frictional resistance contributing to retention. The findings also align with the clinical relevance of axial pull-out testing, as debonding is the most frequently reported failure mode for fiber posts [24]. The analysis of occlusal forces during mastication reported in the literature shows a predominant effect of axial tensile forces, supporting pull-out testing as an appropriate method for evaluating clinical performance.

Eid *et al.* (2019) compared the push-out strength of CAD/CAM-fabricated posts with prefabricated posts and found significantly higher strength values ($p < 0.001$) for CAD/CAM posts regardless of material [22]. Their study also showed that adhesive failure was the most common failure mode. These findings are consistent with the current study, where a pooled standard deviation of 2.37 N resulted in a high Cohen's d value of 41.09, indicating strong separation between groups (G1 and G2).

However, the results of the present study contrast with previous research evaluating individually formed posts such as everStick systems, which reported equal or greater retention for prefabricated posts [25]. Similarly, Parčina-Amižić *et al.* reported higher retention for prefabricated posts compared to individually formed IPN posts. It is important to note that these findings were influenced by post surface treatment methods. In both studies, prefabricated posts were treated with a silane coupling agent, whereas the everStick and IPN posts did not receive comparable treatment [11].

The bonding performance of post systems is strongly influenced by surface pretreatment methods such as silanization, hydrofluoric acid etching, laser conditioning, or adhesive coating [26,27]. In contrast, the customized posts in this study were not subjected to additional surface treatment. Therefore, the higher retention observed is likely due to improved anatomical adaptation rather than surface treatment alone.

Procedural differences should also be considered. Prefabricated posts are rigid and do not conform well to canal anatomy, whereas customized posts require careful composite application to ensure optimal adaptation and minimize void formation. These operator-dependent factors significantly influence interfacial adaptation and seating quality, contributing to improved retention [17]. The low coefficient of variation observed in the customized group further supports the reproducibility of this technique.

Regarding prefabricated posts in group G1, the recorded retention values are consistent with those reported by Kelsy *et al.* (2014), who demonstrated improved bonding with silane treatment and surface roughening. Posts without surface treatment showed significantly lower retention [28]. Aleisa *et al.* (2017) evaluated the effect of different cements and reported higher resistance to debonding with self-adhesive resin cement. The present study demonstrated higher retention values than those reported by Aleisa *et al.*, likely due to differences in post-space depth, storage conditions, and cement type [29].

Overall, the current results demonstrate significantly superior retention of customized composite-relined FRC posts compared with conventional prefabricated posts. Their enhanced anatomical conformity and improved interfacial contact provide a predictable and clinically relevant increase in pull-out resistance. These findings support the clinical use of customized FRC posts, particularly in anatomically challenging canals where optimal adaptation is critical for long-term success.

Limitations

The results revealed in the current research are promising despite the limitations of study design. Only a single type of cement was tested, and samples were stored for a relatively short period of 30 days. Longer-term storage, thermocycling, and cyclic fatigue loading mimicking the conditions of the oral cavity could influence bond durability and more closely approximate clinical scenarios. Moreover, axial tensile forces are the only parameter tested using the pull-out test, whereas restorations in the oral cavity are subjected to multidirectional forces. Future investigations should also assess the failure interface microscopically to determine whether it is located at cement–dentin, cement–post junctions.

CONCLUSIONS

Within the limitations of this in-vitro study, customized fiber-reinforced composite posts demonstrated significantly higher pull-out retention compared with conventional prefabricated posts. The large mean difference, narrow confidence interval, and exceptional effect size indicate an exuberant clinical advantage for customized posts. This enhanced retention is most likely the result of greater anatomical adaptation, which minimizes cement layer thickness and promotes intimate contact with the canal walls. Further long-term and clinically oriented studies are recommended to evaluate the durability of this technique under functional loading.

Future Recommendation

Future research should include clinical trials to validate in vitro findings. Investigations should also assess other directional loading relevant to intra-oral masticatory forces. Furthermore, studies evaluating multiple cement types and microscopical evaluation of the failure mode, may provide insights into improving the mechanical performance of these restorations.

Ethical Approval

Ethical approval was exempted by the Institutional Review Board of King Abdulaziz University, as the study was conducted as an in vitro experiment.

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Declaration of Competing Interests

The authors have no conflicts of interest relevant to this article.

Data and Materials Availability

All data associated with this study are presented within the paper. This study followed EQUATOR guidelines for in vitro research.

REFERENCES

[1] Amarnath, G.S. *et al.* "Effect of post material and length on fracture resistance of endodontically treated premolars: an in-vitro study." *Journal of International Oral Health*, vol. 7, no. 7, 2015, p. 22.

[2] Ahmed, S.N. *et al.* "Survey of dentists to determine contemporary use of endodontic posts." *The Journal of Prosthetic Dentistry*, vol. 117, no. 5, 2017, pp. 642–645.

[3] Figueiredo, F.E. *et al.* "Do metal post–retained restorations result in more root fractures than fiber post–retained restorations? A systematic review and meta-analysis." *Journal of Endodontics*, vol. 41, no. 3, 2015, pp. 309–316.

[4] Goracci, C. and Ferrari, M. "Current perspectives on post systems: a literature review." *Australian Dental Journal*, vol. 56, 2011, pp. 77–83.

[5] Santos-Filho, P.C. *et al.* "Influence of ferrule, post system, and length on biomechanical behavior of endodontically treated anterior teeth." *Journal of Endodontics*, vol. 40, no. 1, 2014, pp. 119–123.

[6] Alharbi, F.A. *et al.* "Fracture resistance and failure mode of fatigued endodontically treated teeth restored with fiber-reinforced resin posts and metallic posts in vitro." *Dental Traumatology*, vol. 30, no. 4, 2014, pp. 317–325.

[7] Wu, M.K. *et al.* "The capability of two hand instrumentation techniques to remove the inner layer of dentine in oval canals." *International Endodontic Journal*, vol. 36, no. 3, 2003.

[8] Grandini, S. *et al.* "Use of anatomic post and core for reconstructing an endodontically treated tooth: a case report." *Journal of Adhesive Dentistry*, vol. 5, no. 3, 2003.

[9] Dietschi, D. *et al.* "Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature, Part II (Evaluation of fatigue behavior, interfaces, and in vivo studies)." *Quintessence International*, vol. 39, no. 2, 2008.

[10] Lassila, L.V. *et al.* "Flexural properties of fiber reinforced root canal posts." *Dental Materials*, vol. 20, 2004, pp. 29–36.

[11] Amižić, I.P. *et al.* "In vitro retention of prefabricated and individually formed posts: A pilot study." *The Journal of Prosthetic Dentistry*, vol. 120, no. 4, 2018, pp. 553–557.

[12] Le Bell, A.-M. *et al.* "Depth of light-initiated polymerization of glass fiber reinforced composite in a simulated root canal." *International Journal of Prosthodontics*, vol. 16, 2003, pp. 403–408.

[13] Bakaus, T.E. *et al.* "Bond strength values of fiberglass post to flared root canals reinforced with different materials." *Brazilian Oral Research*, vol. 32, 2018, p. e13.

[14] Ferrari, M. and Scotti, R. "Fiber posts: characteristics and clinical applications." *Ed Masson*, vol. 12, no. 4, 2002, pp. 1–5.

[15] Faria-e-Silva, A.L. *et al.* "Effect of relining on fiber post retention to root canal." *Journal of Applied Oral Science*, vol. 17, 2009, pp. 600–604.

[16] Lui, J.L. "Composite resin reinforcement of flared canals using light-transmitting plastic posts." *Quintessence International*, vol. 25, no. 5, 1994.

[17] Monticelli, F. *et al.* "Micromorphology of the fiber post–resin core unit: a scanning electron microscopy evaluation." *Dental Materials*, vol. 20, no. 2, 2004, pp. 176–183.

[18] Boksman, L. *et al.* "Fiber post techniques for anatomical root variations." *Dental Today*, vol. 30, no. 5, 2011, p. 104.

[19] Mazzoni, A. *et al.* "Push-out stress for fibre posts luted using different adhesive strategies." *European Journal of Oral Sciences*, vol. 117, no. 4, 2009, pp. 447–453.

[20] Bru, E. *et al.* "Fibre post behaviour prediction factors. A review of the literature." *Journal of Clinical and Experimental Dentistry*, vol. 5, no. 3, 2013, p. e150.

[21] Rasimick, B.J. *et al.* "A review of failure modes in teeth restored with adhesively luted endodontic dowels." *Journal of Prosthodontics*, vol. 19, no. 8, 2010, pp. 639–646.

[22] Eid, R.Y. *et al.* "Effect of fabrication technique and thermal cycling on the bond strength of CAD/CAM milled custom fit anatomical post and cores: An in vitro study." *Journal of Prosthodontics*, vol. 28, no. 8, 2019, pp. 898–905.

[23] Azzam, K. "Influence of adaptation and adhesion on the retention of computer-aided design/computer-aided manufacturing glass fiber posts to root canal." *The Journal of Contemporary Dental Practice*, vol. 20, 2019, pp. 1003–1008.

[24] Nova, V. *et al.* "Pull-out bond strength of a fibre-reinforced composite post system luted with self-adhesive resin cements." *Journal of Dentistry*, vol. 41, no. 11, 2013, pp. 1020–1026.

[25] Al-Tayyan, M.H. *et al.* "Is a 'Flexible' Glass Fiber-Bundle Dowel System as Retentive as a 'Rigid' Quartz Fiber Dowel System?" *Journal of Prosthodontics*, vol. 17, no. 7, 2008, pp. 532–537.

[26] Makarewicz, D. *et al.* "Effect of cementation technique of individually formed fiber-reinforced composite post on bond strength and microleakage." *The Open Dentistry Journal*, vol. 7, 2013, p. 68.

[27] Sipahi, C. *et al.* "Adhesion between glass fiber posts and resin cement: evaluation of bond strength after various pre-treatments." *Acta Odontologica Scandinavica*, vol. 72, no. 7, 2014, pp. 509–515.

[28] Kelsey, W.P. *et al.* "A comparison of the retention of three endodontic dowel systems following different surface treatments." *Journal of Prosthodontics*, vol. 17, no. 4, 2008, pp. 269–273.

[29] Aleisa, K. *et al.* "Pull-out retentive strength of fiber posts cemented at different times in canals obturated with a eugenol-based sealer." *The Journal of Prosthetic Dentistry*, vol. 116, no. 1, 2016, pp. 85–90.