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COMPARATIVE EVALUATION OF PUSH-OUT BOND STRENGTH AND FAILURE MODES OF FIBER POST CEMENTED WITH DIFFERENT ADHESIVE RESIN CEMENTS: AN IN-VITRO STUDY

Dental Science

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ABSTRACT

Aim: To compare the push-out bond strength and modes of failure of fiber post cemented with different adhesive resin cements. **Materials And Method:** Forty five single-rooted teeth were randomly divided into three groups as, group 1- Fluorocore 2+, group 2- Rely-X U200 and group 3-G-Cem, according to the adhesive resin cement used. The roots were subjected to chemo-mechanical preparation and cemented with adhesive resin cement. The teeth were sectioned into slices of the different root thirds and tested for bond strength (push-out). Results were analysed using Chi square, Mann Whitney U and Kruskal Wallis test was used to find the significance of study parameters between three or more groups, with $p = 0.05$ for statistical significance. **Result:** Push out bond strength of Fluorocore 2+ is significantly higher at coronal level than apical level. No significant difference observed between coronal, middle and apical levels in group 2 and in group 3. **Conclusion:** Fluorocore 2+ adhesive resin cement is best to use for luting the fibre post. Fluorocore 2+ forms better bonding with post as well as dentin proving its better efficiency clinically.

KEYWORDS

bond strength, adhesive, fiber post

INTRODUCTION

To reinforce the endodontically treated tooth and protect against fracture, a post (also referred to as a dowel), preferably with a core or coping and a crown or onlay can be used as a superstructure to give coronal-radicular stabilization.[1]

The progress made in the technology of fiber-reinforced materials has overcome some of the limitations of metallic and cast posts. Their advantage is more flexibility, corrosion resistant, non-hypersensitivity, easy retrieval, single visit office placement, ability to bond to the tooth structure and esthetic. It has been reported that cementation of posts with adhesive systems increases the retention of the post, and decreases debonding and micro-leakage at the dentin-fiber post interface.[2]

Separate etch adhesives and self-adhesives are among the most commonly used adhesives for the cementation of fiber posts. Separate etch adhesive system; can be more technique sensitive due to various pretreatment steps (etching, priming, bonding). This limitation is resolved with the introduction of the self-adhesive universal resin cement.[2]

The self-adhesive systems have acid-functionalized monomers or phosphoric acid groups, in their composition to achieve bonding to the tooth substrate. Thus, latter systems reduce the number of clinical steps, the application time and more importantly, it is simple to use and usually are dual cure.[2]

Although fiber-reinforced post systems are becoming very popular, they are not foolproof and failures of restorations have been reported.[2] The most common reason for clinical failure of fiber post is the debonding from dentin, which usually occurs due to reduced bond strength at the post-cement or cement-dentin interfaces. The reduction of bond strength at the post-cement interface depends on many factors, such as the degree of root canal dentin hydration, the adequate use of the surface luting agent and cement, cavity configuration, the use of a sealer containing eugenol, the content of irrigation materials and anatomical differences in root canal dentin tubules.[3]

Debonding of adhesive joints occurs by a process of crack formation, propagation and subsequent joint failure. There are 3 possible mechanisms of failure of adhesive bonding; cohesive, adhesive, and mixed failure.

MATERIALS AND METHOD:

1. **Sample Collection**

Forty five human single- rooted (permanent maxillary central incisors) with sound roots, extracted for periodontal reasons, with fully formed apices and working length of 14 mm were included in this study.Strict anonymity was maintained.

This study was conducted in the Department of Conservative Dentistry and Endodontics, Bharati Vidyapeeth Deemed University Dental College and Hospital, Pune.

2. **Sample Preparation**

All soft tissue remnants on root surface were cleaned and debris removed with ultrasonic scaler and teeth were stored in distilled water until use.

The samples were decoronated transversely 1mm coronal to CEJ using diamond disc to a standardized length of 14 mm.

Finally, a total of 45 roots in which the cervical diameter of their canals was 0.1–0.3 mm larger than the post diameter were selected.

All root canal shaping were prepared with Protaper system till F3 according to the manufacturer's instructions (ProTaper; Dentsply, York PA, USA). Irrigation was done 5ml of 2.5% sodium hypochlorite and normal saline. The prepared root canals were then filled with gutta-percha cones (DiaDent Group International Inc. Burnaby, BC, Canada) and resin sealer (AH Plus, Dentsply York PA, USA) using the lateral condensation technique. Root canal openings were then filled with a temporary restorative material (Cavit; 3M ESPE, St. Paul, MN, USA) and stored in distilled water at 37°C for 48 h.

3. **Post Space Preparation And Luting Procedure:**

Temporary filling material was removed with diamond burs (SS White Burs, Lakewood NJ, USA). Post space preparation was done using special drills provided by the manufacturer for No. 2 Hi-Rem Endodontic Post (Hi-Rem Endodontic Post Overfibers S.R.L, via Malatesta, Italy), till 10mm of length and keeping 4-5mm of the apical gutta-percha intact.

Samples was randomly divided in three experimental groups of 15 samples each (n=15).

Group 1:- In Fluorocore 2+ core build-up material, XP Bond adhesive/ Self cure Activator (SCA): The fiber Post was cleaned with alcohol and air dried. Dental etching gel (Pulpdent, MA, USA) applied to the post space through a needle and rinsed off after 15 sec. Residual moisture was removed using paper points without desiccating the etched dentin surface. XP Bond adhesive was mixed with SCA (1:1),

applied to the post space with a microbrush for 20 s and gently air dried. Fluorocore 2+ base and catalyst were mixed at a ratio of 1:1 for 30 s using auto-mixing syringe and applied on the post and post preparation using endo-applicator tips and the post was seated immediately. The material was allowed to auto cure for 5 mins and light-cured for 40 sec.

Group 2: Rely-X U200. The Fiber Post was cleaned with alcohol and air dried. RelyX U200 was dispensed using clicker and mixed in1:1 ratio, cement was applied directly to the post space through a lentulo-spiral. The post was immediately seated and autocuring of the adhesive cement was allowed for 5 min. Light curing was then performed through the post as in group 1.

Group 3:G-Cem. Same procedure was performed as in group 2.

4. **Sample Testing**

a. **Push Out Bond Strength:**

After 24 hours, the roots were embedded in the resin blocks perpendicular to the long axis of the root canal. Three sections i.e. coronal, middle and apical third, of resin blocks that were horizontally cut with diamond disk under constant water spray. The height of each section was 3mm.[4]

Section of resin block was mounted in a universal testing machine with cervical surface facing the jig. The Cylindrical piston (1mm in diameter) was placed exactly in the middle of the post and the measurement was conducted by the digital caliper. Load was applied in an apico-cervical direction at crosshead speed of 0.5mm/min until the post was dislodged.

The peak force at the point of detachment of the post segment from the test specimen was considered as the point of bond failure and recorded in Newtons. Push-out bond strength values in MPa were calculated by dividing the peak force by the bonded surface area (A) of the post segment.[4] The bonded surface was calculated using the following formula:

$A = \pi \times k(r1+r2)$

Where r1 is the radius of the post in the cervical region and r2 is the radius of the post in the apical region (r1 and r2 calculated by a digital caliper).

K was calculated using the following formula:

$[h^2+(r_1-r_2)^2]^{0.5}$

Where, h is the thickness of each layer in millimeters.

b.**failure Mode Analysis**

After testing, all the sections were analyzed at a magnification of 40 X under stereomicroscope (Teslong Digital Microscope HD 200X Magnification, Made in China).[4]

Failure modes were classified as- adhesive failure between the cement and root canal, adhesive failure between the cement and fiber post, cohesive failure in the cement or fiber post or root dentin and Mixed failure (when more than one classification appeared in the same specimen).[4]

Statistical Analysis

Level of significance was fixed at p=0.05 and any value less than or equal to 0.05 was considered to be statistically significant.

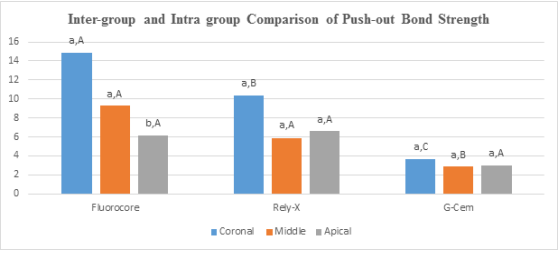
Chi square analysis was used to find the significance of study parameters on categorical scale. Mann Whitney U test was used to find the significance of study parameters on continuous scale between two groups. Kruskal Wallis test was used to find the significance of study parameters between three or more groups.

The Statistical software IBM SPSS statistics 22.0 (IBM Corporation, Armonk, NY, USA) was used for the analyses of the data.

RESULTS:

Among the three groups tested the mean push-out bond strength was significantly higher in fiber posts luted with Fluorocore 2+ cement at coronal level ($p<0.05$). Lowest bond strength values were found in fibre posts luted with G-Cem amongst all the levels. However highest bond strength was seen at coronal level in all there groups (Graph 1).

While comparing modes of failure, in fluorocore 2+ group cohesive failure in fibre post was highest at coronal and middle levels. As we go apically mixed type of failure predominate in all the three groups. Also, in fibre posts luted with Rely-X and G-Cem adhesive failure between cement and dentin was higher (Table 1).



Graph 1: Inter-group and Intra-group comparison of mean push-out bond strength of three groups. Individual comparison was done using Mann Whitney U test. (Note: Capital letter shows inter-group comparison while small letters shows intra-group comparison of mean push out bond strength.)

Table 1: Different Modes of Failures. AD-Adhesive failure between cement and dentin; CP- Cohesive failure in fiber post; CD- Cohesive failure in Root Dentin; M- Mixed Failure.

Modes of Failure	Different modes of failure among the three groups(Values in bracket indicates percentage)								
	Fluorocore 2+			Rely-X			G-cem		
	Coronal	Middle	Apical	Coronal	Middle	Apical	Coronal	Middle	Apical
AD	0	6 (40)	4 (26.7)	10 (66.7)	5 (33.3)	4 (26.7)	11 (73.3)	5 (33.3)	12 (26.7)
CP	11 (73.3)	7 (46.7)	3 (20)	3 (20)	-	-	2 (13.3)	-	-
CD	-	-	-	-	-	3 (20)	-	-	-
M	4 (26.7)	2 (13.3)	8 (53.3)	2 (13.3)	10 (66.7)	8 (53.3)	2 (13.3)	10 (66.7)	11 (73.3)

DISCUSSION

The highest mean push-out bond strength in fiber posts luted with Fluorocore 2+ cement is due to the etching procedure that facilitates the removal of the smear layer, increasing the width of the tubules and allowing the formation of a great number of thicker and larger resinous tags.[6] The etch and rinse adhesive system increases the interfacial adaptation of luting cement by increasing penetration into dentinal tubules, and improving the pattern of dentin hybridization.[5]

Goracci et al. concluded that the interfacial strength and ultrastructure of total-etch, self-etch, and self-adhesive resin cements used for luting glass fiber posts, the values achieved by total etch were significantly higher.[6]

Similarly, Valandro et al evaluated micro-tensile bond strength between a quartz fiber post and a resin cement and concluded that more reliable bond strengths was achieved when using multiple bottles total-etch adhesive systems instead of self-etching adhesives.[7]

Moreover Fluorocore 2+ contains, XP bond combined with self-cure activator (SCA), a dual cure adhesive resin cement. The catalyst in SCA can promote adhesion of compatible dual- curable resin based luting agents to the adhesive layer and accelerates their polymerization. Therefore, application of XP bond/ SCA adhesive to the fiber post surface not only improves the bond strength but also simplifies bonding procedure.[8]

Silva et al have affirmed that Rely X has showed a significantly lower number of penetrated dentinal tubules, lower hybrid layer thickness and the penetration of this cement into the dentinal tubules.[5]

Weak bonding at the coronal and middle level after the use of Rely X and G-Cem than Fluorocore may be due to the fact that although the pH of the cement is very low upon mixing, they cannot demineralize dentinal tubules, and consequently, methacrylate phosphate esters cannot adequately penetrate into the partially dissolved smear layer.

This creates a gap between the surfaces, and decreases the bond strength.[5]

In contrast to this study, Radovic et al evaluated no statistical significant differences in mean push out bond strength of etch-and-rinse and self-adhesive approaches.[9]

The densities and the number of dentin tubules decreased significantly from the coronal to apical root regions. There are fewer tubules per square millimeter in the apical region, which results is formation of less resin tags and reduced bond strength. According to Gwinnett these tags contribute about 30% to the total bond strength.[10]

Similarly, Ankur Dua et al stated that tubule density decreases significantly from coronal to apical root regions. Also, the dentin in the apical region of the root is a less favorable bonding substrate because of areas devoid of tubules, irregular secondary dentin, cementum-like tissue on the root canal wall and numerous accessory canals.[11]

Decreased bond strength in the deeper portions of root canal may also be related to the inadequate access in that region, remnants of gutta-percha and endodontic sealer, difficulties of controlling moisture causing and reduction in the quantity of light transmitted[27] all can result in incomplete infiltration and polymerisation of the resin cement.[11]

The weak push out bond strength of RelyX and G-Cem at middle and apical level demonstrate a dependence on the photo-activation of the cements, in which the curing light is unable to reach the apical areas.

Salas et al also showed that the liquid phosphoric acid produced higher bond strength in the apical region when compared with phosphoric acid gel, in the same concentration of 37%, it is believed that the effectiveness of acid etching of root dentin in the different thirds may significantly influence the results. This was confirmed by the present study in group 1.[12]

In contrast to the present study Gomes GM et al assessed the regional bond strengths to root canal dentin of fiber posts luted with three cementation systems and concluded that the self-adhesive cement RelyX U100 was the only cement not sensitive to the root canal region.[10] In this study same finding was seen in posts luted with G-Cem cement, where mean push-out bond strength values were statistically insignificant in all regions of root ($p>0.05$).

According to stereomicroscopic findings, maximum cohesive failure within post was observed in Fluorocore group at different levels of root which is an indication of the improved bond strength due to surface treatment of post. This may be due to pre-treatment (etching and bonding) done to the post and root dentin surfaces which resulted in higher bond strengths at both interfaces.

Many authors like Choi et al and Goracci et al have reported an increase in the micro-tensile or push-out bond strengths with this pre-treatment procedure, whereas some authors like Matinlinna et al and Amaral et al have reported no significant effect.[6]

RelyX and G-Cem, self-adhesive systems unable to make hybrid layer for better bonding would make the lower bond strength between cement and post which has better condition for bonding with the salinization claimed by the manufacturer.[12] This explains the reason the high number of adhesive failure between cement and dentin and mixed modes of failure at different levels.

This vitro study has limitations, as the tests were carried out in single rooted teeth, with specific dimensions and post preparation, under a static compressive loading applied at a single point and fixed angulation. Thus, dynamic or fatigue behavior cannot be inferred. The ultimate clinical decision making should also consider patient-related variables such as occlusion, masticatory force, level of alveolar bone attachment and parafunctional habits, to maximize the long-term prognosis of endodontically treated teeth. Additional in vivo and in vitro studies are required for the long-term results.

CONCLUSION:

Within the limitations of the study, it can be concluded that,

- Among the three resin cements, Fluorocore 2+ adhesive resin cement is best to use for luting the fibre post.
- Analysing the modes of failure of these resin cements it can be concluded that, Fluorocore 2+ forms better bonding with post as well as dentin proving its better efficiency clinically.
- Also, further in vitro long-term studies using mechanical fatigue tests of teeth restored with bonded fiber post and randomized controlled clinical trials must be carried out for better clinical outcomes.

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