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Research Article

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Comparative Study of Bond Strength of Resin-Modified Glass Ionomer Cement and Flowable Composite with Glass Fiber Posts by Push-Out Test

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Abstract

Introduction: *posts that have been properly fitted can withstand torsion and provide better retention. The purpose of this study was to evaluate the push-out bond strength of glass fiber posts cemented with different luting agents. The push-out bonding strength of glass fiber posts to the root canal was evaluated using resin-modified glass ionomer cement (RMGIC) and flowable composite (FC).*

Materials and Methods: *Thirty single-rooted extracted human mandibular premolars were sectioned 2 mm coronal to the most incisal point of the cementoenamel junction. Root canals were instrumented and obturated with laterally condensed gutta-percha and root canal sealer (ADSEAL). Gutta-percha was removed from the canals to a depth of 11 mm and diameter post spaces with a 1.5 mm were prepared. The specimens were divided into the following 3 groups according to the luting agent used (n=10). The first group utilized FC (HARVARD, Germany) to coat the post, whereas the second group used RMGIC (Meron plus QM, VOCO, Germany). whereas the third group used Resin Cement (ITENA clinical, France) was used as the control. The specimens were cross-sectioned after 24 h. Specimens were cross-sectioned six millimeters thick into coronal using a sectioning machine. The strength of the bond between the luting cement and the posts was measured using push-out bond strength testing. We loaded the components at a cross speed of 0.5 mm/min on a universal testing machine until the bond failed.*

Results: *The FC group had a 73.53N push-out bond strength, whereas the RMGIC group had a 133.55N, whereas the Resin Cement group had a 137.47N push-out bond strength.*

Conclusion: *FC's mean push-out bond strength score is lower than RMGIC's and Resin Cement.*

Keywords: Flowable Composite, Glass Fiber Post, Luting Cement, Resin-Modified Glass Ionomer Cement, Root Canal

1. Introduction

The difficulty of restoring teeth that are endodontically treated has led to a wide range of base restorations. Loss of tooth structure due to endodontic access preparations, caries, and defective restorations makes restoring a pulpless tooth challenging [1]. The length of a post, diameter, design, canal shape and preparation, luting agent, cementation procedure, and other factors all influence post retention [2,3]. A good adaptation of the post to the root canal (RC) will remain for a long time and tolerate torsion forces. The resin adhesives in well-fitting canals provide good retention [4]. The quality of luting cement is the main element in retention. Characteristics such as easy manipulation, a thinner film, extended working time with a fast set, and low solubility are ideal properties in luting cement [5]. However, there have been fewer studies that provide evidence on the comparison of the bond strength of luting cement. Most studies have conflicting results on which of the luting types of cement have superior bond strength [6–8]. Based on the unpredictable results of previous studies, bonding RC posts with resin cement, conventional glass ionomer cement, or resin-modified glass ionomer cement (RMGIC) is recommended for luting fiber posts [9,10]. Unlike conventional GICs, RMGIC presents low sensitivity to moisture and strong bonding to the tooth structure. It also releases fluoride and shows high compression resistance compared to zinc phosphate cement [6,11]. A new modified hybrid resin material was developed recently to overcome the polymerization shrinkage associated with classic composite resin. In 1996, a flowable composite (FC) with a lower filler load was introduced [12]. These materials improved flow, effectively decreased the modulus of elasticity, and reduced micro-leakage by enhancing adaptability and this property generates a stress-absorbing layer [13]. As a result, gap formation at the flowable resin and tooth boundary was reduced. Micromechanical retention and chemical interaction are required for the adhesion between monomer acidic groups and hydroxyapatite [14–16]. Thus, we conducted the present study to evaluate the push-out bond strength of glass fiber posts to the RC using resin-modified glass ionomer cement and flowable composite.

2. Materials and Methods

This study included 30 single-rooted extracted human mandibular premolars extracted due to orthodontic reasons. The G*power software (version 3.1.9.7) was used to calculate the sample size, with a 5% margin of error, 0.6 effect size, and a power of 80%, the calculation provided a total sample size of 30 specimens with three subgroups (n = 10).

All 30 extracted human mandibular premolars had similar sizes (lingual-buccal dimension 6.6 ± 0.4 mm), any tooth with caries and/or previous restorations was excluded. The root surfaces had been cleaned using periodontal curettes, then one by one, each premolar was examined with an optical light microscope (Olympus, USA) to investigate any minor root fractures, then the premolars were stored in sterilized water. At the cementoenamel junction, teeth were sectioned with a high-speed airotor handpiece. The working length was determined by cutting 0.5 mm short of the apex using a #10 K flex file. The root canal was cleaned and shaped using the crown-down technique with a rotary pro-taper nickel-titanium file up to size F2. Irrigation with sodium hypochlorite 5.25% solution, saline, and 17% Ethylenediaminetetraacetic acid (EDTA) was done at the same time. The RCs were dried with paper points after being irrigated with distilled water. Root canals were instrumented and obturated with laterally condensed gutta-percha and root canal sealer (ADSEAL). The teeth were then stored in deionized water for 24 h to create post spaces. Later, each one of the 30 premolars was soaked into a resin block (feiying, Anyang Yingpai Dental Material, China) 2 mm below the cemento-enamel junction (CEJ) to simulate the alveolar bone level.

the RC walls of the specimen were individually enlarged using low-speed drill tips. The depth of the post space was
11 mm. The specimens were divided into 3 groups.

(a) (b)

Figure 1: (a) (The research sample) Single-Rooted Extracted Human Mandibular Premolars Teeth, (b) Mounted Molds Cross-Sectioned 6 mm thick into coronal parts.

Group 1: The RCs were etched for 10s with 37% phosphoric acid, then rinsed with water and dried. A micro brush was used to apply the single-bond universal adhesive to the RCs. After that, the post (NexPost) was coated with FC (HARVARD, Germany) and put into the RC, with the excess resin later removed. Then the components were light-cured for 60 s.

Group 2: The RC wall was etched for 10 s with 37% phosphoric acid, then rinsed with a water syringe and dried with a paper tip. The post was put in the RC and covered with RMGIC (Meron plus QM, VOCO, Germany), and the post was light-cured for 60 s.

Group 3: The RC wall was etched for 10 s with 37% phosphoric acid, then rinsed with a water syringe and dried with a paper tip. A micro brush was used to apply the single-bond universal adhesive to the RCs. After that, the post (NexPost) was coated with resin cement (ITENA clinical, France) and put into the RC, with the excess resin later removed. Then the components were light-cured for 60 s.

All specimens were cross-sectioned 6 mm thick into the coronal parts by a sectioning machine yielding 10 specimens per group (Figure 1b).

The push test was used to calculate the bond strength between the luting cement and the post. On the testing machine, the post was loaded with a 0.8 mm in diameter cylindrical plunger.

Figure 2: Testing Machine to Assess Push-Out Bond Strength.

The plunger point was positioned to touch only the post, leaving the surrounding post space walls. Loading was done on a universal testing machine (Tinius Olsen H50T) at 0.5 mm/min crosshead speed until bond breakdown occurred.

The data were analyzed using unpaired Student's t-test p, and the scores were tested for a significant difference.

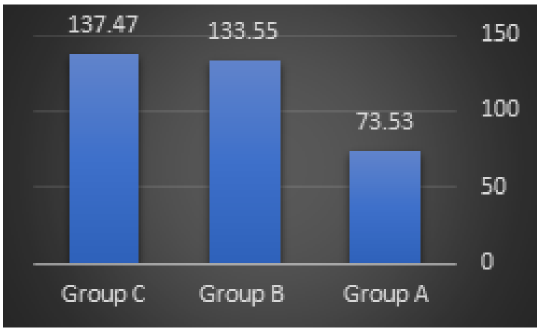

Figure 3: Results Bar Chart

Figure 4: Samples after Push-Out Test

Statistically, the fracture strength values were analyzed using the one-way ANOVA test. Bonferroni post-hoc test was used for the multiple comparisons to determine the significance of differences between groups, and in all the analyses, the level of significance was set to be $\alpha = 5\%$.

3. Results

The mean of Bond Strength of group A (73.53N) was smaller than the mean of group B (133.55N), which in turn was smaller than the mean of group C (137.47 N).

Groups	*Mean (newtons)*	*Standard Deviation*	*Highest Value*	*Lowest Value*
A(FC)	73.53	10.89	90.70	61.00
B(RMGIC)	133.55	18.31	155.70	102.00
C(RC)	137.47	21.76	172.00	106.40

Table 1: Results Table

Source	*Sum of squares*	*Df*	*Mean square*	*F*	*P*
Between Groups	25683.37	2	12841.68	41.55	0,000
Within Groups	8345.37	27	309.09		
Total	34028.73	29			

Table 2: Statistical Analysis (One-way ANOVA)

From the above table, we note that the value of the significance level P-value is smaller than the value 0.05 when comparing the three research groups (group A:FC) - (group B:RMGIC) - (group C:RC, the control group) using the one-way ANOVA analysis of variance test, that is, at the confidence level of 95%, there are statistically significant differences in the averages of the Bond Strength between the three research groups, and to determine which groups differ from the others in the averages of the number of the Bond Strength, post-tests were conducted (Bonferroni) Post Hoc Tests To study the significance of the bilateral differences in the average number of the Bond strength between the three research groups.

Comparison groups		**difference between the averages**	**P-value**	**Significance of differences**
Group A	Group B	-60.01	0.000	There are statistically significant differences
	Group C	-63.94	0.000	There are statistically significant differences
Group B	Group A	60.01	0.000	There are statistically significant differences
	Group C	-3.92	0.622	There are no statistically significant differences
Group C	Group A	63.94	0.000	There are statistically significant differences
	Group B	3.92	0.622	There are no statistically significant differences

Table 3: Post Hoc Tests (Bonferroni)

4. Discussion

4.1. Materials and Methods Discussion

This study was conducted on extracted human teeth due to orthodontic reasons to imitate the conditions of clinical reality, and it is approved in most studies similar to the nature of this study [17]. The teeth were filled using an epoxy resin-based filling paste, as many studies indicated that the filling pastes based on zinc oxide and eugenol weaken the retention of Glass fiber posts bonded using resin cement compared to the filling pastes based on epoxy resin [18].

The control sample was bonded by a resin cement based on the use of an Etch-and-rinse resin Cement, dual-curing, which gave significantly higher bonding strength than the glass fiber posts bonded with a resin cement based on a Self-adhesive resin cement [19].

As for the test method, the retention of the root posts Is mainly measured using the Microtensile Test or the Push-Out Test [20]. Roydhouse (1970) Was the first to advocate for the push-out test in dentistry. According to reports, when push-out tests were done on the entire post or thick root Portions using a thin-slice specimen, non-uniformed stress developed at the adhesive barrier.

The thin-slice push-out test allowed for a more uniformed stress distribution along with the bonded interface. The test was performed at a speed of 0.5 mm/min until the post separated from the root dentin, which is the speed used in many similar studies examining the retention of the Glass fiber posts within the root canal [21].

According to previous literature, RMGIC has shown superior physical properties, such as less sensitivity to moisture, high dimensional stability, chemical, and micromechanical bonding, higher bonding to the tooth, enhanced adaptation to canal walls, hybrid layer formation, and hygroscopic expansion leading to increased frictional resistance [22-26].

The type of RC also affects retention, as Maryam et al. found that the narrow canal held water due to surface tension, making it difficult for the bonding agent to replace it. As a result, even though the RCs were dried using paper points, the bond strength of the etch and rinse technique was lowered due to increased moisture content [27].

Ferrari et al. also established that different sections of the same RC did not respond to acid etching in the same way, and as a result, dentine bonding abilities vary at different depths inside the same RC [28].

The hydrophilic monomers in the self-etching adhesives are more concentrated. The water content in the solvent affects the combination of adhesive and light-cured composite. Suh BI et al. reported that a high concentration of acidic monomers in adhesive systems reduced the rate of polymerization for light-curing composites [29].

4.2. Results Discussion

The average amount of Bond strength of the first group A (FC) was 73.53 N, and the average amount of Bond strength of the second group B (RMGIC) was 137.47 N, while the average amount of Bond strength of the third group (control) (resin cement) was 137.47 N. Conducting appropriate statistical analyzes shows the following:

The results of the statistical study indicated that there were statistically significant differences between the first group and the second group in the research sample, where the average amount of bond strength of the composite sealing group was lower and with a statistically significant difference than that of the resin-modified glass group.

This may be due to the light cure of the cement In the first group, which does not allow cure of the deep parts of It inside the root canal, which are difficult for light to reach, and thus the weakness of the bond strength with the post, while the type of cure in the second group was dual cure, that Is, it begins with the induction of light and the reaction continues chemically, which allows cure reaction to be completed for the deep parts that light cannot reach. The results of this study agreed with Cheruvathoor 2021[21].

The results of the statistical study indicated that there were statistically significant differences between the first group and the third group in the research sample, where the average amount of Bond strength of the FC group was lower and with a statistically significant difference than that of the RC group. The results of this study agreed with Giachetti 2009 [30].

The results of the statistical study indicated that there were no statistically significant differences between the second group and the third group In the research sample, where the average bond strength of the RMGIC group was very slightly lower than that of the RC group. The results of this study agreed with Pereira 2013 and Li 2014 [31,32].

5. Conclusions

The bond strength of the endodontically treated and restored teeth with Glass fiber posts is significantly affected by the cement used for luting. We conclude that resin cement and resin-modified glass ionomer cement (RMGIC) have a more resistant mean push-out bond strength score than flowable composite (FC). It is critical to preserve as mush tooth structure as possible during the preparation. conservative post preparation should thus be a primary goal of both endodontic therapy and future restorative procedures. FC has a variable composition, and as a result, the material has a wide spectrum of mechanical and physical properties. To select the appropriate materials, clinicians must be aware of their indications for a specific clinical situation.

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