Original Article

Comparative evaluation of pull-out bond strength of fiber post using different luting cements in endodontically treated teeth: An *in-vitro* study

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ABSTRACT

Aim: This study was aimed to evaluate and compare the pull-out bond strength of fiber post using glass ionomer cement (GIC), resin-modified glass ionomer cements (RMGIC), self-etch adhesive resin cement, and self-adhesive resin cement in endodontically treated teeth.

Materials and Methods: Forty single-rooted teeth with single canal were decoronated, endodontically treated, post space were prepared and divided into four groups (n = 10) based on the cement used for luting the fiber post. Group 1: GIC, Group 2: RMGIC, Group 3: Self etch adhesive resin cement, Group 4: Self-adhesive resin cement. Pull-out test was evaluated for the prepared samples. Statistical analysis was performed using analysis of variance and Tukey's test (P = 0.05).

Results: The mean pull-out bond strength of Group 4 was statistically higher than Group 1,2 and 3. Group 1 showed the least bond strength among all the groups.

Conclusion: Within the limitation of this study, self-adhesive resin cements provide better bond strength of fiber post to root canal compared to self-etch adhesive resin cement and glass ionomer based cements.

Keywords: Fiber post, glass ionomer cement, pull out test, resin cement, self-adhesive cement, self-etch adhesive cement

INTRODUCTION

The loss of a large amount of tooth structure due to caries, fracture, endodontic access, and previous restorations can widely affect the rehabilitation of endodontically treated teeth. These endodontically treated teeth will then need to be reinforced by the placement of the post. Glass fiber posts have gained importance and are an excellent choice as they minimize dentin removal and preserve root structure and strength.[1]

One of the major factors which can influence the retention of fiber post is the cementation technique which is used to create a link between post and root canal dentin.[2] The integrity of the dentin-cement-post sandwich interface is critical for post retention[3] as post debonding is the most common cause of failure.[4] The type of cement selected for the luting of the post is very critical for all types of posts. Several studies have reported adhesive failure at the post cement interface.

The most common luting agents used for cementation are Glass Ionomer, Resin-Modified Glass Ionomer, and Resin

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cements. Glass Ionomer-based cements provide chemical adhesion and have a similar coefficient of thermal expansion as compared to the tooth structure and are dimensionally stable at high humidity and biocompatible with fluoride releasing the property. However, they have less tensile strength resulting in a lack of adequate strength and toughness.[3] Resin cements, on the other hand, are the newer types and can bond to the tooth structure and internal surface of restoration and have high compressive, flexural, and tensile strength.[5] They form resin-dentin interdiffusion zone and resin tags which provide micromechanical interlocking between resin and demineralized root dentin.

However, the high configuration factor associated with long, narrow post space results in the generation of extensive polymerization shrinkage stresses that might affect the integrity of the resin dentin bonding interface. Hence, judicious selection of luting cement is crucial for the stability and retention of the post. Many studies are available in the literature for evaluating the bond strength and luting of these cements individually, although there is no consensus regarding the ideal luting agent.[1,2] Thus, the aim of this study was to analyze and measure the pull-out bond strength of fiber post luted using four different cements, i.e., Glass Ionomer Cement (GIC) (GC Gold Label Luting and Lining, GC Corporation), Resin Modified GIC (Fuji II LC Improved, GC Corporation), Self-etch adhesive resin cement (Core X Flow, Dentsply) and Self-adhesive resin cement (Maxcem Elite, Kerr).

MATERIALS AND METHODS

Forty extracted single-rooted teeth with single canal were selected. Radiographs were taken from buccolingual and mesio-distal angulation to confirm single canal. Teeth were cleaned off any soft tissues and kept in 3% sodium hypochlorite (Prime Dental Products Pvt Ltd, India) for 2 h for surface disinfection and then stored in saline (Swaroop Pharmaceuticals Pvt Ltd., India) until use. The crown of each tooth was resected coronally around cement-enamel junction to maintain a standard length of 14 mm. Working length was established 1 mm short of apex using a size 10 K file (Mani Inc., Japan). The root canal was instrumented using hand files till apical size 40. 1 ml of 3% sodium hypochlorite was used as irrigation after each instrumentation with final rinse of saline. The canals were dried using paper points and obturated using the cold lateral compaction technique. With gutta percha (Dentsply Maillefer, Switzerland) and AH Plus sealer (Denstply DeTrey GmbH, Konstanz, Germany). The teeth were stored at 37°C and 100% humidity for 1 week to allow complete set of sealers.

After 1 week, gutta-percha was removed till 9 mm to prepare post space using peeso reamer till number 3. The post space was flushed with saline and dried. After preparation, 40 specimens were randomly divided into four groups based on cement used for luting of posts ($n = 10$).

- Group 1: Conventional GIC-GC Gold Label Luting and Lining Cement (GC Corporation, Tokyo, Japan)
- Group 2: Resin-Modified GIC-Fuji II LC Improved (GC Corporation, Tokyo, Japan)
- Group 3: Self-etch adhesive resin cement-Core-X Flow (Dentsply, Konstanz, Germany)
- Group 4: Self-adhesive resin cement-Maxcem Elite (Kerr Company, Orange, USA).

Size 0 prefabricated fiber posts (Selfpost, Medicept UK Ltd, UK) were not etched luted in the post space prepared using the chosen material which was mixed according to the manufacturer's instructions.

The teeth were stored in distilled water at 37°C for 24 h and were mounted on self-curing acrylic blocks vertically along their long axis. The Universal testing machine (Asian Test Equipments, India) 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 results were statistically analyzed.

Statistical analysis

Data were collected and subjected to analysis using the Statistical Package for the Social Sciences (SPSS) version 21. Pull-out bond strength scores were presented as means along with standard deviation. Graphs were prepared on Microsoft excel.

Overall group comparison of pull-out strength was made using one-way Analysis of Variance test along with *post hoc* pairwise comparison using Tukey's test. The level of statistical significance was set at 0.05.

RESULTS

Table 1 show the mean pull-out bond strength (in newtons) of all four groups. Group 4 shows the highest pull-out bond strength (65.90 ± 5.01 N) followed by Group 3 (41.97 ± 7.27 N), followed by Group 2 (36.57 ± 4.69 N) and by Group 1 (26.08 ± 4.34 N) having the least value. Mean pull-out bond strength was found to be in the following order: Group 4 > Group 3 > Group 2 > Group 1.

Post hoc pairwise comparison using Tukey's test showed that the difference in mean pull-out bond strength between

Table 1: Mean and standard deviation of all the groups

Group	n	Mean±SD	Force in Newtons 95% CI for mean		Minimum	Maximum
			Lower bound	Upper bound		
1	10	26.08[a]±4.34	22.97	29.19	20.59	32.36
2	10	36.57[b]±4.69	33.22	39.93	30.40	44.12
3	10	41.97[b]±7.27	36.76	47.17	33.34	53.93
4	10	65.90[c]±5.01	62.31	69.48	55.89	72.56

Different suprascript alphabets indicate statistically significant differences. SD: Standard deviation, CI: Confidence interval

Group 4 with that of Group 1, Group 2, and Group 3, were all statistically significant. The difference in mean pull-out bond strength between Group 3 and Group 2 was not found to be statistically significant. While both Group 3 and Group 2 showed a statistically significant difference from Group 1 with respect to mean pull-out bond strength.

DISCUSSION

As the post is luted in long and narrow post spaces, the luting of the post can be challenging. There can be the inclusion of void in the case of conventional cements and polymerization shrinkage in resin cements which can lead to compromised retention. The major cause of fiber postfailure is the loss of retention, therefore, the cement used for luting of fiber post plays an important role. The pull-out test reflects the tensile and shear bond strengths simultaneously and hence, it simulates the clinical failure scenario more realistically than the push-out test.[3]

The results showed self-adhesive resin cements have higher bond strength in comparison to other cements which were in accordance with other studies.[6-9] The result could be attributed to the fact that they are less technique sensitive, have greater moisture tolerance and their composition allows for better adhesion. According to Radovic *et al*.,[10] 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.

Contrary to the result of the present study, Calixto *et al*.[11] reported in his study that the etch-rinse and self-etch adhesive systems based resin cements have better bonding of fiber post in comparison to self-adhesive resin cements which was attributed to the possible deficient hybridization of dentin along the root canal walls and limited etching potential in self-adhesive cements. It was postulated that a deeper resin-dentin interdiffusion zone results in thicker hybrid layer and hence better bond strength. However, a study was reported by Bitter *et al*. in which he found out that hybridization can not always be correlated to the bond strength of cement and the chemical interactions between the adhesive cement and hydroxyapatite is more crucial for root dentin bonding than the ability to hybridize dentin.[6]

Varied result from our study was also found in a study by Nova *et al*. who reported Maxcem Elite to have lower bond strength in comparison to another self-adhesive cement Rely X Unicem.[12] This was assigned to the differences in acidic group monomers and their concentrations which lead to different etching patterns and wetting ability causing differences in chemical adhesion to dentin.

Self-etch adhesive resin cement includes acidic monomer solutions which either make the smear layer permeable to allow the formation of hybrid layer interface or hybridized smear layer.[8] The advantage of the self-etch technique is that the depth of demineralization and resin infiltration occurs simultaneously.[13] In this study, Self-Cure Activator was used in 1:1 ratio with self-etch monomer to uniformly polymerize the cement along the entire post space length. Although it is less technique sensitive, there are difficulties in conveying sufficient amount of primer-adhesive solution to the apical region of canals and manipulation problems arise from inadequate root canal access.[14] This can lead to unpredictable bonding of self-etch adhesive resin cements. The root canal is a long and confined space where the length and diameter of applicator tips do not guarantee the extent of its reach to the full prepared space which may lead to voids in the filling space. This could be one of the reasons for inferior bond strength in our study.

Another important factor to be taken into consideration for bonding of self-etch adhesive cement is the pH of the acidic monomer which penetrates the smear layer during the bonding. The self-etch adhesive used in the present study has a mild pH (>2.5) formulation which can be attributed to the low bond strength of this group. The same was found out in a study reported by Sterzenbach *et al*. that self-etch adhesive resin cements have less bond strength which was assigned to the use of mild self-etch adhesive in their study as it results in insufficient dissolution of the smear layer with less resin tags and non-uniform hybrid layer formation.[8]

In the present study, both the resin cements showed better pull-out bond strength than resin-modified glass ionomer cements (RMGIC) and GIC with results being statistically insignificant with RMGIC and significant with GIC. The adhesion of RMGIC relies 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.[15] 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.[16]

Contrary to our study, Pereira *et al*. found greater bond strength values when fiber posts were cemented with GICs and RMGICs than with dual-cured resin cements.[17,18] This was attributed to hygroscopic expansion in RMGIC which enhances the frictional resistance to post dislodgement and results in a more intimate adaptation between cement and dentin. GICs and RMGICs set with two different reactions. The first reaction consumes all the water available in their composition and the second reaction uses water from other sources, such as dentinal tubules.[19] Initially, the water kept for only 24 h in water after cementation of posts so less absorption leads to a slight setting contraction but subsequent hygroscopic expansion. In their study, teeth remained immersed in water during all cementation procedures and for 1 week after cementation, whereas in the present study samples were hygroscopic expansion is expected. According to Reis KR, RMGICs absorb large amounts of water in the 1st week and show variable volumetric expansion between 3.4% and 11.3% and they attract water due to the presence of hydrophilic resin monomers in the cement layer.[15]

The GICs showed the lowest mean pull-out bond strength as compared to other groups which were in accordance with other studies.[15,20,21] The adhesion mechanism of GIC is purely chemical in nature leading to the formation of an "ion-exchange" layer which consists of reciprocal diffusion of ions from GIC and dentin, and a chemical bond is found between carboxyl groups of polyakenoic acid and the calcium component of hydroxyapatite.[21] The chemical interaction is favorable, but failure occurs as the cohesive failure of the cement rather than at the chemical interface between ionomer and dentin. Moreover, GICs require 4–6 weeks to attain the maximum strength.[22] The voids due to air entrapment seem to reduce the bond strength of GICs.[23]

CONCLUSION

Within the limitations of this study, it can be inferred that the self-adhesive resin cements have better bond strength in comparison to self-etch resin and glass ionomer-based cements. The bond strength of cements in the root canal also depends on various other factors such as length, design, diameter, composition, surface treatment of post, cement thickness, polymerization mode, and cavity configuration factor. As these factors were the limitations of the study, they were kept standardized and not evaluated individually. However, more studies are required to evaluate the influence of different factors on the bond strength of luting cements.

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Conflicts of interest

There are no conflicts of interest.

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