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Research Article

Fracture Resistance of Endodontically Treated Teeth Restored Using Multifiber Posts Compared with Single Fiber Posts

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Purpose. The aim of this in vitro study was to evaluate the fracture resistance and type of failure of two adhesive fiber post systems used to restore endodontically treated teeth. *Material and Methods*. Twenty-seven extracted premolars were selected and divided into three groups ($n = 9$): a control group restored with direct composite core (group 1), teeth restored with single fiberglass posts (group 2), and teeth were restored with multifiber posts (Biolight Plus System) (group 3). Fracture resistance was measured by applying axial compressive loads parallel to the longitudinal axis of the tooth until failure. Data was analyzed with one-way ANOVA followed by post hoc Turkey tests. *Results*. The results showed that the mean forces to failure of the control group (0.068 kN) were significantly lower than those restored with either fiberglass post systems ($p = 0.013$). There was no significant difference between the multifiber and the single fiberglass post system in terms of resistance to fracture ($p = 0.097$). Although there are more teeth fractured favorably (above the CEJ) in the Biolight Plus group (77.7%) compared to both the control and fiberglass post groups, it was not statistically significant ($p = 0.226$). *Conclusion*. Within the limitations of this study, restoring endodontically treated with a multifiber post system is an adequate alternative to single fiberglass post system in terms of resistance to fracture.

1. Introduction

The quality of coronal restoration of endodontically treated teeth (ETT) plays a major factor in securing treatment success and the long-term survival of these teeth [1]. Yet, this has been challenging especially when tooth structure loss is extensive [2]. Where there is only one remaining dental wall or none, placement of intraradicular posts and core has been advocated to ameliorate the retention of coronal restoration and improve the distribution of occlusal forces along the tooth structure, thus increasing resistance to fracture [3, 4].

Several factors influence the fracture resistance of teeth restored with post and core, such as the amount of remaining tooth structure [5], and the physical and mechanical properties of the post [3, 6]. Prefabricated fiberglass posts are one of the main types of posts currently available which have been promoted over the previous metal posts due to their improved aesthetic qualities. In addition, their mechanical properties allow better transmission of stresses along the root walls, thus decreasing the possibility of root fracture [3]. Single fiberglass posts, on the other hand, require drilling the canal to create post space, which may entail excessive removal of tooth structure, further weakening the root [7].

Recently, a multi-fiber-reinforced composite post system (Biolight Plus) has been introduced. Each post is comprised of a bundle of fibers that can be adapted to the root canal anatomy with the advantage of no extra root canal drilling required [7]. Limited literature is available regarding the performance of this system.

The aim of this study was to examine the current system by comparing fracture resistance and mode of failure of ETT restored using the Biolight Plus system with those restored with single fiberglass posts.

2. Material and Methods

Twenty-seven natural intact premolars, extracted for periodontal or orthodontic reasons, were selected for this cross-sectional randomized controlled in vitro study. The criteria for tooth selection included the following: single straight root canals; no visible caries, fractures, or cracks on examination under the operating microscope (A3 series; Global, Surgical Corporation, USA); no signs of internal or external resorption or calcification; and a completely formed apex. Teeth with excessively short roots were also excluded. Preoperative radiographs were taken to confirm canal anatomy and measure the bucco-lingual to mesio-distal diameter of the canals. Canals with a ratio >2 were excluded. G∗Power 3.1 software (Heinrich-Heine-Universität, Düsseldorf, Germany) was used to calculate the sample size. An effect size $(f) = 0.7$ was considered, estimating the power at 87% and a 0.05 type 1 error probability.

Ethical approval was obtained from Princess Nourah Bint Abdul Rahman University Institutional Review Board, and the study was conducted at Princess Nourah Bint Abdul Rahman University (PNU) Dental College Simulation Lab and King Saud University Eng. Abdullah Bugshan Research Chair for Dental and Oral Rehabilitation Lab.

2.1. Root Canal Preparation. The external root surface of the teeth was cleaned with an ultrasonic scaler and rinsed with distilled water to remove any calculus or soft tissue. Subsequently, the teeth were stored in saline solution until they were prepared. Crowns were sectioned 1.5 mm above the cemento-enamel junction (CEJ), and coronal preparation was done using a cylindrical round-ended 1 mm diamond bur (Medin, A.S. Czech Republic). A 1.5 mm ferrule was prepared and measured using a dental surveyor, and dentinal thickness was verified using a dental gauge caliper. Access cavities were prepared using endodontic access burs, and then, working length was determined with a size10 K-file (Medin, A.S. Czech Republic). ProTaper Universal files (Dentsply Maillefer, Ballaigues, Switzerland) were used to prepare the root canals until file size F3. Canal instrumentation was carried out according to the manufacturer's instructions on a 16 : 1 contra-angle handpiece attached to an electric motor (X-smart Endodontic Rotary Motor, Dentsply-Sirona, United States) at 350 rpm. EDTA 17% cream (MD-ChelCream Meta Biomed, Korea) was placed on the tip of each file before inserting it into the canal. Canals were irrigated between file usage with 3 mL of 2.5% NaOCl, and upon completion of instrumentation, it received a final rinse with 5 mL saline. Size F3 paper points were used to dry the canals, and then, gutta percha cones F3 (Dentsply-Sirona, United States) were fitted according to the working length and cemented with AH plus sealer (Dentsply-Sirona, United States). The apical 5 mm of the canal was obturated using continuous wave vertical condensation technique with a B&L Alpha II heat source (B&L Biotech, United States).

2.2. Post Space Preparation and Cementation. Teeth were randomly divided into 3 experimental groups ($N = 9$) as seen in Figure 1.

Group 1 was a control group in which no post was placed. The canals were backfilled with thermoplasticized gutta percha from a B&L Beta II heat source (B&L Biotech, United States), and a core build-up was placed using Multi-Core Flow material (Ivoclar Vivadent, Schaan, Liechtenstein) applied according to the manufacturer's instructions. Bonding secured using a dual-cure universal adhesive system (ExciTE F DSC adhesive from Ivoclar Vivadent, Schaan, Liechtenstein) which was applied with a microbrush, air-thinned, and then cured for 20 seconds.

In Group 2, each tooth received single fiberglass post (Red, Rely X 3M Espe, Minnesota, United States) (Table 1). According to the manufacturer's instructions, post space was prepared with corresponding drills, and then, posts were fitted to length and cemented.

Core build-up was performed using MultiCore Flow material (Ivoclar Vivadent, Schaan, Liechtenstein).

For canals in group 3, multiclustered fiberglass posts (Biolight Plus, Bio Composants Médicaux, Tullins, France) (Table 1) were adapted into the coronal two-thirds of the canal. Fibers for the cluster were removed until the post could be fitted to the required length. Following the manufacturer's instructions, post space was cleaned and etched, and then, dual-cure bonding agent ExciTE F DSC adhesive (Ivoclar Vivadent, Schaan, Liechtenstein) was applied and then cured for 20 seconds. The posts were cemented using MultiCore Flow material (Ivoclar Vivadent, Schaan, Liechtenstein) and the core.

2.3. Measuring Compressive Load to Fracture Mode of Fracture. Teeth were stored in 37°C/100% humidity for 72 hrs post canal filling and then imbedded individually up to 1 mm below the CEJ in a cylindrical mold of self-curing acrylic resin and light body polyvinyl siloxane to simulate the periodontal ligament. The specimen blocks were mounted on a special fixture on a computer-controlled universal testing machine (Instron 8967, MA, USA). An axial compressive load parallel to the tooth longitudinal axis with a steel oblique compressive head was applied. The rate of compressive loading was 2 mm/min until failure (fracture). The force at fracture was measured in newton (N) (Figure 2).

Specimens were then evaluated under a digital microscope (Nikon SMZ1000) to define the fracture mode. Fractures above the CEJ were considered restorable and defined as favorable, while those occurring below the CEJ were deemed nonrestorable and unfavorable.

2.4. Statistical Data Analysis. SPSS (IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY IBM Corp) statistical software was used to analyze the data. The Shapiro–Wilk test was used to check data normality. A one-way ANOVA followed by Tukey's tests was performed to compare the

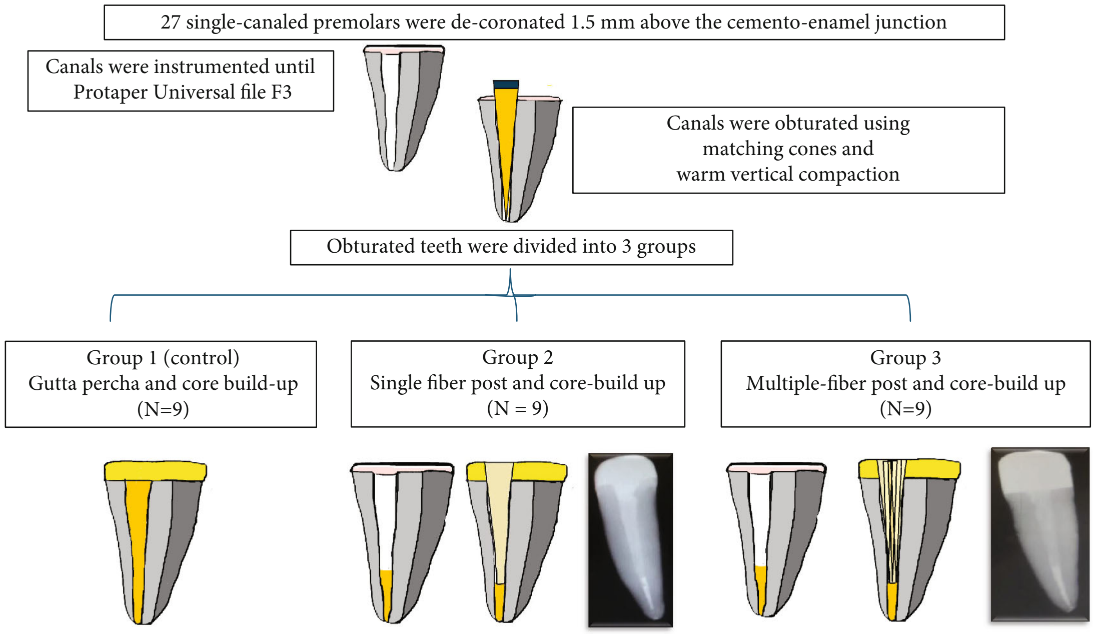

Figure 1: Illustration depicting teeth preparation and the three experimental groups of the study.

Table 1: Post and core materials used in the study and their composition and characteristics.

Material	Composition	Dimensions	Flexure strength (MPa)	Push-out bond strength (MPa)	Ref.
Biolight Plus, Bio Composants Médicaux	Micropost consisting of silane glass fibers connected with urethane dimethacrylate resin-filled particles and ytterbium	0.3 mm	Higher than 1000 (according to the manufacturer)	3.88	[8–11]
Rely X 3M Espe	Resin matrix: epoxy resin, zirconia filler	0.8-1.6 mm	945	3.5	[11, 12]
MultiCore Flow, Ivoclar	Bis-GMA, urethane dimethacrylate, triethylene glycol dimethacrylate Inorganic fillers (barium glass, Ba-Al-fluorosilicate glass, silicon dioxide, and ytterbium trifluoride)	0.04-25 μm	114	199	[13, 14]

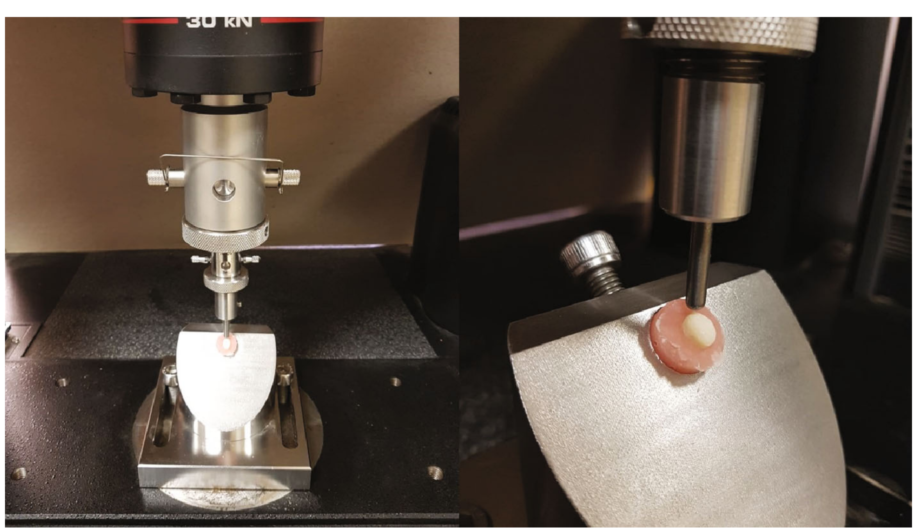

Figure 2: Photo experimental set up for measure compressive load to fracture.

mean loads to failure between the three groups. Pearson's chi-square test was used to compare the mode of fracture. Statistical significance was set at p value of < 0.05.

3. Results

The maximum loads to failure for the three groups can be seen in Figure 3. The highest value of 1.30 kN was recorded in the Biolight Plus group, while the lowest (0.43 kN) was recorded in the control (no post) group. There was a significant difference between the means of maximum loads to failure (Table 2). Multiple comparison of the means showed that the loads to failure were significantly lower in the control group when compared with either the single fiberglass post or the Biolight Plus post (Table 3). However, there was no significant difference in the resistance to fracture between the Biolight Plus and the single fiberglass post groups ($p = 0.971$).

Although there are more teeth fractured favorably (above the CEJ) in the Biolight Plus group (77.7%) compared to both the control and fiberglass post groups (66.6% and 33.3%, respectively) (Figure 4), this did not prove to be statistically significant ($p = 0.226$).

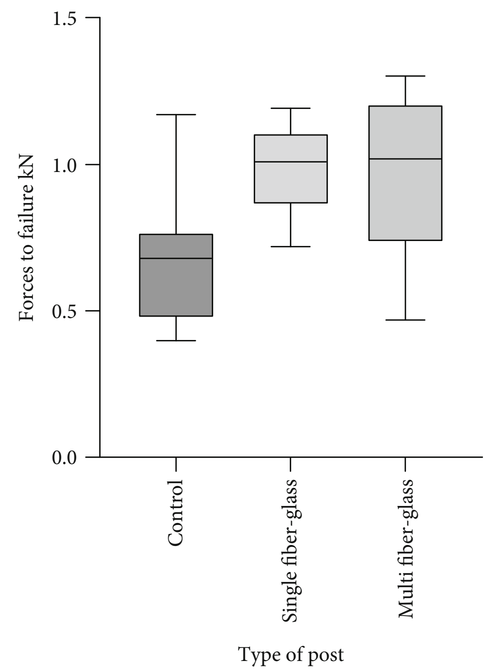

Figure 3: Distribution of maximum loads to failure among the 3 groups: control, fiber post, and Biolight Plus.

4. Discussion

Placement of intraradicular posts and core has been advocated for restoring ETT when the remaining tooth structure cannot provide adequate retention for the indicated full coverage crowns [3, 4]. Many studies [15–17] showed that single fiberglass posts are considered a favorable treatment option, because they can provide an acceptable aesthetic outcome, as well as allow even stress distribution along the dentine of the root, thus enhancing fracture resistance.

However, these post systems have several drawbacks, one of which is that they require considerable removal of tooth structure to accommodate the shape of the post. It has been proven that such a preparation might debilitate the root [18], because of the prevalence of radicular cracks which increase the possibility of root fracture and, consequently, losing the tooth [19, 20]. Therefore, it may be advisable to insert a post without reducing the thickness of the radicular dentine [21]. This study employed using a multifiber post system (Biolight Plus) that allows post placement without the need for further post space preparation.

The present study applied compressive loading parallel to the longitudinal axis of the tooth, which can partially simulate mastication forces [22]. Fiber composite materials are particularly sensitive to such forces, as they fail under compression parallel to the direction of the fibers at lower stress than tension loading [23]. Thermocycling, however, was not carried out because many studies suggested it has a negative influence on the dentine-composite interfaces, consequently decreasing the resistance of teeth to fracture [24–26].

The findings showed no significant difference in fracture resistance between the two types of posts. As for the control group, where no post system was placed, the loads to failure were significantly lower compared to single fiberglass and Biolight Plus posts. Moreover, the incidence of irreversible failure (below the CEJ) was 33.3% but decreased with the placement of either the single or multifiberglass post techniques. This is in accordance with Faria et al. [18], who reported that the type of fracture is more favorable of teeth restored by fiberglass posts (cervical root fracture), consequently fewer opportunities of tooth loss. Cast metal posts, however, were associated with more aggressive tooth fracture (middle root fracture) and greater chances of tooth loss.

There are limited studies about the multifiberglass post system; however, our study agrees with Richert et al., who found that multifiber posts presented similar risk of fracture compared to single fiberglass posts [7]. Spicciarelli et al. [22] also concluded that the application of either single fiberglass post or multifiber posts in oval canals enhanced the resistance form of the restoration.

Furthermore, another study [27] deduced that the shape of fiberglass posts has a significant influence on stress distribution at the postdentin interface. In other words, placement of elliptical fiber post has superior stress distribution when compared to the rounded fiber post. This proposes that it is better for the fibers to be placed on the circumferential portions of the root and not only in its centre. The multifiber post system may favor achieving such a preferable distribution.

It is also important to take into consideration the mechanical characteristics of build-up material, since differences in mechanical properties (e.g., Young's module) could lead to premature failures [28].

Retreating canals with fiberglass posts is challenging. Using ultrasonic tips to remove the post can raise the root surface temperature to values beyond the allowed physiological limits [29]. This was shown to differ between high

Table 2: One-way ANOVA analysis of means of maximum loads to failure.

Type of post	N	Mean	Std. deviation	Std. error	Sum of squares	df	Mean square	Sig.
Control	9	0.679	0.233	0.077	0.523	2	0.261	0.013*
Single fiberglass	9	0.985	0.152	0.051	1.210	24	0.050	
Biolight Plus	9	0.961	0.271	0.090	1.733	26		
Total	27	0.875	0.258	0.049				

*The mean difference is significant at the 0.05 level.

Table 3: The post hoc Tukey test to compare means of maximum loads to failure.

Post type	Mean difference	Std. error	Sig.
Control			
Fiberglass	-0.306	0.10584	0.021*
Biolight Plus	-0.282	0.10584	0.035*
Single fiberglass			
Control	0.306	0.10584	0.021*
Biolight Plus	0.0244	0.10584	0.971
Biolight Plus			
Control	0.2822	0.10584	0.035*
Fiberglass	-0.0244	0.10584	0.971

*The mean difference is significant at the 0.05 level.

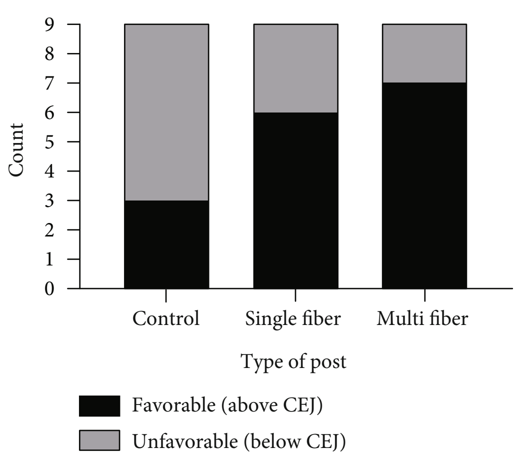

Figure 4: Distribution of favorable and unfavorable line of fracture among the 3 groups.

density and hollow posts [29]. Exploring whether Biolight Plus multifiber glass posts are easier to retreat compared to single fiberglass posts would be an intriguing area for further study.

Although the present findings indicate that placement of either post systems has improved ETT resistance to fracture. The study did not fully replicate the clinical situation which includes thermal changes encountered in the oral cavity and masticatory forces. It also does not address using these systems in different teeth. Further studies simulating clinical states, such as dynamic load application and long-term clinical tests, will be necessary for further assessment of the performance of the Biolight Plus multifiber post system in restoring ETT. In conclusion and within the limitations of this study, there was no significant difference in fracture resistance between EET restored with single fiberglass and multifiber posts. This result would suggest using multifiber posts as an alternative approach to single fiberglass post techniques.

Data Availability

Data will be available upon request.

Conflicts of Interest

There are no known conflicts of interest associated with this publication that could have influenced its outcome.

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