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To Evaluate the Pull-Out Bond Strength of Fiber Post Cemented with Three Different Luting Cements – An Invitro Study

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ABSTRACT :
AIM *: The aim of the study is to evaluate the pull out bond strength of fiber post using different luting cements in endodontically treated teeth.*
MATERIALS AND METHODOLOGY*: Thirty single rooted teeth with single canal are decoronated ,endodontically treated, post space is prepared and divided into three groups (n=10) based on the cement used for luting the fiber post ;Group – 1 : SureFil SDR Flow Cement, Group – 2 : RelyX™ U200 Cement ,Group – 3 : Resin Modified Glass Ionomer Cement (GC FujiCEM). Pull-out test was evaluated for the prepared samples using Universal Testing Machine. Statistical analysis was performed using ANOVA and Tukey's test.(P<0.05)*
RESULTS : *The mean pull-out bond strength of Group -2 was statistically higher than all the other groups. Group – 3 showed the least bond strength among the groups tested.*
CONCLUSION *: Within the limitations of the study, self - adhesive resin cements provide better bond strength of fiber post to root canal when compared to other cements.*
KEYWORDS *: Pull-Out Bond Strength, Fiber Post, SureFil SDR Flow, RelyX™ U200, GC FujiCEM.*

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I. Introduction

The rehabilitation of endodontically treated teeth is often compromised because of extensive loss of tooth structure damage due to caries, fracture, and any previous restoration, etc.[1] These teeth can be functionalized using indirect or direct restorations.[2]

To achieve maximum retention and stability of the final coronal restoration, clinicians often prefer an intraradicular post placement.[3]Over a period of time, different post-core systems that have been cast/machined from metal were used but it lead to the weakening of the roots leading to root fracture. Duret et al, 1990 elaborated on a non-metallic material for the fabrication of posts based on the carbon-fiber reinforcement principle. These posts have a modulus of elasticity and high tensile strength similar to that of dentine.[4]

Glass fiber posts are predominantly used among the various commercially available fiber posts, as they minimize dentine removal and also enable uniform distribution of stresses along the post -cement-dentin interface and to the remaining tooth structure thereby reducing the risk of vertical root fracture.[2]

Among the various factors that influence the retention of fiber post, the type of luting cement selected for luting the post is very critical as it creates a link between post and core root canal dentine.[1]

The most common agents used for cementation are Glass ionomer cement, Resin -modified glass ionomer cement, and Resin cement.

Resin- modified Glass ionomer materials are hybrid materials of traditional glass ionomer cement and resin composites. These materials exhibit properties intermediate of two such as adhesion to the tooth structure, esthetics, fluoride release, high compressive, flexural, and tensile strength.[5] They further form resin-dentine interdiffusion zone and also resin tags which form micromechanical interlocking between resin and demineralized root dentine.

In 2002, self-adhesive cement was introduced as a new subgroup of resin cement, to integrate the beneficial characteristics of different cement classes into a single product.[6]

In 2009, SureFil SDR flow, a new flowable composite was introduced with the incorporation of Stress Decreasing Technology (SDR). The manufacturer claims that these bulk-fill composites exhibited exceptional clinical performance due to their excellent physical properties, remarkable handling characteristics, and outstanding quality control.[7]

Giovannetti A et al, in 2012, described that SDR flow when used to lute fiber posts showed similar retentive strength to those that were specifically marketed for cementation purposes.[8]

RelyX U 200 is another self-adhesive resin cement with properties such as excellent bond strength to dentin, enamel, and restorations; long-term stability, and retention.[9]

Lorenzetti et al 2019 reported that RelyX U 200 showed better bond strength results when used as luting cement for fiber post cementation.[10]

In literature, many studies elaborated on evaluating the bond strength and luting of various cement individually, but there is no consensus about the ideal luting cement.[1]

The present study aims to evaluate the pull-out bond strength of fiber post using different luting cement in endodontically treated teeth.

II. Materials and methodology

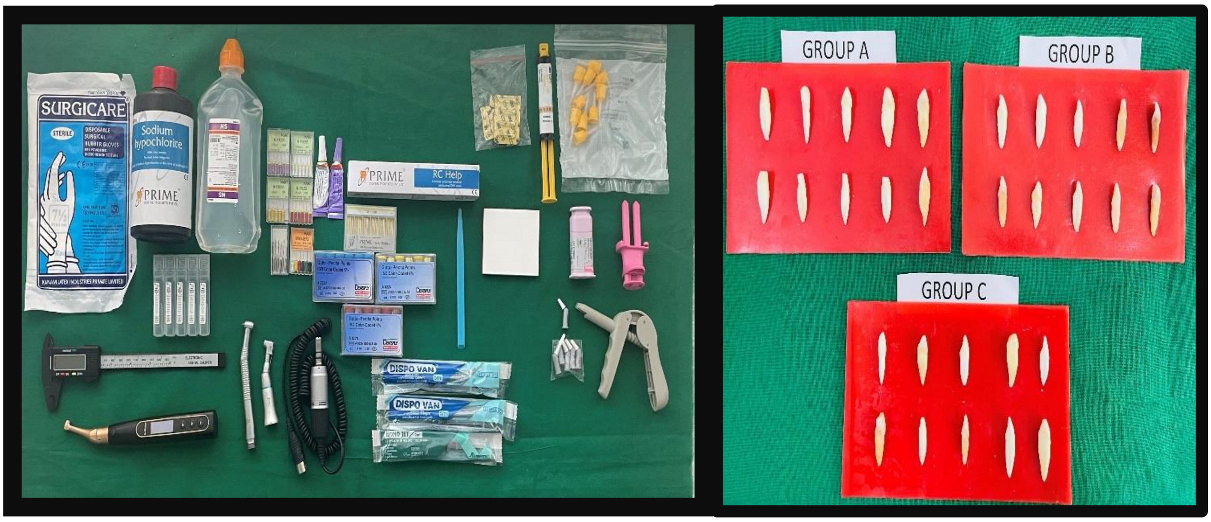


FIGURE 1: MATERIALS REQUIRED FOR THE STUDY

Thirty extracted single-rooted teeth with a single canal were selected. Radiographs were taken from buccolingual and mesiodistal angulation to confirm a single canal. Teeth were cleaned off soft tissues and kept in 3% sodium hypochlorite (Prime Dental Products Pvt Ltd, India) for 2 hours for surface disinfection and then stored in saline until use. The crown of each sample was resected coronally around the cementoenamel junction using a diamond disc to maintain a standard root length of 14mm.

oot canal treatment was performed after negotiating the patency and establishment of a working length 1 mm shorter than the root length measured by visual detection of the #10 k- file through the major apical foramen. The root canals were instrumented using NiTi rotary file system from S1 to F2 (ProTaper file system, Dentsply Maillefer, Ballaigues, Switzerland) and irrigated with 3% sodium hypochlorite between the files. The smear layer was finally removed using 17% EDTA for one minute. The canals were dried using paper points and obturated with single cone gutta-percha points (F2 gutta-percha, ProTaper, Dentsply Maillefer, Ballaigues, Switzerland) and root canal sealer (AH Plus, Dentsply Sirona, Ballaigues, Switzerland). The teeth were stored at 37℃ and 100% humidity for 1 week to allow a complete set of sealer.

After 1 week, gutta-percha was removed till 9mm to prepare post space using peeso reamer till number 2. The post space was flushed with saline and dried. After preparation, thirty specimens were randomly divided into 3 groups based on the cement used for luting of posts (n= 10).

Group 1: SureFil SDR flow (Dentsply)

Group 2 : RelyX^{TM} U 200 (3M ESPE)

Group 3: Resin Modified Glass Ionomer Cement (GC FujiCEM)

Size 0 prefabricated fiber posts (RelyXTM Fiber Post 3D Glass Fiber Post,3M ESPE) were not etched luted in the post space prepared using the chosen material which was mixed according to the manufacturer's instructions.(FIGURE 2)

The teeth were stored in distilled water at 37℃ for 24 h and were mounted on self-curing acrylic blocks vertically along their long axis (FIGURE 3). The Universal testing machine (Fuel Instruments And Engineers, Pvt. Ltd) was used to evaluate the pull-out bond strength of each specimen. The force required to pull out the post was recorded in Newton (N) and the results were statistically analyzed (FIGURE 4).

FIGURE 2: POST CEMENTATION PERIAPICAL RADIOGRAPH WAS RECORDED FOR VERIFICATION OF THE POST FIT.

FIGURE 3: SAMPLES WERE MOUNTED ON SELF-CURING ACRYLIC BLOCKS

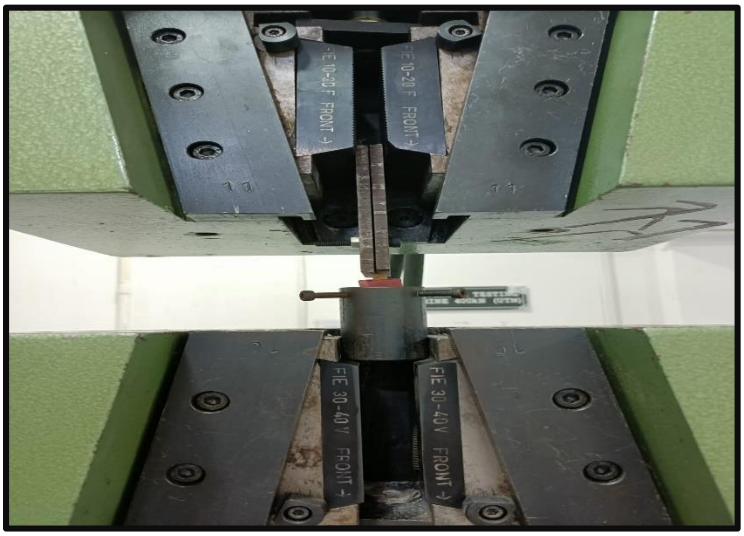


FIGURE 4: PULL OUT BOND STRENGTH EVALUATION DONE WITH UNIVERSAL TESTING MACHINE

III. Statistical analysis

Data were collected and Statistical Package for the Social Sciences (SPSS) version 21 was used to analyze the data. Pull-out bond strength scores were presented as means along with standard deviation. Overall group comparison of pull-out bond strength was made using one -way Analysis Of Variance test (ANOVA) along with Post HOC pair wise comparison using Tukey's test. The level of significance was set at 0.05 ($P< 0.05$). Graphs were prepared in Microsoft excel.

IV. Observation and results

The mean pull–out bond strength of all three experimental groups (in Newtons) is in Table 1. Group 2 showed the highest pull–out bond strength (141.33 ± 5.04) followed by Group 1 (126.74 ± 3.55) and Group 3 (94.63 ± 1.83) having the least value.

Table 1: Mean and Standard Deviation of all the Groups

GROUP	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	P-Value
					Lower Bound	Upper Bound			
SDR FLOW	10	126.74	3.55279	1.12349	124.1935	129.2765	120.30	130.90	**.000***
RELY X U200	10	141.33	5.04568	1.59558	137.7155	144.9345	132.05	148.60	
RMGIC- GC FUJICEM	10	94.63	1.83260	.57952	93.3150	95.9370	92.60	97.86	
Total	30	120.90	20.16182	3.68103	113.3668	128.4239	92.60	148.60	

The mean pull–out bond strength was found to be in the following order, GROUP 2 > GROUP 1 > GROUP 3.
In table 2, the ANOVA test showed that the difference in mean pull–out bond strength between GROUP 2 with that of GROUP 1 and GROUP 3 were all statistically significant.

Table 2: ANOVA Results of Mean Pull-Out Bond Strength

	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	11415.509	2	5707.754	413.210	**.000***
Within Groups	372.957	27	13.813		
Total	11788.466	29			

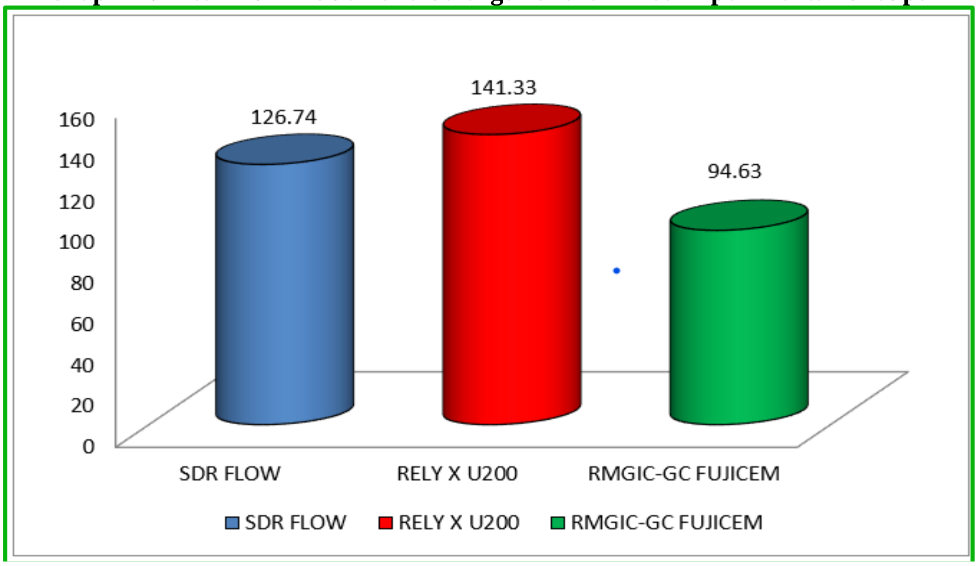
In table 3, Post HOC Tukey's test showed a statistically significant difference found in the mean pull-out bond strength of GROUP 1 Vs GROUP 2; GROUP 2 Vs GROUP 3; and GROUP 1 Vs GROUP 3.

Table 3: Post Hoc Tukey's Test of Pull – Out Bond Strength

(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
SDR FLOW	RELY X U200	-14.59000	1.66212	**.000***	-18.7111	-10.4689
	RMGIC- GC FUJICEM	32.10900	1.66212	**.000***	27.9879	36.2301
RELY X U200	SDR FLOW	14.59000	1.66212	**.000***	10.4689	18.7111
	RMGIC- GC FUJICEM	46.69900	1.66212	**.000***	42.5779	50.8201
RMGIC- GC FUJICEM	SDR FLOW	-32.10900	1.66212	**.000***	-36.2301	-27.9879
	RELY X U200	-46.69900	1.66212	**.000***	-50.8201	-42.5779

A graphical representation of the mean pull-out bond strength of the three experimental groups is in Graph 1 mentioned below.

Graph 1 : Mean Pull – Out Bond Strength of the Three Experimental Groups



V. Discussion

In the literature, different experimental tests are mentioned for evaluating the strength of the bond between the root canal dentine and the fibre posts such as the pull-out test, the pushout test, and the micro tensile test.[6]

The pull-out test stimulates the clinical scenario more realistically than the push-out test as the pull-out test reflects the tensile and shear bond strengths simultaneously.[1] In most clinical scenarios, the most commonly used fibre posts are either cylindrical or conical in shape.[11] Some studies reported that the cylindrical posts increase the risk of friction at the interface between the dentine and resin cement and between the post and the cement used for luting.[12]

Conical fibre posts due to their design will result in improved adaptation of the post to the root canal anatomy, which results in minimal loss of residual root structure and also eliminates some of the friction between the luting cement and the post placed.[13] Hence, in the present study, conical fibre posts (Rely X fibre post) were used for the evaluation of the pull-out test. These conical posts adapt to the root canal walls extremely well, especially in both apical and middle portions of the root.[14]

The resin fiber posts have biomechanical characteristics which are more similar to the natural dentinal structure than any other posts used previously.[15] It has excellent transverse strength and acts as a shock absorber, dissipating much of the stress placed on the finished restoration, transmitting only a small fraction of these forces to the dentinal walls.

The use of a light-transmitting glass fiber post has been claimed to improve polymerization through the depth of post spaces.[16] Transluscent fiber posts allows light to be transmitted into the root canal. This could increase the degree of conversion of the dual cured composite resins with a consequent improvement of their mechanical properties such as modulus of elasticity and hardness.[17] Hence in this study glass fiber posts were chosen for the pull out strength test.

The interfaces of materials with different moduli of elasticity represent the weak point of a restorative system, as the toughness/stiffness mismatch, influences the stress distribution.[18] Thus, the strength of endodontically treated teeth is affected by the material as well as the design of the post and core. The choice of appropriate restorations should be guided by both physical properties and esthetics.

Adhesive interfaces of bonded restorations transmit and distribute occlusal forces to the remaining tooth structures homogeneously, potentially strengthening the restored tooth and increasing its resistance to fracture.[19]

The C-factor, defined as the ratio of bonded to unbonded surface areas of cavities, is highly unfavorable in root canals, where it can range from 20 to 200.[20]

In order to reduce the risk of debonding due to polymerization shrinkage, low viscosity flowable composites with low elastic modulus can be used as the luting agent [21], so that it can act as a stress absorber[22], releasing contraction stresses and improving marginal integrity of the restoration.[23]

Good bonding is achieved when the material is able to create an intimate adhesion with the post , by creating a monoblock.[24]

Root canal obturations, being indirect fillings of the root canal space created by cleaning and shaping, may be regarded as secondary monoblock systems. A primary monoblock has only one interface that extends cicumferentially between the material and the root canal wall.

The combined use of a core material and a cement/sealer in contemporary obturations and fiber post adhesion introduces additional interfaces into a monoblock.[25]

Tertiary monoblocks are those in which a third circumferential interface is introduced between the bonding substrate and the abutment material. Fiber post that contain either an external silicate coating or those that contain unpolymerized resin composite for relining root canals that are too wide or not perfectly round for the fitting of conventional fiber post are considered as tertiary monoblocks [26]

Thus every component of tooth or restorative material is directly or indirectly bonded to every other component. The bonding strength at each interface is stronger than the bond of the tooth to itself. The advantage of the bonded post is its ability to distribute stresses placed on the restoration over a larger radicular surface.

In our present study, the results showed showed that self-adhesive resin cements have higher bond strength in comparison to other cements which were in accordance with other studies.[27,28,29,30]

According to the manufacturer's instructions (3M ESPE), the procedure used for post luting requires no pretreatment because the machine-shaped outer surface of the post will provide a sufficient retentive surface for the resin cement, despite its inert chemical behavior.[31]

Self-adhesive resin cements present multifunctional monomers with phosphoric acid groups which demineralize and infiltrate root dentin forming the good micromechanical bond. The setting reaction takes place due to extensive cross-linking of monomers and creates high molecular weight polymers.

Water which is released during the process contributes to the initial hydrophilicity of cement that provides improved adaptation to the tooth structure, according to Radovic et al. [32]

The adhesion mechanism of these cements are claimed to rely on micromechanical retention and chemical interaction between monomer acidic groups and hydroxyapatite (Bishara SE et al , 2006, Goracci C et al 2006, Sirimai S et al , 1999) [33]

More recently dual cure polymerizing resin luting agents have been introduced and compared with light cured composites , it is generally accepted that dual cured and self cured composites produce lower shrinkage stresses due to their lower curing rates that allow more stress relief by polymer flow (Feng L et al, 2006) [34]

As per previous studies conducted, Self Adhesive Resin Cements cannot form a hybrid layer into the root canal, as they are unable to etch through the smear layer formed during the mechanical instrumentation, or after the post space preparation.[35]

Because aggressive acid etching is detrimental to the dentine adhesion of these cements, due to their inability to infiltrate the collagen depleted by the etching step, the post space was cleaned with 17% EDTA solution to remove the smear layer that developed., thus allowing the dentinal tubules of the root canal to be opened for better adhesion of the SARC to the dentine.[36,37]

In the present study, both the resin cements showed better pull-out bond strength than resin-modified glass ionomer cement and the results were stastistically significant, which were accordance to many studies.[38]

This result could be due to various factors such as they are less technique sensitive, have greater moisture tolerance and their composition allows for better adhesion.

The adhesion of RMGIC depends on the technology of GIC modified by the addition of hydrophilic resinous monomers (HEMA [2-hydroxyethyl methacrylate] and dimethacrylate). Hence, this cement presents with dual setting reaction which is characterized by an initial monomer polymerization followed by classic acid-base reaction.[39]

The nonsignificant difference in the bond strength of RMGIC with self-etch adhesive resin cements in our study can be assigned to the capability of HEMA present in RMGIC to penetrate into dentinal tubules up to a depth of 1.5 µm forming a micromechanical bond.[40]

VI. Conclusion

Within the limitations of this study, it can be inferred that the self-adhesive resin cements have better bond strength in comparison glass ionomer-based cements and resin cements evaluated in this study provided adequate retention to fiber posts.

However, more studies are required to evaluate the influence of different factors on the bond strength of luting cements

VII. Clinical significance

The relining procedure of fiber posts with composite and the proper selection of luting resin cement are important for increasing bonding effectiveness to the post.

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