Original Article

An In-Vitro Study Comparing The Push Out Bond Strength Of A Fiber Post System Employing Four Different Resin Cements.

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Abstract

Background: Debonding is one of the common reasons for failure in fiber-reinforced composite posts, and it tends to occur at the post space-dentin adhesive contact. The goal of this investigation was to evaluate the push-out bond strength of a fiber-reinforced post system by using four distinct types of resin cement.

Materials and Methods: This in-vitro research used a decoronation technique on forty mandibular premolars, and endodontic treatment was performed on the roots. After the post space preparation was complete, the root specimens were divided up into four groups of ten each and categorized accordingly. The following are the names of the four resin cement systems that were used to cement fiber-reinforced composite posts: (a) Multilink Speed, (b) Rely X Unicem, (c) Calibra, and (d) Permaflo DC. Three portions of each root were cut to a thickness of three millimeters, and these parts were prepared. The bond strength values were determined by performing a push-out test using a universal testing machine at a crosshead speed of one millimeter per minute (mm/min). After compiling the results, a post-hoc Scheffe test and multivariate analysis of variance (MANOVA) were carried out on the data.

Result: The product with the greatest mean push-out bond strength was Rely X Unicem, followed by Multilink Speed and then Permaflo DC. Calibra was found to have the mean push-out bond strength that was the lowest. Using the MANOVA and post-hoc Scheffe tests, we discovered that the push-out bond strength of resin cement varied significantly across the various root canal areas. These variations were statistically significant.

Conclusion: The mean push-out bond strength of Rely X Unicem was the greatest, followed by Multilink Speed and Permaflo DC in that order. When compared to Calibra, the mean push-out bond strength was found to be the weakest.

Keywords: Fiber post, push out, resin cement

INTRODUCTION

Teeth that have been endodontically treated have a lower moisture content and are more likely to suffer coronal damage from dental caries. This decreases the tooth's rigidity, which might result in fractures from previously placed restorations. 1 As a consequence of this, there is an increase in the probability that the treated tooth may fracture while being used. The restoration of the tooth with no pulp should make the tooth more fracture-resistant when it has been completed. Posts are recommended for use in teeth that have suffered substantial tooth damage in order to preserve the core that replaces the missing coronal structure. When the remaining cervical dental tissue is unable to provide support and retention, it may be necessary to consider placing a second post. In the last several decades, the post material that has been used the most often for post and core repairs has been metal cast posts. When opposed to dentin, conventional cast posts have a higher modulus of elasticity, which results in more stiffness. Additionally, conventional cast posts need many appointments in order to be fabricated. These three disadvantages were noticed with conventional cast posts. 4 Problems such as loss of retention of post or crown, root fracture, and danger of corrosion when using various metals have been documented, which led to the search for posts with more favorable load bearing and retentive property combinations. 5, 6

Clinical investigations have revealed a success rate of between 95 and 99% for teeth that were repaired using fiber-reinforced posts, and over the course of the research, there was no occurrence of root fracture. The major benefits of fiber posts include their modulus of elasticity, which is comparable to dentine; high fatigue; tensile strength; and the ability to be cemented with an adhesive luting material, which prevents the development of friction between the posts and the root canal walls. This allows the applied force to be distributed evenly along the length of the post. 7 Surface treatment treatments that make use of mechanical or chemical agents have been recommended as a way to enhance the binding strength between pre-fabricated posts and resin cement. The purpose of the chemical treatment is to roughen the surface of the post in order to improve the mechanical interlocking between the post and the resin cements. Recent research has demonstrated that providing a post surface pre-treatment to fiber and the materials that are utilized for core build-up results in a stronger link between the two. 8, 9

Recent investigations suggested that fibre post repairs may be unsuccessful as a result of debonding of the posts. Micro tensile and push-out tests have been used to determine the degree of post retention across the various post space areas. Micro tensile tests make it possible to get a more equal distribution of stress along the bonded contact. The strength of the link between the post material and the resin luting agent, as well as the bond strength between the post space dentin and the resin luting agent, is critical to the retention of fibre posts in the roots. When push-out tests are performed, the majority of the retention will be caused not only by the adhesive bonding agent, but also by the micro retention that results from the frictional fit between the two surfaces. Due to the significant number of early failures that occur during specimen preparation, a recent research concluded that push out tests are the most trustworthy way for assessing binding strengths between fiber posts and post space dentin.

MATERIALS AND METHODS

The Department of Endodontics was in charge of carrying out this in-vitro research investigation. For the purpose of this study, the Department of Oral and Maxillofacial Surgery provided the researchers with forty single-rooted mandibular premolar teeth that had previously been removed from human patients for orthodontic treatment.
Standards for admittance.
1. A complete, erect, single-rooted, lower premolar that has just one root channel in its structure.
2. Teeth that have fully developed root systems
3. Teeth that have patent canals inside them
4. Teeth that are devoid of any anatomical variations
5. Teeth that are devoid of any signs of dental caries.

Exclusion conditions
1. Teeth that have apices that are open
2. Calcified canals
3. Teeth with several roots
4. Variations in the anatomy of the radicles

The ultrasonic scaler was used to remove any debris and soft tissue that was attached to the teeth. In order to prevent the teeth from drying out before the next phase of the investigation, they were preserved in 0.9% normal saline.

Preparation of samples for examination

The recommendations and rules set out by OSHA and CDC regarding the storage of extracted premolar teeth were followed. The procedure for preparation and irrigation was carried out by a single operator, and it was standardized to apply to all of the groups. An endodontic access bur was used in order to prepare the access cavity. Barbed broaches were used to clean out the pulp from the root canals. The patency of the apical foramen was assessed by inserting a No. 10 K-file into the root canal until the tip of the file was visible at the apical foramen, and then subtracting 1 mm from that length. This allowed the length of the root canal to be accurately measured. Teeth were instrumented using a master apical file with a size of No. 30 all the way up to the apical foramen. The canal was next prepared using the step back method, after which the channel was flared, and H-files were used to do circumferential filing around the canal. As an irrigant, 10 milliliters of sodium hypochlorite was applied in increments of consecutive filing. During the biomechanical preparation process, a recapitulation was carried out using files of a lesser size. Irrigation with 10 milliliters of sodium hypochlorite and 10 milliliters of 17% EDTA solution for three minutes each was used to remove the smear layer. The final wash was performed using 10 milliliters of sterile water. Paper points were used to dry out all of the canals. Obturation was achieved by using AH Plus sealer in conjunction with lateral condensation of gutta-percha. After that, the teeth were decorated with a diamond disk 1 mm above the cementum-enamel junction (CEJ) and the root canals were made with peaso reamers to a depth of 10 mm. The purpose of this was to shield the roots from any light that may have come from the outside. Following the completion of the post space preparation, a solution containing 17% EDTA was used to remove the smear layer. The teeth were then divided into four groups, each having ten teeth, using a random assignment method.
• Posts in Group 1 will be luted using the Multilink Speed algorithm.
• Posts in Group 2 will be luted using the Rely X Unicem formula.
• In Group 3, the font Calibri will be used to format the posts.

• Posts in the Group 4 arena will be luted using permanent DC.

Following a one-week period during which all of the roots were kept at 37 degrees Celsius in water that had been distilled, the roots were then sectioned using a diamond disc at a low speed while being sprayed with water. After obtaining slices with a thickness of 2.2-2.5 millimeters, one was taken from the cervical third of the post (about 1 millimeter below CEJ), one from the middle third, and another from an apical third of the post. In order to conduct the push out test, specimens were first put in a specialized device, which consisted of a stainless steel base with a central opening of 2.5 millimeters in diameter. This device was then attached to the bottom portion of the universal testing machine. The post that was then cemented into the root canal was positioned such that it was perfectly aligned with the central orifice. Each root slice was positioned such that the coronal side faced the base when it was placed there. The metallic test point, which had a diameter of 1.0 mm, was fastened to the top section of the universal testing machine and positioned in the middle in respect to the fiber post. In order to avoid contamination of the base in the region where the tooth and post interface is located, no adhesive substance was utilized to secure the dental slice. A pace of 0.5 millimeters per minute was used for the push out strength test until the post became dislodged. The presence of a sudden decline along the load/time curve recorded by the testing machine provided conclusive evidence for this assertion. The findings were subjected to statistical analysis, in which a multivariate analysis of variance (MANOVA) and a post-hoc Scheffe test were used.

RESULTS

The purpose of the present research was to test the push-out bond strength of a fiber post system utilizing four different resin cements at three distinct post space areas (3 mm coronal, 3 mm middle, and 3 mm apical) of root dentine. In terms of the incisal area, the mean push-out bond strength of Rely X Unicem was the greatest, followed by Multilink Speed and then Permaflo DC. The mean push-out bond strength was found to be the weakest for Calibra (Table 1). Using MANOVA, we found that the push out bond strength of resin cement varied significantly depending on the root canal area. These variations were statistically significant (Table 2). In a similar fashion, the mean push-out bond strength of Rely X Unicem was the greatest in the middle area, followed by Multilink Speed and Permaflo DC in that order. In respect to Calibra, the mean push out bond strength was determined to be the lowest (Table 1). The multivariate analysis of variance (MANOVA) revealed that the push-out bond strength of resin cement varied significantly depending on the location of the root canal. In terms of the incisal area, the mean push out bond strength of Rely X Unicem demonstrated statistically significant differences when compared to the values shown by all of the other resin cements through Scheffe post-hoc testing. However, there was not a discernible difference identified when comparing Calibra to Multilink Speed, Calibra to Permaflo DC, or Multilink Speed to Permaflo DC. All of the resin cements showed statistically significant differences in relation to the middle and apical regions, with the exception of Multilink in relation to Permaflo DC in the middle region and Multilink in relation to Calibra in the apical region, where there were no significant differences found.

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.
Incisal	Rely X Unicem	10	17.5
	Calibra	10	**12.1**
	Multilink speed	10	12.1
	Permaflo DC	10	**11.9**
Middle	Rely X Unicem	10	12.1
	Calibra	10	6.89
	Multilink speed	10	9.89
	Permaflo DC	10	9.78
Apical	Rely X Unicem	10	5.78
	Calibra	10	3.88
	Multilink speed	10	4.1
	Permaflo DC	10	4.66

DISCUSSION

The effectiveness of endodontic treatment is contingent on appropriate post-endodontic restoration, which is performed in order to provide pulpless teeth the ability to function as an essential component of the masticatory apparatus. Pulpless teeth offer numerous difficulties of restorative issues such as loss of tooth structure caused by cavities, fracture, and previously existing faulty restorations. These problems might make it difficult to restore the tooth.

When a tooth has had endodontic treatment done to it, the placement of an intracoronal post serves mainly the purpose of retaining the core structure for eventual restoration. Cast metal alloy posts and prefabricated metal posts constructed of a variety of metal alloys, including stainless steel and titanium, are only two of the many kinds of posts that have been used in the past. The cast post core technology requires intricate laboratory methods, and the most significant disadvantage of metal posts is their stiffness, which is caused by their high modulus of elasticity. Differences in the stiffness of the post and root dentine have been suggested as a possible cause of root fractures. Stress concentrations inside the root have been shown to contribute to irreversible failures. In recent years, non-metallic posts having biological and physical qualities comparable to dentine's have been created. These posts have been designed to replace traditional dental implants.

The fact that fiber posts may be bound to the tooth and have a modulus of elasticity that is near to that of dentin are said to be some of the benefits of using fiber posts. This supposedly results in better post flexibility. Fiber posts, which are composed of quartz and glass fibers encased in a resin matrix, have been included into the structure in order to maintain its aesthetic quality. These posts are made up of unidirectional fiber, and they are gaining in popularity due to the fact that they have a strong binding to dentine and allow light to pass through them. According to the findings of an in-vitro investigation, fiber posts are less likely to produce vertical root fracture than stainless steel posts are. This is due to the fact that stresses seem to be absorbed by the post and core rather than being transmitted to the root structure. The poor preservation of posts is the most prevalent and widespread downside of post cores. The retention of the post is impacted by a variety of factors, including the cement, post material, surface structure, post length, and quantity of surviving tooth structure. 1 There are a number of different post surface pre-treatment processes that include the use of mechanical or chemical agents that have been recommended in order to strengthen the bond strength that exists between the post and the resin cement. 10 Extensive research has been conducted on in-vitro investigations evaluating the influence of cement on the retention of the post. According to a number of studies, the use of resin cement greatly improves the retention as well as the fracture resistance of teeth by providing adhesive bonding. Because light cannot go very far into the inside of the root canal, it is advised that you use a resin cement that can either cure on its own or in two stages.

According to the findings of this in-vitro investigation, the bond strength values achieved by Rely X Unicem were much greater than those achieved by other materials. It is possible that these values are equivalent to those of luting agents that involve many steps. When measured against the binding strength of other self-adhesive materials, Rely X Unicem recorded much higher values. It is possible that the outcomes attained might be attributed to the use of the cement and post-combination that was advised by the makers. In this particular research, only one kind of fiber post was used since our primary objective was to evaluate the binding strengths of various resin cements, and we needed to ensure that everything was consistent. Variations in the manner of application are also likely responsible for the observed differences. An extension tip was used to inject Rely X Unicem into the root canal. This reduced the likelihood of bubble formation and air trapping, which in turn would contribute to an improvement in the marginal adaption of the material, both to the dental substrate and to the fiber post. In their study, Simonetti et al. compared the superior sealing ability of Rely X Unicem dispensed with an extension tip to that of Multilink Speed, Calibra, and Permaflo DC, all of which were injected into the root canal using a lentulo spiral or were directly deposited on the post surface. Both of the self-adhesive cements that were used in this investigation had a consistency similar to that of paste when mixed together. After the base and catalyst have been combined on a glass pad using an auto-mixing tip, the combined substance is transferred to a lentulo spiral for insertion into the root canals. This approach proved to be less practicable due to the fact that it may raise the possibility of air entrapment, which would result in the production of voids and interfacial defects, which would hasten premature failure in the presence of cyclic loads.

The bond strengths of Multilink Speed were much lower than those of Rely X Unicem. Although there were some inconsistencies in the degree of demineralization and the depth of resin penetration, the material was able to demineralize the tooth substrate to some extent. This was determined by using light microscopy. The material gave off the appearance of being porous at the dentine site bond, most likely as a result of the inadequate polymerization process. It is possible that the presence of leftover acidic monomers at the bottom of the adhesive contact represents weak regions since these monomers may maintain their etching potential, which puts the adhesion in jeopardy. Because of the existence of these regions and the collagen fibers that are exposed, the adhesive joint would suffer from early degradation, which would therefore restrict the bonding capacity of the material and shorten the service life of the repair. To determine how long these self-adhesive cements will remain effective, further research has to be conducted.

Ageing tests are used in a great number of investigations to determine how long bonded interfaces will remain functional. Thermocycling, as discovered by Mosharraf and Haerian11, has the potential to boost the retentive strength, particularly for Rely X Unicem. It is a porcelain and tooth surface that does not need to be pre-treated in order to use Rely X Unicem, which is a convenient dual-curing resin cement. After it had reacted with the dentin, a new component called methacrylated phosphoric ester was produced. Each methacrylated phosphoric ester monomer has two or more PO3z4 and two C5C double bonds as its constituent parts. Phosphate and the Ca21 surface of the tooth combine to generate a chemical bond that is stable and increases the adhesive force on tooth tissue. The presence of an unsaturated double bond determines whether or not something is highly reactive and strongly crosslinked. The good mechanical qualities of resin cements are maintained during polymerization thanks to the strongly crosslinked structure. 12 The purpose of the thermal modifications was to encourage full chemical polymerization, with the ultimate goal of increasing its bonding capacity. Self-adhesive cements function as dual-cure materials, which means that the chemical polymerization may be completed by irradiating the cement with light.

When Rely X Unicem was solely allowed to auto-cure, Balbosh and Kern13 achieved lower bond strengths and saw a reduction in the material's mechanical characteristics. Between Rely X Unicem and Multilink speed, there was found to be no discernible difference in the amount of monomer conversion that took place. In this particular research, the method of extracting fiber posts was not analyzed. The specimens lacked any kind of coronal tooth structure when they were created. The amount of coronal tooth structure that was still present after endodontic treatment was a significant factor in determining how long the restoration will last in a patient's tooth. 11 It was not possible to assess the influence of fatigue loading and temperature cycling on the push out bond strength of a glass fiber-reinforced composite post system in the research that was carried out.

CONCLUSION

The following are some of the conclusions that may be drawn from the research, bearing in mind its limitations: In terms of the incisal area, the mean push-out bond strength of Rely X Unicem was the greatest, followed by Multilink Speed and Permaflo DC. When compared to Calibra, the mean push out bond strength was found to be the weakest. The mean push out bond strength of Rely X Unicem was the greatest in the middle area, followed by the mean push out bond strength of Multilink Speed and Permaflo DC. In regard to Calibra, the mean push out bond strength was found to be the weakest. The mean push out bond strength of Rely X Unicem exhibited statistically significant differences when compared to the bond strengths of the other resin cements in the incisal area. When using four different resin cements, the push out bond strength of a fiber was greatest in the incisal area of root dentine, in comparison to the middle and apical regions of the root dentine.

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