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Original Research

Comparative Evaluation of Push Out Bond Strength of a Fiber Post System using Four Different Resin Cements: An *In-Vitro* Study

Anshuraj Kopal Ashok Kumar Das[1], B C Muddugangadhar[2], G S Amarnath[3], Ashu Garg[1], Ullash Kumar[1], T R Poonam Rao[1]

Contributors:

[1]Post-graduate Student, Department of Prosthodontics including Crown and Bridge and Implantology, M R Ambedkar Dental College and Hospital, Bengaluru, Karnataka, India; [2]Reader, Department of Prosthodontics including Crown and Bridge and Implantology, M R Ambedkar Dental College and Hospital, Bengaluru, Karnataka, India; [3]Professor and Head, Department of Prosthodontics including Crown and Bridge and Implantology, M R Ambedkar Dental College and Hospital, Bengaluru, Karnataka, India.

Correspondence:

Dr. Das AKAK, Department of Prosthodontics including Crown and Bridge and Implantology, M R Ambedkar Dental College and Hospital, Bengaluru, Karnataka, India. Phone: +91-9886425114. Email: dr.anshuraj.kopal@gmail.com

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Abstract:

Background: Debonding is one of the frequent causes of failure experienced in fiber-reinforced composite posts, and establish along post space-dentin adhesive interface. The purpose of this study was to assess push-out bond strength of a fiber-reinforced post system using four different resin cements.

Materials and Methods: In this *in-vitro* study 40 mandibular premolars were decoronated, and roots were treated endodontically. Following the post space preparation, the roots were grouped into four groups of 10 specimens each. Fiber-reinforced composite posts were cemented with four resin cement systems: (a) Multilink Speed, (b) Rely X Unicem, (c) Calibra, and (d) Permaflo DC. Three sections of each root, with a thickness of 3 mm, were prepared. The push-out test was with a universal testing machine at a crosshead speed of 1 mm/min, and bond strength values were evaluated. The data were analyzed with using multivariate analysis of variance (MANOVA) and *post-hoc* Scheffe test.

Result: The mean push-out bond strength was highest for Rely X Unicem (18.0 ± 1.81), followed by Multilink Speed (13.1 ± 0.75) and Permaflo DC (12.8 ± 0.95). The lowest mean push-out bond strength was seen with Calibra (11.8 ± 0.69). There were statistically significant differences seen in the push-out bond strength of resin cement in different root canal regions using MANOVA and *post-hoc* Scheffe test.

Conclusion: Mean push-out bond strength was highest for Rely X Unicem, followed by Multilink Speed and Permaflo DC. Lowest mean push-out bond strength was seen with respect to Calibra.

Key Words: Fiber post, push out, resin cement

Introduction

Endodontically treated teeth have decreased moisture content and suffer coronal destruction from dental caries, which reduces stiffness leading to fractures from previously existing restorations.[1] This results in an increase in the likelihood of fracture of treated tooth during the function. The restoration of the pulpless tooth should increase resistance of the tooth to fracture. In teeth with extensive tooth destruction, posts are advocated to retain the core that replaces lost coronal structure.[2]

Post should be considered when remaining cervical tooth tissue can no longer provide support and retention. In the last few decades, metal cast posts have been most commonly used for post and core restorations.[3] Disadvantages were observed with conventional cast posts, such as rigidity due to its high modulus of elasticity when compared to dentin, they also require multiple appointments for fabrication.[4] Problems such as loss of retention of post or crown, root fracture and risk of corrosion when different metals have been reported, resulted in search for posts with more favorable load bearing and retentive properties.[5,6]

Clinical studies have reported a success rate of 95-99% for teeth restored with fibre-reinforced posts; with no development of root fracture during study duration. Major advantages of fiber posts are their modulus of elasticity, which is similar to dentine, high fatigue, tensile strength and can be cemented with an adhesive luting material avoiding development of friction between posts and root canal walls so that force applied would be distributed evenly along length of post.[7] In order to improve bond strength between pre-fabricated posts and resin cement, surface treatment procedures have been suggested by using mechanical or chemical agents. The chemical treatment is aimed at roughening post surface enhancing mechanical interlocking between post and resin cements. Recent studies have shown that post surface pre-treatment increases bond strength between fiber and materials used for core build-up.[8,9]

Recent trials indicated that fibre post restorations may fail due to debonding of posts. Post retention in different regions of post space has been measured with micro tensile and push-out tests. Micro tensile tests permit more uniform stress distribution along the bonded interface. Retention of fibre posts in roots depends on the bond strength between post material and a resin luting agent, bond strength between post space dentin and

resin luting agent. In push-out tests major portion of retention will be created not only by adhesive bonding agent, but also by micro retention from the frictional fit between two surfaces. Recent study revealed that push out tests is a more reliable method for determining bond strengths between fiber posts and post space dentin because of high number of premature failures occurring during specimens preparation.

Materials and Methods

This *in-vitro* study was conducted in the Department of Prosthodontics. Forty single rooted mandibular premolar human teeth extracted for orthodontic reasons were used in this study, which were collected from the Department of Oral and Maxillofacial Surgery.

Inclusion criteria

1. Intact, straight single rooted lower premolar with single root canal
2. Teeth with complete root formation
3. Teeth with patent canals
4. Teeth without anatomic variations
5. Teeth free of dental caries.

Exclusion criteria

1. Teeth with open apices
2. Calcified canals
3. Multi rooted teeth
4. Variations in radicular anatomy.

All soft tissue and debris on the teeth were removed using ultrasonic scaler. Teeth were stored in 0.9% normal saline to prevent dehydration till the further period of study.

Armamentarium

Instruments used:

1. Diamond disc with mandrel
2. Airotor hand piece (NSK, Japan)
3. Diamond points (Endo access bur)
4. Straight explorer
5. Endodontic files
   - K files
   - H files
6. Disposable syringe
7. Barbed broaches
8. Micro motor with straight hand piece
9. Micro motor with contra angle hand piece
10. Plastic spatula
11. Mixing pad
12. Custom made jig
13. Gates Glidden drill
14. Endogauge
15. Tweezers
16. Latex gloves
17. Absorbent paper points
18. Spreaders
19. Peaso reamers
20. Endodontic explorer.

Materials used:

1. Normal saline solution (0.9%)
2. Sodium hypochlorite (5.25%)
3. Gutta percha points
4. AH Plus sealer
5. Fibre posts
6. Multilink speed
7. Calibra
8. Rely X Unicem
9. Permaflow DC
10. 17% ethylenediaminetetraacetic acid (EDTA) solution.

Preparation of specimens

Extracted premolar teeth were stored as per recommendation and guidelines laid by OSHA and CDC. Procedure for preparation and irrigation was standardized for all groups and performed by a single operator. Access cavity was prepared using an endodontic access bur. Root canals were cleared of pulp using barbed broaches. Patency of apical foramen was determined by passing a No. 10 K-file into the root canal until the tip of file was visible at the apical foramen, and then 1 mm was subtracted from that length. Teeth were instrumented to a No. 30 size master apical file up to the apical foramen. Then canal was prepared by step back technique and flaring of canal was done, followed by circumferential filing using H-files. 10 ml of sodium hypochlorite was used as irrigant in between successive filing. Recapitulation with smaller size files was done during biomechanical preparation. The smear layer was removed by irrigation with 10 ml sodium hypochlorite and 10 ml of 17% EDTA solution, each for 3 min. Final rinse was done with 10 ml of sterile water. All canals were dried with paper points. They were obturated with lateral condensation of gutta-percha with AH Plus sealer. Later, teeth were decoronated 1 mm above the cementum-enamel junction (CEJ) with diamond disk and root canals were prepared with peaso reamers to the depth of 10 mm. The roots were embedded in plaster blocks to avoid light from outside. After post space preparation 17% EDTA solution was used to remove the smear layer. Then teeth were randomly assigned to four groups containing 10 teeth each.

- Group 1: Posts will be luted with Multilink Speed.
- Group 2: Posts will be luted with Rely X Unicem.
- Group 3: Posts will be luted with Calibra.
- Group 4: Posts will be luted with Permaflo DC.

All the roots were stored at 37°C in distilled water for 1-week and the roots were sectioned perpendicular to the long axis with the diamond disc in low speed with water spray. Slices of 2.2-2.5 mm thickness were obtained, one from cervical third (approximately 1-mm below CEJ), one from middle third, and another from an apical third of the post. For push

out the test, specimens were mounted in customized device (a stainless steel base with a 2.5 mm diameter central orifice) fixed to the lower part of the universal testing machine. The post cemented into root canal was positioned exactly in line with central orifice. The coronal side of each root slice was positioned in contact with the base. The metallic test point (1.0 mm diameter) was attached to upper part of universal testing machine and centralized in relation to fiber post. No adhesive material was used to fix the dental slice to prevent contamination of base at the tooth-post interface area. The push out strength was performed at a speed of 0.5 mm/min until dislodgement of post. This was confirmed by the appearance of sharp drop along the load/time curve recorded by testing machine. The results were statistically evaluated by using multivariate analysis of variance (MANOVA) and *post-hoc* Scheffe test.

Results

Present study was conducted to evaluate push-out bond strength of fiber post system at different post space regions (coronal 3 mm, middle 3 mm, apical 3 mm) of root dentine using four different resin cements. With respect to incisal region, mean push-out bond strength was highest for Rely X Unicem (18.0 ± 1.81), followed by Multilink Speed (13.1 ± 0.75) and Permaflo DC (12.8 ± 0.95). Lowest mean push-out bond strength was seen with Calibra (11.8 ± 0.69) (Table 1). There were statistically significant differences seen between push out the bond strength of resin cement in different root canal region using MANOVA (Table 2). Similarly, in the middle region, mean push-out bond strength of Rely X Unicem was highest (12.7 ± 0.91) followed by Multilink Speed (10.2 ± 0.49) and Permaflo DC (10 ± 0.43). The lowest mean push out bond strength was seen in relation to Calibra (7.3 ± 0.5) (Table 1). There was statistical significant difference seen in push out bond strength of resin cement in different root canal region using MANOVA (Table 2). With respect to incisal region, mean push out bond strength of Rely X Unicem showed statistically significant differences when compared to all other resin cements using Scheffe *post-hoc* tests. However, no significant difference was found in between Calibra versus Multilink Speed, Calibra versus Permaflo DC and Multilink Speed versus Permaflo DC (Table 3). In relation to middle and apical region, all the resin cements showed statistically significant differences except for Multilink versus Permaflo DC in middle region and Multilink versus Calibra in apical region, where no significant differences was found (Table 3).

Table 1: Descriptive statistics of push out bond strengths of resin cements in relation to different root canal regions.

Root canal regions	Type of resin cement	Number of samples (*n*)	Mean	SD
Incisal	Rely X Unicem	10	18.0	1.81
	Calibra	10	11.8	0.69
	Multilink speed	10	13.1	0.75
	Permaflo DC	10	12.8	0.95
Middle	Rely X Unicem	10	12.7	0.91
	Calibra	10	7.3	0.5
	Multilink speed	10	10.2	0.49
	Permaflo DC	10	10	0.43
Apical	Rely X Unicem	10	6.5	0.59
	Calibra	10	4.4	0.37
	Multilink speed	10	4.3	0.46
	Permaflo DC	10	5.2	0.59

SD: Standard deviation

Discussion

The success of endodontic therapy depends on adequate post endodontic restoration to make pulpless teeth function as an integral part of the masticatory apparatus. Pulpless teeth present various challenges of the restorative problems such as loss of tooth structure by caries, fracture and previously existing defective restorations.

The introduction of the intracoronal post in endodontically treated teeth serves primarily to retain core structure and later restoration. Many different types of posts have been used such as, cast metal alloy posts and prefabricated metal posts made of various alloys such as stainless steel and titanium. The cast post core system needs elaborate laboratory procedures and rigidity due to its high modulus of elasticity is the major drawback of metal posts. Root fractures have been attributed to differences in the rigidity of the post and root dentine with stress concentrations inside root leading to irreparable failures. In recent years, non-metallic posts with biological and physical properties similar to that of dentine have been introduced.

The advantages claimed for fiber posts are that post can be bonded to the tooth, and modulus of elasticity is close to that of dentin resulting in greater post flexibility. To preserve esthetics, fiber posts have been introduced, which are made of quartz and glass fibers embedded in a resin matrix. These posts are composed of unidirectional fiber and are becoming more popular because of their good bond strength to dentine and light transmission. An *in-vitro* study suggested that fiber posts are less likely to cause vertical root fracture as compared to stainless steel posts because forces are apparently absorbed by the post and core and not transferred to the root structure. The most common disadvantage of post cores is poor retention of posts. The cement, post material, surface structure, post length and amount of remaining tooth structure all affect retention of the post.[1] In order to improve bond strength between the post and resin cement, many post surface pre-treatment procedures have been suggested regarding the use of mechanical or chemical agents.[10] *In-vitro* studies regarding effect of cement on retention of post has been investigated extensively. Studies have shown that use of resin cement significantly increases retention and fracture resistance of tooth by providing adhesive bonding. The use of self-cure or dual cure resin cements is recommended because of limited penetration of light into depths of root canal.

Table 2: Push out bond strengths of resin cements in relation to different root canal regions.

Source	Root canal regions	Type III sum of squares	df	Mean square	i	*P* value
Corrected model	Incisal	232.206[a]	3	77.402	59.288	<0.001**
	Middle	148.502[b]	3	49.501	130.170	<0.001**
	Apical	31.148[c]	3	10.383	39.191	<0.001**
Intercept	Incisal	7785.662	1	7785.662	5963.616	<0.001**
	Middle	4045.328	1	4045.328	10637.870	<0.001**
	Apical	1065.953	1	1065.953	4023.658	<0.001**
Type of resin cement	Incisal	232.206	3	77.402	59.288	<0.001**
	Middle	148.502	3	49.501	130.170	<0.001**
	Apical	31.148	3	10.383	39.191	<0.001**
Error	Incisal	46.999	36	1.306		
	Middle	13.690	36	0.380		
	Apical	9.537	36	0.265		
Total	Incisal	8064.867	40			
	Middle	4207.520	40			
	Apical	1106.638	40			

**$P<0.001$ - highly significant using MANOVA. [a]Adjusted $R^2=0.818$, [b]adjusted $R^2=0.909$, [c]adjusted $R^2=0.746$

Table 3: Comparison of push out bond strengths of resin cements in relation to different root canal regions.

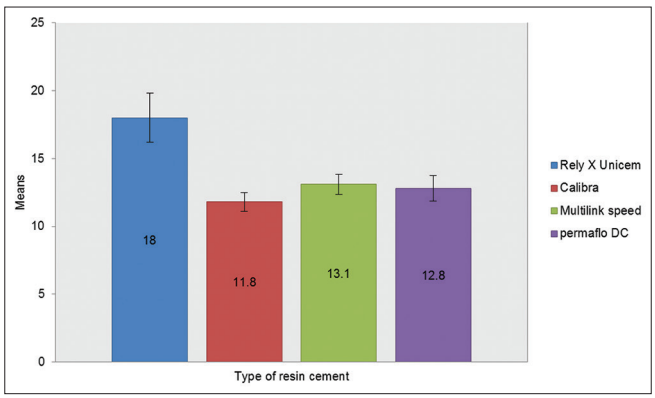
Root canal regions	Type of resin cement	Number of samples (*n*)	Mean±SD
Incisal	Rely X Unicem	10	18.0±1.81[a-d]
	Calibra	10	11.8±0.69[a,b]
	Multilink speed	10	13.1±0.75[a,c]
	Permaflo DC	10	12.8±0.95[a,d]
Middle	Rely X Unicem	10	12.7±0.91[a-d]
	Calibra	10	7.3±0.5[a-d]
	Multilink speed	10	10.2±0.49[a-c]
	Permaflo DC	10	10±0.43[a,b,d]
Apical	Rely X Unicem	10	6.5±0.59[a-d]
	Calibra	10	4.4±0.37[a,b,d]
	Multilink speed	10	4.3±0.46[a,c,d]
	Permaflo DC	10	5.2±0.59[a-d]

SD: Standard deviation, Same letters - significant difference between the groups ($P<0.05$) using Schefee post-hoc test

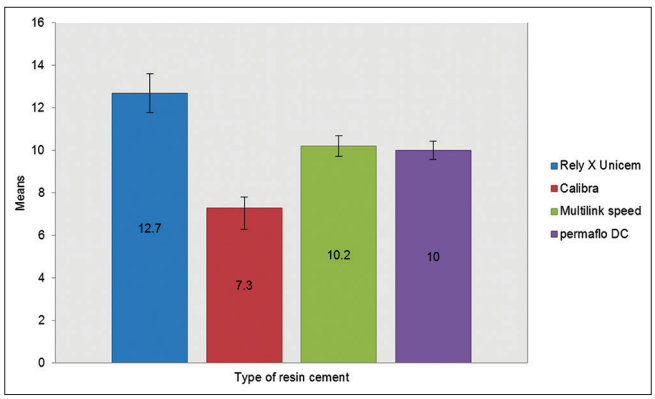
The results of this in-vitro study show Rely X Unicem attained higher bond strength values when compared to other materials. These values may be comparable to those of multi-step luting agents. When compared to another self-adhesive materials, Rely X Unicem registered higher bond strength. The use of cement/post-combination as recommended by manufacturers may have accounted for results obtained. In the present study, only one type of fiber post was used, as the main purpose was to estimate bond strengths of different resin cements and we have to standardize it. Differences in application mode may have similarly influenced the results. Rely X Unicem was inserted into the root canal utilizing an elongation tip, resulting in less chance of bubble formation and air entrapment, which would lead to an improvement in marginal adaptation of material, both to dental substrate and to fiber post. Simonetti *et al.* addressed higher sealing ability of Rely X Unicem dispensed with elongation tip in comparison with Multilink Speed, Calibra and Permaflo DC, which were inserted into root canal with a lentulo spiral or directly applied on post surface. The two self-adhesive cements employed in the present study have a paste-to-paste composition. Base and catalyst are mixed together through an auto-mixing tip on a glass pad and the material then inserted into the root canals with a lentulo spiral. This method appeared less feasible as it could increase the risk of air entrapment causing formation of voids and interfacial defects that would expedite premature failure in the presence of cyclic stresses.

Multilink Speed bond strengths were lower than those of Rely X Unicem. The material was able to partially demineralize the dental substrate, although discrepancies between the degree of demineralization and depth of resin penetration were assessed by light microscopy. At dentine site bond, the material appeared porous, probably due to the incomplete polymerization reaction. The presence of residual acidic monomers at the bottom of adhesive interface may represent weak areas as they can retain their etching potential, thus jeopardizing adhesion. These areas and presence of exposed collagen fibers, the adhesive joint would experience premature degradation, hence limiting the bonding potential of material and reducing the service life of restoration. Further studies should be performed to assess the longevity of these self-adhesive cements.

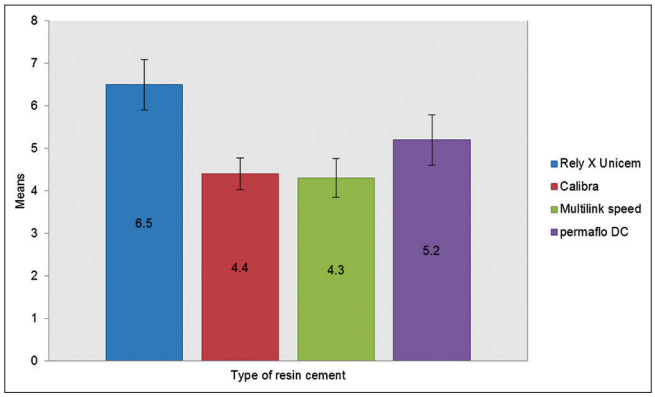
Many studies are performed using ageing tests to assess the longevity of bonded interfaces. Mosharraf and Haerian[11] found thermocycling may increase the retentive strength, especially for Rely X Unicem. Rely X Unicem is convenient dual-curing resin cement and do not require pre-treatment of porcelain and tooth surface. When it mixed with dentin, and a new component methacrylated phosphoric ester was combined. Each methacrylated phosphoric ester monomer consisted two or more PO 3z 4 and two C5C double bond. Phosphate and Ca21 tooth surface form a stable chemical union, which raise the adhesive force to tooth tissue. Unsaturated double bond decides highly reactive and highly crosslinked. After polymerization, highly crosslinked structure perpetuate



Graph 1: Push out bond strengths of resin cements in relation to incisal regions.



Graph 2: Push out bond strengths of resin cements in relation to middle region.



Graph 3: Push out bond strengths of resin cements in relation to apical regions.

favorable mechanical properties of resin cements.[12] Thermal changes were intended to promote complete chemical polymerization, thus enhancing its bonding potential. Self-adhesive cements work as dual-cure materials, where the chemical polymerization can be completed by light irradiation.

Balbosh and Kern[13] attained inferior bond strengths and decreased mechanical properties when Rely X Unicem was only auto-cured. No differences in the degree of monomer conversion were found between Rely X Unicem and Multilink speed.

In this study, mode of pushing out fiber posts was not determined. The specimens were made with no coronal tooth structure. The amount of remaining coronal tooth structure played major role in the durability of the restoration of endodontically treated teeth.[11] In conducted, effect of fatigue loading and thermal cycling on push out the bond strength of glass fiber-reinforced composite post system were not determined.

Conclusion

The present *in-vitro* study was conducted to evaluate push-out bond strength of a fibre post system with four different resin cements and to check difference in bond strength of a fibre post system at different post space regions (coronal 3 mm, middle 3 mm, apical 3 mm) of root dentine using four different resin cements. The bond strength values were obtained using the universal testing machine. The obtained data were subjected to statistical analysis.

Within limitations of the study, following conclusions were made:

1. With respect to incisal region, mean push-out bond strength was highest for Rely X Unicem followed by Multilink Speed and Permaflo DC. Lowest mean push out bond strength was seen with respect to Calibra (Graphs 1-3).
2. In middle region, mean push out bond strength of Rely X Unicem was highest followed by Multilink Speed and Permaflo DC. Lowest mean push out bond strength was seen in relation to Calibra (Graph 2).
3. In incisal region, mean push out bond strength of Rely X Unicem showed statistically significant differences when compared to all other resin cements (Graph 1).
4. Push out bond strength of a fibre was more in incisal region as compared to middle and apical region of root dentine with four different resin cements (Graphs 1-3).

References

1. Standlee JP, Caputo AA. Endodontic dowel retention with resinous cements. J Prosthet Dent 1992;68(6):913-7.
2. Chappell RP, Cobb CM, Spencer P, Eick JD. Dentinal tubule anastomosis: a potential factor in adhesive bonding? J Prosthet Dent 1994;72(2):183-8.
3. Mendoza DB, Eakle WS. Retention of posts cemented with various dentinal bonding cements. J Prosthet Dent 1994;72(6):591-4.
4. Asmussen E, Attal JP, Degrange M. Factors affecting the adherence energy of experimental resin cements bonded to a nickel-chromium alloy. J Dent Res 1995;74(2):715-20.
5. Torbjörner A, Karlsson S, Syverud M, Hensten-Pettersen A. Carbon fiber reinforced root canal posts. Mechanical and cytotoxic properties. Eur J Oral Sci 1996;104(5-6):605-11.
6. Morgano SM. Restoration of pulpless teeth: application of traditional principles in present and future contexts. J Prosthet Dent 1996;75(4):375-80.
7. Yoshiyama M, Matsuo T, Ebisu S, Pashley D. Regional

bond strengths of self-etching/self-priming adhesive systems. J Dent 1998;26(7):609-16.
8. Rosin M, Splieth C, Wilkens M, Meyer G. Effect of cement type on retention of a tapered post with a self-cutting double thread. J Dent 2000;28(8):577-82.
9. O'Keefe KL, Miller BH, Powers JM. *In vitro* tensile bond strength of adhesive cements to new post materials. Int J Prosthodont 2000;13(1):47-51.
10. Zalkind M, Shkury S, Stern N, Heling I. Effect of prefabricated metal post-head design on the retention of various core materials. J Oral Rehabil 2000;27(6):483-7.
11. Mosharraf R, Haerian A. Push-out bond strength of a fiber post system with two resin cements. Dent Res J (Isfahan). 2011;8 Suppl 1:S88-93.
12. Liu C, Liu H, Qian YT, Zhu S, Zhao SQ. The influence of four dual-cure resin cements and surface treatment selection to bond strength of fiber post. Int J Oral Sci 2014;6(1):56-60.
13. Balbosh A, Kern M. Effect of surface treatment on retention of glass-fiber endodontic posts. J Prosthet Dent 2006;95(3):218-23.