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Comparative evaluation of the regional micro push-out bond strength of pre-fabricated resin post system using various self-etch adhesive systems: An *in vitro* study

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Abstract
Aim: The purpose of this study was to evaluate the micro push out bond strength of a pre-fabricated fiber post luted with various self-etch adhesive cements at cervical, middle and apical thirds of the post space region.
Methods: Thirty freshly extracted human maxillary central incisors were selected for the present study. After preparation, each specimen was embedded in chemically cured acrylic resin and were randomly assigned to three groups: A, B and C. Each root was sectioned perpendicular to the long axis using a microtome and subjected to micro-push-out bond strength.
Results: Among the 3 groups tested, the cervical region demonstrated significantly higher bond strength values of 20.6 ± 6.2 MPa (Group A), 24.7 ± 2.7 MPa (Group B) and 39.6 ± 7.2 MPa (Group C).
Conclusion: Push-out bond strength values were higher in cervical region followed by middle third and least strength was seen in apical third of post space region.

Keywords: Prefabricated resin post, micro push out bond strength, self-etch adhesive, rely X ARC, rely X U 200

1. Introduction

The restoration of the endodontically treated teeth still remains a challenge for physicians globally. Tooth with inadequate crown structure may require placement of post to retain core material. Initially metal posts were used to retain core. However, the use of metal posts lead to unsalvageable fracture of the tooth. This limitation was overcome by the introduction of glass and fiber reinforced posts. Glass fiber reinforced post systems were considered to be non rigid post which upon bonded to the root dentin creates functionally homogenous unit and could achieve a tooth post core monoblock. This monoblock effect helps in enhancing uniform distribution of masticatory load on the root surface and decrease in the clinical failures of the endodontically treated teeth [1]. However, presence of rigidity in the glass fibre post has led to the development of fibre post which possessed elastic modulus and toughness similar to dentin. It also possesses high impact over resistance, shock absorption and increased fatigue resistance properties when used along with resin luting cement. Modulus of elasticity of composite resin (5.7-25 GPa) and fibre posts (16-40 GPa) are comparable to that of dentin [2] and have the advantage of reducing the risk of root fracture. Fibre reinforced post system reduces the tooth fracture and display high survival rates when compared to teeth restored with rigid zirconia or metal posts that results in failure [3]. During the manufacturing process of fibre posts, fibres are pre-stressed and subsequently resin are injected as filler under pressure to fill spaces between the fibres, giving them solid cohesion [4, 5].

Recently developed self-etch adhesive resin cements do not require pre-treatment of the dentin. As these cements do not use an adhesive system, they drastically reduce the number of application steps, shortening the clinical treatment time and minimizing the procedural errors throughout the treatment phases [6, 7]. Moreover, self-adhesive cements contain multifunctional phosphoric acid methacrylate's that are reputed to react with the hydroxyapatite of hard tooth tissue. Previously, bond strength between post and tooth has been measured through conventional tensile testing on external root dentin or the post space surface with pull out and push out methods. Compared to the conventional push out test, micro push out bond test are reported to be more advantageous [8].

Therefore, in the present study a comparative evaluation of micro push out bond strength of pre-fabricated fibre post luted with self-etch adhesive resin (RelyX ARC & RelyX U200) to the root dentine at various regions (Cervical, Middle and Apical thirds) have been carried out and the outcome of the results are reported.

2. Materials and Methods

Thirty freshly extracted human maxillary central incisors, with straight root canals measuring 16-17 mm were selected for the study. The specimens utilized for this study were within one month of extraction and found to be free of cracks, caries, fractures and fully developed apices. The teeth were stored in deionized water containing 0.1% thymol until used for the study purpose. Collection, storage, sterilization and handling of extracted teeth samples were performed according to the guidelines issued by the Occupational Safety and Health Administration (OSHA) as well as Center for Disease Control and Prevention (CDC) [9].

Using a slow speed handpiece under cooling water 1.5-2 mm coronal to the cemento-enamel junction was removed with a diamond disk to achieve uniform root lengths of 14 mm. The pulp tissue was removed and canal patency was determined by passing a size of 10 K-file (Mani & Co) through the apical foramen. Working lengths were established by passing the instrument beyond the apex and shortening it by 1 mm. By using the step back technique, the root canals were sequentially enlarged up to the apex till ISO size 50 K-file (Mani & Co) followed by ISO size 60, 70 and 80. The irrigants used were NaOCl (5.25%) and EDTA (17%). The enlarged canals were rinsed with distilled water and dried with paper points. Following this they were obturated using gutta-percha and AH plus sealer by cold lateral compaction. The post spaces were prepared 24 hours after completing the endodontic procedures. Four millimetres of intact gutta-percha was left behind to preserve the apical seal. The post spaces were all prepared to a depth of 10 mm with paeso-reamer up to size #3. Following post space preparation, the canals were irrigated with sterile water and dried with paper points. Presence of any residual gutta-percha in the walls of post-space was checked using radiographs. After preparation, each specimen was embedded in chemically cured acrylic resin. The roots were randomly assigned to three groups:

- **Group A (E-FRC-ARC):** Fiber resin post (ESPE Rely X, 3M) + Etching done for 20 seconds. Washed and air dried + Adper Single bond adhesive applied and light cured for 20 seconds (3M ESPE) + Self etch adhesive (Rely X ARC resin cement - 3M).
- **Group B (NE-FRC-U200):** Fiber resin post + no prior etching and bonding done + Self etch adhesive (Rely X U 200 resin cement - 3M).
- **Group C (E-FRC-U200):** Fiber resin post + Etching done for 20 seconds and washed and air dried + Self etch adhesive (Rely X U 200 resin luting cement - 3M).

The cementation of the posts of three groups was performed in the following sequence. In group I, etching was done for 20 seconds, washed and air dried followed by use of absorbent points. Bonding agent was applied to the root dentin using Endo applicator tips and light cured for 20 seconds. In group II, no prior etching and bonding was done, the prepared post space was dried with larger paper points and small cotton rolls. This was followed by the preparation of resin luting cement from the base and catalyst paste of self-adhesive cement. The mixed cement was applied onto the surface of the posts and into the orifice of the root canals for all the three groups. The posts were inserted into the canal to the full depth by using finger pressure and excess was removed. Light curing was performed for 40 seconds through the posts in all the groups. In group III, prior etching was done followed by the use of the resin cement (RelyX U200) as in group II. After preparation, each specimen was embedded in chemically cured acrylic resin (Figure 1a).

(a) (b)

Fig 1: (a) Fabrication of the samples. (b) Sectioned samples showing cervical […], middle [..] and apical [.] cross sectoins

2.1 Micro-Push out Testing

The micro-push out bond strength testing was done at Central Institute for Plastics Engineering and Technology. The coronal, middle and apical portion of post space region of the root (Figure 1b) was sectioned perpendicular to the long axis with a microtome to create 1 mm thick slices. Each slice was marked on the coronal side with an indelible marker. The push-out tests were performed at a cross head speed of 1 mm/min by using a universal testing machine. Care was taken to center the push-out pin on the center of the post surface, without stressing the surrounding post space walls. The load was applied on the apical side of the root slice to avoid any limitation of post movement due to post space taper. The force at the point of extrusion of the post segment from the thick slice was taken as point of bond failure and the value was recorded in Newton and converted to mega pascal (MPa).

2.2 Statistical Analysis

Using the software Statistical Package for Social Sciences (SPSS, version 20.0), the recorded results were statistically analyzed. Descriptive analysis followed by ANOVA and multiple comparison tests were used at $P < 0.05$ levels of significance.

3. Results

The mean push-out bond strength values (MPa) obtained for the different groups are represented in Table 1-3. The results showed that in Group C statistical higher bond strength values were observed in the cervical third of post space region when compared to Group A and Group B. However, no significant differences were observed between Group A and Group B (Table1). As for the middle region, Group C and Group B possessed highly significant difference when compared to Group A. No significant differences were observed between Group C and Group B (Table 2). From the apical third of post space region it was found that while Group C exhibited significant difference between Group A, no such differences were seen between Group C and Group B as well as between Group A and Group B (Table 3).

Table 1: Cervical Third of Post Space Region

Groups	Mean ± SD (MPa)	Significant Groups	*P* Value
Group A (GA) (E-FRC-ARC)	20.6 ± 6.2	GA vs GB GA vs GC	0.269 (NS) 0.000 (S)
Group B (GB) (NE-FRC-U200)	24.7 ± 2.7	GB vs GA GB vs GC	0.269 (NS) 0.000 (S)
Group C (GC) (E-FRC-U200)	39.6 ± 7.2	GC vs GA GC vs GB	0.000 (S) 0.000 (S)

NS – Not Significant, S – Significant at $P < 0.05$

Table 2: Middle Third of Post Space Region

Groups	Mean ± SD (MPa)	Significant Groups	*P* Value
Group A (GA) (E-FRC-ARC)	9.99 ± 2.52	GA vs GB GA vs GC	0.001 (S) 0.000 (S)
Group B (GB) (NE-FRC-U200)	16.7 ± 2.8	GB vs GA GB vs GC	0.001 (S) 0.062 (NS)
Group C (GC) (E-FRC-U200)	20.72 ± 5.22	GC vs GA GC vs GB	0.000 (S) 0.062 (NS)

NS – Not Significant, S – Significant at $P < 0.05$

Table 3: Apical Third of Post Space Region

Groups	Mean ± SD (MPa)	Significant Groups	*P* Value
Group A (GA) (E-FRC-ARC)	5.17 ± 2.78	GA vs GB GA vs GC	0.078 (NS) 0.048 (S)
Group B (GB) (NE-FRC-U200)	9.18 ± 4.2	GB vs GA GB vs GC	0.078 (NS) 0.972 (NS)
Group C (GC) (E-FRC-U200)	9.58 ± 4.53	GC vs GA GC vs GB	0.048 (S) 0.972 (NS)

NS – Not Significant, S – Significant at $P < 0.05$

The intra group comparison has showed that cervical third of post space region demonstrated significantly higher bond strength values when compared with middle and apical third of post space region in all the groups tested (Table 4).

Table 4: Intra Group Comparison

	Regions	Mean ± SD (MPa)	Comparison	*P* Value
Group A (GA) (E-FRC-ARC)	Cervical (I)	20.6 ± 6.27	A(I) vs A(II)	0.000*
			A(I) vs A(III)	0.000*
	Middle (II)	9.99 ± 2.52	A(II) vs A(III)	0.043*
	Apical (III)	5.17 ± 2.78		
Group B (GB) (NE-FRC-U200)	Cervical (I)	24.7 ± 2.7	B(I) vs B(II)	0.000*
			B(I) vs B(III)	0.000*
	Middle (II)	16.7 ± 2.8	B(II) vs B(III)	0.000*
	Apical (III)	9.18 ± 4.2		
Group C (GC) (E-FRC-U200)	Cervical (I)	39.6 ± 7.29	C(I) vs C(II)	0.000*
			C(I) vs C(III)	0.000*
	Middle (II)	20.72 ± 5.22	C(II) vs C(III)	0.001*
	Apical (III)	9.58 ± 4.53		

* Significant at $P < 0.05$

4. Discussion

Several studies have proved that the successful clinical performance of resin post systems bonded with adhesive resin systems is most likely due to their good retentive values and better distribution of mechanical stresses [10]. The durability of fiber-reinforced composite post restoration depends on the formation of a strong bond between the resin luting cement and dentin, as well as between the resin cement and the fiber post, enabling the interface to effectively transfer stress under functional loading [11]. Fiber post are composed of unidirectional quartz or glass fibers embedded in a resin matrix. During manufacturing process these fiber post are prestressed and subsequently resin is injected under pressure to fill the spaces between the fibers, giving them solid cohesion. Adhesive retention of the fiber post are influenced by the dentin bonding agent, luting cement, cement thickness, polymerization modes and the type of surface treatment.

Cementation of fiber posts is technique sensitive and some variables may impair the bond between cement and dentin. The various factors that hamper bonding within the root canal space include various materials used during endodontic treatment [12], root canal morphological variations [13], control of dentin moisture, voids in resin cements and curing of resin cement at the middle and apical root thirds [14]. Successful treatment requires good bonding between resin cement and post, as well as resin cement and dentin, since the poor bonding at these interfaces may lead to debonding and/or fracture of the post and core [15]. To resolve these drawbacks, self- etch adhesive cement RelyX U200 was introduced which does not require any pre-treatment of the dentin, such as etching, priming or bonding. It requires shorter application time and less technique sensitive. Previous studies have proved that the glass FRC posts had better adhesion to the root dentin when dual cure adhesive system like RelyX ARC was used [16]. Hence the present study has evaluated the push-out bond strength of the glass FRC posts system with self-etch adhesive cement (RelyX U200 and RelyX ARC) to root dentin at various regions (cervical, middle and apical region of post space). Few authors have reported that mild self-etch adhesives failed predominantly under the hybrid layer after water-aging, which may also result in insufficient removal of smear layer [17], which in turn can lead to less potential to micro mechanical inter-locking. Since RelyX U200 has a pH of 2 it comes under the classification of a mild self-etch adhesive system [18]. Hence, in the present study, prior etching of the root dentin was performed before the use of RelyX U200 systems.

Comparison of the bond strength values between the regions have revealed that cervical region demonstrated significantly higher bond strength values when compared with middle and apical third in all the groups tested. This increased bond strength values could be due to the presence of higher resin tag density in the cervical third compared to the middle and apical thirds of the root canals. Ferrari *et al.* evaluated the dentine morphology in terms of tubule orientation, revealed the presence of higher tubule density in the cervical region compared with the middle and the apical parts of the root canal [19]. The number of dentinal tubules decreases from the cervical to the apical third of the root. The dentine hybridization is not uniform in the apical third which in turn has a negative influence on the displacement resistance to the root dentin [19]. Mallmann *et al.* evaluated the micro tensile bond strength in different regions of root dentin and found that the cervical and the middle third had higher bond strength when compared with the apical third [20].

In the present study parallel-tapered fiber post were used, thereby decreasing the diameter of post in apical third of post space region. The decrease bond strength values in apical third of post space region could be due to the increase in resin cement thickness at this region when compared to cervical and middle third of post space region, where the post is cylindrical with close adaptation to root canal dentin. Also, the resin matrix of RelyX U200 cements consists of a multi-functional acid methacrylate (Phosphoric acid methacrylate) that infiltrate into the tooth substrate, resulting in micromechanical retention. Manufacturer claims that this unique formulation increases the mechanical properties and overall adhesion performance.

5. Conclusion

Within the limitations of the study the following conclusions were drawn. Push-out bond strength values were higher in cervical third of post space region followed by middle third region and least strength was seen in apical third of post space region. RelyX U200 with etching produced the highest bond strength values in cervical third of post space region when compared to other groups. RelyX U200 with or without etching resulted in higher bond strength values in middle third of post space region when compared to RelyX ARC. RelyX U200 with etching had superior bond strength values when compared to RelyX ARC in apical third of post space region.

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