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Research Article

EVALUATION OF PUSH-OUT BOND STRENGTH OF BIOLOGICAL DENTIN POST TO ROOT CANAL DENTIN WHEN LUTED WITH FOUR COMMERCIALLY AVAILABLE LUTING CEMENTS. AN INVITRO STUDY"

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A R T I C L E I N F O

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A B S T R A C T

Background: The primary goal of any restorative treatment is to bring back the tooth to form and function. Teeth with severe coronal damage requires additional retentive steps to retain the core, postendodontically. Posts are an easy and reliable method to achieve additional retention and thereby increase the longetivity of the tooth. Endodontically treated teeth appear to have a better clinical outcome when adhesive methods and posts are minimally invasive. Although there are many commercially available post types, none fully satisfy the optimum biological and mechanical qualities. An innovative alternative strategy for the repair of a severely injured tooth is the use of biological post. Therefore the purpose of the study is to evaluate the push-out bond strength of biological dentin post to root canal dentin when luted with different luting cements.
Methods: Eighty single rooted teeth were selected and decoronated 14 mm from the apex of the tooth. The teeth were prepared and obturated, then divided into four groups of 20 samples each. The post spaces were prepared and biological dentin posts were cemented in group I with Type 1 GIC, in group II with Multilink N and in group III with Solocem and in group IV with Rely X U 200 luting cements. The specimens were sectioned into three slices of 3 ± 0.5 mm thickness to perform the push out test using universal testing machine. Thus, collected data was statistically analysed using one-way analysis. Multiple comparisons between the material groups and the position groups was made using TUKEY'S HSD post hoc test.
Results: The push out bond strength of group IV was significantly higher than that of group I , group II,group III and group IV ($P < 0.05$). No statistically significant difference was found between group I, group II and group III. There was significant difference between coronal, middle and apical thirds in groupII groupIII and groupIV.
Conclusion: Among the luting cements used, RelyX U200 offers superior bond strength at cervical middle and apical sections of the dentin post luted to root dentin. Self adhesive resin cements offer superior bond strength than conventional GIC, when luted with biological dentin posts. Further research has to be undertaken to consider biological dentin post as a viable alternative to conventional posts.

INTRODUCTION

An endodontically treated tooth must be restored back to form and function with a thorough awareness of its physical and biomechanical qualities, as well as its anatomic, endodontic, periodontal, restorative and occlusal principles.

The restorative segment that is put into the root canal to support the maintenance of a core component is referred to as a post. The post's main goal is to increase the resistance form of crown and root to support the core material.

It is desired that the physical characteristics of the post, match with that of dentin tissue. A perfect post would distribute the functional loads evenly along the root surface so that the root surface undergo least amount of stresses under masticatory loading. The post material should ideally resemble dentin in terms of aesthetics, physical characteristics including compressive strength, elastic modulus, thermal expansion, and predictable bonding. However, none of the posts meet all the mechanical and biological requirements. Dentin alone is the only substance that can possess all of these qualities.

The use of natural tooth pieces to rebuild the lost component of the tooth has been proposed as a novel and biomimetic technique. This "biological restorative" technique posseses ideal mechanical and biological properties. The use of root dentin itself as post material is one such novel idea Posts are cemented or luted onto dentin surfaces using luting cements, Ideal luting cements should have good physical properties including bond strength. Regarding the degree to which

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various luting agents adhere to endodontic posts and root canal dentin, several in vitro experiments have produced conflicting findings.

In various parts of the root canal, the bond strength of posts to root canal dentin may differ. This variation might be the result of challenges with controlling moisture, degree of taper, size and width of the post and canal etc. In this study three different self adhesive luting resin cements has been used to cement the biological dentin post to root canal dentin. Along with traditional type I GIC luting cement as control Therefore , the aim of this study was to determine the push out bond strength of biological dentin post when luted with different luting cements .The null hypothesis was that no significant differences in bond strength values would be found between the four luting cements to the biological dentin post.

METHODOLOGY

Tooth sample collection

The sample size was calculated using the nMaster 2.0 sample size calculator prior to the collection of tooth samples. Eighty samples were chosen as the total sample size for the experiment with a statistical power of 99%. The chosen samples were kept in a container with 10% formalin for two weeks in accordance with CDC (centres for disease control and prevention) recommendations. In order to safely handle the samples, the teeth were autoclaved for 40 minutes and stored in aqueous solution containing 0.2% thymol (to prevent dehydration) after being cleaned using an ultrasonic scaler machine to remove any hard or soft deposits from the crown and root surfaces. Samples were evaluated in accordance with the inclusion and exclusion criteria:

Inclusion Criteria

1. Single-rooted permanent teeth extracted for periodontal or orthodontic reasons.
2. Teeth with Fully developed apices.

Exclusion Criteria

1. Teeth with calcified canals.
2. Teeth with external and internal resorption.
3. Previous endodontic treatment (post or crowns).
4. Teeth with trauma or pathology or root caries.
5. Teeth with multiple canals.

Preparation of samples

Samples that met the inclusion requirements were decoronated using a diamond disc mounted to a high-speed lathe with intermittent water cooling to achieve the standard length of around 14mm from the apex to standardize the specimen . All specimens were verified radiographically to ensure patency and almost straight canals. The working length was then established using a 10k file. Each apex was covered in sticky wax to replicate the clinical situation. The roots were then randomly divided into four groups (n=20 per group) after the specimens had been mounted using modelling wax. The root canal instrumentation was done with K- files and rotary files with sodium hypochlorite irrigation between each file. All canals were enlarged up to size 30 6%. Final irrigation with 5ml 17% EDTA and saline were done. The root canals were dried with paper points. Canals were obturated with corresponding gutta-percha cones and sealer using cold lateral compaction method. After completion of endodontic treatment, the teeth were stored in 100% humidity for one week at 37°C, to allow the sealer to set. After one week, the gutta-percha was removed from the coronal aspect of each root with a Peeso reamer #3 (Dentsply-Maillefer, Ballaigues, Switzerland) leaving 4 mm gutta percha in the apices, to preserve the apical seal. The post spaces were prepared to a depth of 10 mm with the appropriate drills. A new drill was used for every five specimens. Following the post-space preparation, the root canals were rinsed with NaOCl. Final irrigation was done with17% EDTA & distilled water and post-space dried with paper points.

Fabrication of Biological Dentin Post

Freshly extracted teeth were mounted and subjected to CAD-CAM by using advanced software at the Central Institute of Plastics and Engineering Technology, Chennai, India.

The milling was accomplished through manual part programming (which consists of G and M codes to mill objects) in a 3-axes computer numeric control milling machine (which possesses x, y, and z axes for milling movements). All the information (desired dimensions of the dentin post) was fed to the CAM software that designed the computer model and generated a set of instructions for the milling machine to produce 80 dentin posts of standardized shape and dimensions (1.5-mm diameter, 17-mm length) similar to FRC posts.

The prepared post spaces were irrigated with 0.2% chlorhexidine, rinsed with water for 10 seconds, and dried with paper points.

All posts were marked at a distance of 10 mm from the apical end. The posts were cleaned with 70% ethanol for 60 seconds, rinsed with distilled water, and air dried. Before the cementation procedures, the post surfaces did not undergo any pretreatment. The dentin posts were periodically verified in the prepared post space throughout the process.

Following the satisfactory adaptation of the biological post, Specimens were then divided into four groups based on the type of cement luted to the biological dentin post. Each group consisted of 20 specimens. The four experimental groups were

Group 1:- biological dentin post luted using Type-1 GIC Control (GC)
Group 2:-biological dentin post luted using Multilink N (IVOCLAR)
Group 3:-biological dentin post luted using Solocem adhesive resin (Coltene)
Group 4:- biological dentin post luted using RelyX U200. (3M)

The canals and dentin post were etched using 35% phosphoric acid (Ultra-Etch, Ultradent, South Jordan, UT, USA) for 15 seconds and rinsed with distilled water. Excess water was removed from the post spaces with a gentle stream of air and paper points.

For cementation of dentin posts, equal amounts of luting pastes were mixed and applied onto the surface of the posts and into the root canals with a Lentulo spiral instrument (Dentsply/Maillefer). The posts were inserted into the canal, to a full depth, by using gentle finger pressure, and the excess was immediately removed with a disposable brush. For self adhesive cements, the remaining cement around the post was protected with oxygen-inhibiting gel (Oxyguard II, Kuraray).

After the cementation procedures, all specimens were stored in sterile saline in a light-proof box for one week at 37°C. Next, each root was sectioned perpendicular to the long axis with a diamond disk at low speed under constant distilled water cooling to create 3 mm-thick slices. In this manner; from each root, three post/dentin sections (coronal, middle, and apical) were obtained. Due to the tapered design of the posts, post diameters were measured on each surface of the post/dentin sections, using digital calipers (Electronic digital caliper, Minova Co, Japan), with 0.01 mm accuracy.

The push-out test was performed by using the universal testing machine at a crosshead speed of 1 mm/ minute, using a pin (diameter 1.2 mm,1.0 mm and 0.7mm) on the center of the apical aspect of the post surface in an apical-coronal direction, without stressing the surrounding post space walls. The peak force (N) required to extrude the post from the root slice was recorded. To express the bond strength in MPa, the load at failure (N) was divided by the area of the bonded interface.

Micro push out bond strength :- $A = 2\pi r \times h$
where π is equal to 3.14 is the constant, r is the root canal radius, and h is the thickness of the slice in millimetres .

Statistical analysis

Data was analysed using IBM,SPSS(statistical package for social sciences .IBM Co2013.version 22.0:Armonk,NY) was used for the analyses of the data .Comparison of mean pushout bond strength was done using one way ANOVA test .Likewise intergroup comparison of mean pushout bond strength of the four different cements at apical, middle and cervical sections was also done using oneway ANOVA.

Multiple comparisons between the material groups and the position groups was made using TUKEY'S HSD post hoc test. Level of significance was fixed at $p<0.05$ and any values less than or equal to 0.05 was considered statistically significant.

RESULTS

The mean push-out bond strength (in MPa)value was highest for the cervical third (7.78) and least for the apical third (7.33) and statistically not significant as p value is not less than 0.5 when evaluating the pushout bond strength of dentin post to root canal dentin in the coronal, middle, and apical portions of Group A.

Additionally, Group B's pushout bond strength of the biological dentin post between the cervical, middle, and apical regions is 0.000. The comparison between the cervical, middle, and apical regions is statistically significant since the p value is less than 0.05. The mean push out bond strength (in MPa) value was highest for the cervical third (8.47) and lowest for the apical third(7.07).

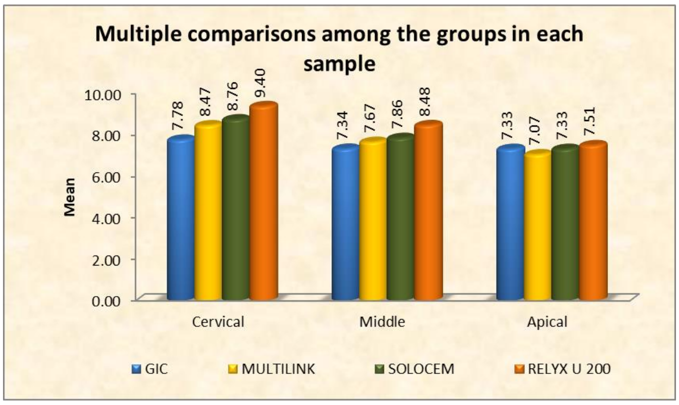
And for Group C, the p value of the biological dentin post's pushout bond strength between the cervical, middle, and apical regions is 0.003. The comparison between the cervical, middle, and apical regions is statistically significant since the p value is less than 0.05. The mean push out bond strength (in MPa) value was highest for the cervical third (8.76) and lowest for the apical third(7.33).

Table 1 Mean Values of Push out Bond Strength in MPA

Group	Cervical	Middle	Apical
I	7.78	7.34	7.33
II	8.47	7.67	7.07
III	8.76	7.86	7.33
IV	9.40	8.48	7.51

Table 2 Inter-Group Multiple Comparison of Push out Bond Strength At Coronal, Middle And Apical Level

Level	Group	Mean difference	P Value
CORONAL	I/II	-0.69	0.281 NS
CORONAL	II/III	-0.93	0.082 NS
CORONAL	III/IV	-0.64	0.353 NS
CORONAL	I/IV	-1.62	0.000 S
MIDDLE	I/II	-0.33	0.688 NS
MIDDLE	II/III	-0.19	0.926 NS
MIDDLE	III/IV	-0.62	0.175 NS
MIDDLE	I/IV	-1.14	0.002 S
APICAL	I/II	0.25	0.786 NS
APICAL	II/III	-0.26	0.777 NS
APICAL	III/IV	-0.18	0.906 NS
APICAL	I/IV	-0.19	0.900 NS



Multiple Comparison of Mean Push out Bond Strength of Dentin Post Among The Groups In Each Sample

Additionally, the pushout bond strength of the biological dentin post between the cervical, middle, and apical regions is 0.000 for Group D. The comparison between the cervical, middle, and apical is statistically significant since the p value is less than 0.05, and the mean push-out bond strength (in MPa) value was highest for the cervical third (9.40) and lowest for the apical third(7.51).

When comparing multiple groups, The dentin post luted using RELYX U200 had the highest mean push out bond strength at cervical level (9.40), while the sample luted using GIC had the lowest (7.78).The dentin post luted with RELYX U200 had the highest mean push out bond strength at the middle level (8.48), whereas the sample luted with GIC had the lowest (7.34). The dentin post luted using RELYX U200 had the highest mean push out bond strength at the apical level (7.51) and the sample luted with MULTILINK N had the lowest (7.07). The mean push out bond strength was highest for the cervical third, followed by the middle and apical third, when comparing the apical, middle, and cervical thirds.

DISCUSSION

A post is a relatively rigid, restorative, material placed in the root of a nonvital tooth that retains the core. The primary function of the post is to aid in the retention of the restoration and to protect the tooth by dissipating or distributing forces along the tooth. The evaluation of whether a post is needed depends on how much natural tooth structure remains to retain a core buildup and support the final restoration after caries removal and endodontic treatment .[1]

A wide variety of materials have been used for posts ranging from wooden posts to metal posts. The posts are generally categorized as custom-fabricated and prefabricated posts.[2]

Traditionally, cast posts with cores and ceramic posts were used which are now being widely replaced by fiber posts because of the similarity of the Elastic modulus of root dentin, thereby reducing the risk of root fractures.[3] However, failure of fiber post have been reported due to the dislodges of a post within the canal system which could be related to this damage on the adhesive cement layer when exposed to functional loading.[4]

Several authors have suggested that biological dentin post has advantages over conventional post systems .Biological dentin posts are made from extracted natural teeth and it strengthens root canals[5]. It has advantages such as : does not create undue stress on dentinal walls, preserves the internal dentin walls of the root canal, presents total biocompatibility, favoring greater tooth strength and greater retention of these posts compared to prefabricated posts, presents resilience comparable to the original tooth offers excellent adhesion to the tooth structure and composite resin .A dentin post forms a micromechanical homogenous unit with the root dentin, resulting in uniform stress distribution. The similarity in the elasticity of a dentin post to that of root dentin may allow post-flexion to mimic tooth flexion so that the post acts as a shock absorber, transmitting only a fraction of the stresses placed on the tooth to the dentinal walls .[6]

The luting cements used in this study are Multilink N, RelyX U200, Solocem, and GC Luting cement.

In this study Group A represents biological dentin post-luted using GIC.(GC LABEL1). Several authors suggest the use of luting GIC to cement posts.

Jefferson Ricardo PEREIRA (2014)et al.conducted a study on "Push-out bond strength of fiber posts to root dentin using glass ionomer and resin modified glass ionomer cements" and they concluded that (1) the bond strength of fiber posts to root dentin varied according to the cement used for post cementation; (2) higher bond strength values were observed when fiber posts were cemented using Luting & Lining Cement, Fuji II LC Improved, and Ketac Cem; (3) the post level did not influence the bond strength of fiber posts to root dentin .[7]

Krittika Samaddar et al (2021) had done a case report on "GIC as fiber post cementation material" used Glass ionomer cement (GIC GC Gold Label 1 Luting & Lining) cement and they concluded Fiber post cementation with GIC is effective, cost-efficient and less techniquesensitive. Therefore, GIC as a fiber post cementation material should be more widely utilized.[8]

In this study, the post level did not influence the bond strength of dentin posts luted using GIC to root dentin ($P>0.05$) for group 1. The mean pushout bond strength of apical, middle, and cervical sections was almost around 7MPa and they were statistically insignificant

In this study, GROUP 2 represents biological dentin post luted using Multilink N showed third-highest bond strength after RelyX U200 and Solocem at cervical & middle sections and showed the least mean push-out bond strength at the apical level. The self-etch adhesive seals the dentin and ensures marginal integrity and high bond strength on enamel and dentin, which is attained in only ten minutes. Several studies have been conducted to evaluate the push-out bond strength of Multilink N.

Iswarya R et al conducted a study on "An In-vitro evaluation of push-out bond strength of two different fiber reinforced composite post systems using two different luting cements" used Variolink II and Multilink N luting resin cements and they have concluded that - Group I and Group III where Variolink II was used for cementation of posts to the root canals, showed higher mean bond strength values when compared to Group II and Group III in which Multilink N was used as adhesive.

In this study compared to all other resin cements luted to dentin posts, RelyX U200 showed higher mean push out bond strength for cervical, middle and apical sections. *Bogdan Baldea (2013) et al* conducted a study on "Push-out bond strength and SEM analysis of two self-adhesive resin cements: An in vitro study" used Relyx U200 and Maxcem Elite as luting agents and concluded that The mean push-out bond strength of teeth samples containing RelyX U200 was higher than that observed for Maxcem Elite.[9]

In the present study, prior etching of the root dentin was performed before the use of RelyX U200 systems.The resin matrix of RelyX U200 cements consists of a multifunctional acid methacrylate (Phosphoric acid methacrylate) that infiltrate into the tooth substrate, resulting in micromechanical retention. Manufacturer claims that this unique formulation increases the mechanical properties and overall adhesion performance.

In this study, the push out bond strength for cervical samples of dentin posts were higher irrespective of the groups . Resin cements need a reliable bonding interface that is difficult to obtain, especially at the apical level of the post space. The decrease bond strength values in apical third of post space region could be due to the increase in resin cement thickness at this region when compared to cervical and middle third of post space region, where the post is cylindrical with close adaptation to root canal dentin .[7] This increased bond strength values could be due to the presence of higher resin tag density in the cervical third compared to the middle and apical thirds of the root canals.[10] *Giudice et al*. (2015) evaluated the dentine morphology in terms of tubule orientation, revealed the presence of higher tubule density in the cervical region compared with the middle and the apical parts of the root canal. The number of dentinal tubules decreases from the cervical to the apical third of the root. The dentine hybridization is not uniform in the apical third which in turn has a negative influence on the displacement resistance to the root dentin.[11]Rely X U 200 showed higher bond strength values at cervical, middle and apical sections

Within the limitations of the study it can be inferred that resin cements offer superior bond strength than conventional luting GIC when biological dentin post is cemented to root dentin. Among the resin cements compared ,Multilink N showed the least bond strength at apical level & GIC showed least bond strength at cervical and middle sections and Rely X U 200 showed maximum bond strength at cervical, middle and apical sections. The mean pushout bond strength of dentin post is comparable to FRC posts as per available data. Therefore biological dentin posts can be a viable biomimetic alternative to FRC post. Further clinical trials are warranted to reaffirm the positive use of biological dentin posts

CONCLUSION

Within the limitations of this study, it can be concluded that biological dentin post cemented with resin cements offer comparable bond strength value to conventional FRC posts. Among the resin cements compared RelyX U200 offers superior bond strength at all sections of dentin post luted to root dentin. Biological dentin posts can be a viable alternative to FRC posts. Further clinical trials are warranted to recommend this novel idea in clinical practice.

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