Original Article

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Dentistry Section

Fracture Resistance of Endodontically Treated Roots Restored with Fiber Posts Using Different Resin Cements- An In-vitro Study

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ABSTRACT

Introduction: The influence of the remaining coronal tooth structure along with intra-radicular esthetic posts increases fracture resistance of fractured teeth especially in the anterior region. The advent of resin based luting cements improves the adhesion of fiber posts.

Aim: To evaluate the fracture resistance of endodontically treated roots restored with fiber posts using different resin cements – Calibra (etch and rinse), PermaFlo® DC (self-etch primer) and SmartCem2 (self-adhesive).

Materials and Methods: Extracted human maxillary central incisors having similar dimensions were decoronated at the Cemento-Enamel Junction (CEJ) to create 16mm long specimens and endodontically treated. A total of 45 teeth were divided into three groups with 15 teeth each for cementation of easy fiber posts (size1, 0.8mm diameter). Post spaces were prepared to a depth of 10mm. Group 1 – Caulk 34% phosphoric acid gel, dual cure adhesive Prime and Bond NT followed by luting of post with Calibra cement. Group 2 – Ultra – etch then Primer A and Primer B, and PermaFlo® DC was used to cement the post. Group 3 – SmartCem2 [1:1 ratio] was used to cement the post. The excess lengths of posts were seared and teeth were mounted on acrylic blocks and loaded under compressive force to the long axis of the tooth which increased in periodic pattern of 1mm/min. The value of the force at which each root section gets fractured was noted. The data were statistically analysed using ANOVA and Tukey's Test.

Results: The mean fracture load (and SD) were as follows Group 1 – 762.400 (251.490); Group 2 – 662.933 (206.709); Group 3 – 657.800 (57.372). No statistically significant differences were seen among all three Groups, p-value (0.228).

Conclusion: Posts cemented using self -adhesive resin cement SmartCem2 have highest fracture resistance and bonding efficacy of self-adhesive technique showed reliably better results but was comparable to total–etch and self–etch techniques.

Keywords: Cementation, Dental bonding, Dental cements, Dental dowel, Root canal preparation

INTRODUCTION

Assessment and restitution of mutilated endodontically treated tooth has been a widely discussed theme in dental literature. The substantial loss of coronal tooth structure due to caries, fracture and access preparations enhance complications of restoring endodontically treated teeth and in turn affect the ability to predict restorative success.

It is well established that endodontically treated teeth have reduced resistance and higher susceptibility to fracture and hence these teeth require corono-radicular stabilization, especially the anterior teeth so as to provide retention and resistance form for the restoration [1]. Mutilated anterior teeth need the placement of a post due to shearing forces generated by the envelope of function. Presently the volume of the remnant natural tooth substance and the size of the pulp chamber to retain a core-build up should be judiciously evaluated in any clinical situation [1].

Post placement aids in the retention of the restoration and to protect the tooth by dissipating forces along the long axis of the tooth [2]. Various parameters like the post length, diameter, design, and the cement used to retain the post as well as the restoration and whether post is active or passive play an important role in the retention [3]. Using the current adhesive techniques, when posts are bonded well to the tooth along with the resin cement a monobloc type of restoration is achieved.

Fiber-reinforced composite post systems have been introduced with the proclamation of avoiding root fractures due to a modulus of elasticity close to that of dentin, producing a stress field similar to that of natural teeth whereas metal posts exhibit high stress concentrations at the post dentin interface [4]. Current fiber posts are composed of unidirectional fibers enclosed in a matrix in which a resin reinforcing quartz or glass fibers are immersed in order to obtain improved mechanical strength, retention and corrosion properties with respect to metallic posts that are more prone to fatigue, failure and corrosion [5-7]. In comparison with conventional cementation the retentive effect of adhesive systems for posts cementation improves marginal adaptation, increases post retention, relieves stresses within the root and optimizes fracture patterns in relation to re-restoration and increases fracture resistance [8]. Therefore this in-vitro study was undertaken to evaluate fracture resistance of endodontically treated roots restored with fiber posts using resin cements and compare these cements that utilize three currently available adhesive approaches: [Table/Fig-1] etch-and-rinse (calibra), self-etch (permaflo DC) and self-adhesive (smartcem 2).

Calibra® Esthetic Resin Cement (Dentsply Maillefer)	PermaFlo® DC (Ultradent Products. Inc.)	SmartCem2 (Dentsply)
Base Paste Barium boron fluoro alumina silicate glass Bis-GMA Polymerizabledi methacrylate resins Hydrophobic Amorphous Silica Colorants are inorganic iron oxides and titanium dioxide. **Catalyst Paste** Barium boron fluoro alumina silicate glass Bis-GMA Polymerizabledi methacrylate resins Hydrophobic Amorphous Silica Benzoyl peroxide	**Primer A** NTG-GMA indirect bonding/luting primer Ethyl alcohol Acetone **Primer B** Adhesive primer Acetone Dehydrated Alcohol	UDMA Resin EBPADMA Urethane Resin Di- and tri-functional diluents PENTA Proprietary photoinitiating system Proprietary self-cure initiating system 69% fillers by wt, 46% by vol.
Total Etch Adhesive system	Self -Etch adhesive system	Self - Adhesive system

[Table/Fig-1]: Composition of resin cements used in the study.

MATERIALS AND METHODS

This in-vitro study was carried out in 2013, in the Department of Conservative Dentistry and Endodontics, Krishnadevaraya College of Dental Sciences, 45 human maxillary central incisors free of caries, fractures, cracks, cervical abrasion, erosion and restorations having approximately similar dimensions were selected.

The extracted teeth were cleaned of soft tissue, calculus, debris with ultrasonic scaler and were stored in saline solution at room temperature till further use for the study.

All the specimens were divided into three Groups, each Group containing 15 samples each for cementation of the EasyPostTM (Dentsply Maillefer - size 1, 0.8mm diameter). The teeth were decoronated at the Cemento-Enamel Junction (CEJ) using a diamond disc to create 16mm long specimens, followed by determining the canal patency by passing a size 10K file through the apical foramen. Working lengths were established by using a number 10K or 15K file by passing through the canal so that 1.0mm of the file is visible through the apical foramen and then reducing 2mm for actual working length determination. The canals were coronally enlarged with gates glidden drills (size 1-3) and canal instrumentation was performed using K files and number 40K file being master apical file followed by step back preparation up to size 70K file. During instrumentation canals were irrigated with 2.5% sodium hypochlorite solution and 17% EDTA. The obturation was performed till the CEJ using guttapercha and AH plus sealer with cold lateral compaction. Guttapercha was then removed with peso reamers (sizes 1-3) from the coronal and middle thirds of the roots leaving 5mm of intact guttapercha in the canal.

The post space were prepared to depth of 10mm, pre-drill firstly with easy post largo drill number 1 and then by precision drilling with the calibrating drill number 1. Following post space preparation the canals were irrigated with sterile water and dried with paper points. Radiographs were taken to evaluate the presence of any residual guttapercha on the walls of the canals, and if present were removed. The cementation of posts was done as follows using different resin cements.

group 1-Cementation of easy post using Calibra

group 2-Cementation of easy post using PermaFlo® DC

group 3-Cementation of easy post using SmartCem2

GROUP-1 – Calibra

The teeth were preconditioned with caulk 34% phosphoric acid gel for 30 seconds rinsed thoroughly with water through a syringe and paper points. A dual cure dental adhesive Prime and Bond NT was applied and light cured. The easy posts were then silanized using calibre silane coupling agent onto the posts and were air dried gently.

The base paste and regular viscosity catalyst paste were dispensed from the syringe in 1:1 ratio onto a clean mixing pad. The cement was mixed for 20-30 seconds and was spread on the surfaces of posts and into the post space preparation using a syringe. The posts were seated immediately and stabilized with the application of moderate and consistent pressure and the excess cement was cleaned followed by light curing for 20 seconds.

Group-2 PermaFlo® DC

The post spaces of teeth were etched with ultra-etch for 20 seconds, the excess etchant was sucked off with Endo-eze tip, the post spaces were rinsed thoroughly using three way syringe and lightly air dried leaving thepost spaces slightly damp. Primer A (1-2 drops) was placed into the post space and agitated full length of the canal for 10 seconds using a deliver – eze brush. Then Primer B (2-4 drops) was placed into the preparation for 10 seconds, air dried using the three way syringe with pressure for 10 seconds and light cured. PermaFlo® DC cement was expressed to the full length of the post space and delivered using even pressure starting apically and moving coronally. The post was inserted slowly displacing the excess cement and light cured for 20 seconds.

Group-3 SmartCem2

The teeth selected for this group were rinsed and dried using a syringe. The cement was dispensed in equal proportions (1:1 ratio) onto a mixing pad and mixed for 20-30 seconds. The cement was applied into the prepared canals and the posts were inserted and stabilized with moderate pressure, excess cement was removed and light cured for 20 seconds.

The excess length of posts in all specimens was seared using a diamond disc and all the 45 specimens were mounted vertically on an acrylic resin block having the same dimension and covering 5mm of the apical portion inside the block, placing 10mm outside the block. The mounted blocks were placed on the base of the machine and a rod of 3mm diameter was placed on the coronal end, and the samples were tested to measure the fracture toughness using universal testing machine (Instron). Force was applied and was gradually increased in periodic pattern of 1mm/min. during testing the value of the force at which each root section gets fractured was noted.

The data collected were statistically evaluated using ANOVA-test and Tukey's test at 95% level of significance and the fracture toughness of the endodontically treated root restored with fiber posts using different resin cements was assessed and compared.

RESULTS

Group-3 SmartCem2 showed highest fracture resistance (762.40) compared to Group 1 Calibra (total – etch) (662.93) and Group-2 PermaFlo® DC (self – etch) resin cements whereas, PermaFlo® DC Group 2 (657.80) showed the least fracture resistance [Table/Fig-2]. Fracture load (compressive) was measured in kilograms.

Analysis of the Results

The results were statistically analyzed using ANOVA and Tukey'S Post-Hoc test for inter Group comparison.

These parameters were analyzed using Tukey's Post-Hoc pairwise comparison at 95% level of significance [Table/Fig-3].

According to the group wise comparison statistically no significant differences were found among all the three groups, but SmartCem2 (self-adhesive) resin cement showed better results which were comparable to group 1 Calibra (total – etch) and group 2 PermaFlo DC (self – etch) resin cement.

DISCUSSION

Groups	Mean Fracture Resistance Value Measured in Kilograms	Std. Deviation	F Value	p-Value	N
SmartCem2	762.40	251.490	1.529	0.228	15
Calibra	662.93	206.709			15
PermaFlo® DC	657.80	57.372			15

[Table/Fig-2]: Difference of fracture resistance values between the three groups, SmartCem2, Calibra and PermaFlo® DC using ANOVA.

Groups	p-Value	Sig	N
SmartCem2 with Calibra	0.317	NS	15
SmartCem2 with PermaFlo® DC	0.281	NS	15
Calibra with PermaFlo® DC	0.997	NS	15

[Table/Fig-3]: Inter Group comparison using Tukey's Post-Hoc. NS: Not Significant.

Often endodontically treated teeth experience tissue loss due to prior pathology or treatment procedures [1,9]. The loss of dentin tissue will compromise the mechanical integrity of the remaining tooth structure. As the fracture resistance of the tooth is influenced by the lost tooth tissue as well as its localisation [2], in the present study restoration of endodontically treated teeth was aimed at increasing the fracture resistance of teeth especially in cases with extensive tooth destruction.

The ability of posts to distribute stress in a favourable manner recommended their use for the reinforcement of remaining tooth structure by some researchers that would further improve the fracture resistance of restored teeth [10,11]. Motivated by the desire to conserve the remaining sound tooth structure, fiber-reinforced post systems have become popular, especially because enlargement of the root canal space is directional and the hazard of root perforation is eradicated. In the present study easy postTM a composite post with a combination of an epoxy resin matrix reinforced with zirconia enriched silicon fibers was used. An alluring advantage of this post is, it has a longitudinal modulus of elasticity and a shear bond similar to dentin along with the conception of monobloc dentin post core system through dentinal bonding [10,12].

Several factors play an important role in accurate selection of a pre-fabricated esthetic post biomechanical and physical properties, shape and diameter of the post, cost and technique sensitivity [13]. According to studies, longer fiber posts (12mm or 8mm long) were associated with higher fracture resistance of teeth when compared with shorter ones (4mm long) [14]. A conservative minimal post-space preparation results in more remaining dentin rendering greater resistance to root fracture [15].

Adhesive resin cements are preferred for dowel concentration as they can potentially bond to the post and the tooth structure and thus increase retention. A buffer zone between the post and the dentin is rendered by the luting cement, which might affect the distribution of stress upon loading [12,13]. The chemical interaction between the post surface and the resin material used for luting or core-build up aids in the bonding of fiber posts to composite materials. In the present study: the specimens were tested for fracture resistance mounted on the universal testing machine and a compressive loading was applied along the long axis of the post cemented roots with a load rate of 1mm/min^{-1} which increased until fracture occurred.

In the present study Group-3 easy fiber posts cemented using smartcem2 resin cement (self-adhesive) showed highest fracture resistance with the mean value of 762.40kgs and Group-2 PermaFlo® DC (self-etch primer) showed the least fracture resistance. However, there were no statistically significant differences between the Groups. In the present study group-1 Calibra (etch and rinse) group-2 PermaFlo® DC (self-etch primer) have almost similar fracture resistance values and were lower compared to group-3 SmartCem2 (self-adhesive).

Group-1 needed pre-treatment such as application of etchant, primer and adhesive and group-2 needed pre-treatment such as application of primer A and B and adhesive prior to cementation. However, for SmartCem2, a one-step self-adhesive dual cured resin cement, no pre-treatment prior to cementation was required and mixing was carried out using an electronic mixing device, rather than by hand, thus showing better fracture resistance than calibra and PermaFlo® DC. Group-1 easy fiber posts cemented using Calibre resin cement showed intermediate fracture resistance with mean value of 662.933kgs. A chemical coupling at the fiber-reinforced composite post resin cement interface is only possible between the resin cement and exposed fibers or filler particles of the post. The bonding between the methacrylate based resin cements and the epoxy resin matrix of the pre-fabricated fiber reinforced composite posts does not occur due to the difference in chemistry. Group 2 showed least fracture resistance with a mean value of 657.800kgs. A study reported that micro leakage was significantly higher at the cement-root dentin interface when fiber post was cemented with a self – etching primer in comparison with etch and rinse adhesives [16]. Group-3, SmartCem2 which is self-adhesive resin cement exhibited highest fracture resistance. The technique of SmartCem2 is less sensitive as compared to two-step etch and rinse and self-etch primer.

Self-adhesive resin cements contain conventional mono-, di-, and or multi-methacrylate monomers, carboxylic or phosphoric acid functionalized monomers, fillers and photo-initiators [17]. A curing mechanism occurs based on a free radical redox polymerization and an acid-base reaction due to this unique composition. The pH rises due to the ionic cross links that are formed between the calcium or aluminium ions and acid groups as the reaction proceeds. Since, redox initiators and photo initiators have been described to be sensitive to acidic monomers, the neutralization of pH is of relevance [10]. The lack of dentin pre-treatment constitutes an attractive alternative for post cementation using self-adhesive resin cements as the technique and operator sensitivity is reduced when compared to group-1 and group-2. During the luting procedures (situation we find in the root canal) if the substrate is non-etched dentin and if certain pressure is applied it has been lately proven that there are encouraging results. Therefore, the bonding mechanism of self-adhesive resin cement is still debated (Be menck et al., 2004). Due to lower filler content and because of low luting thickness in bonding applications hydrated substances more efficiently facilitate ionization of the acidic monomers followed by acid-base neutralization reactions involving the tooth and the base filler. Rely X Unicem a self – adhesive resin cement despite its superficial interaction with this tissue produced an effective adhesion presenting similar or even higher bond strength values to root dentin than conventional resin cements [17]. As SmartCem2 has proven to have very low solubility, expansion and low film thickness it can be concluded that penetration of cement was better resulting in better bonding efficiency [18].

LIMITATION

Although Smartcem 2 (selfadhesive) resin cement seems to be a reliable and simplified cementation technique as compared to calibra (total etch) and PermaFlo® DC (self etch) resin cements, the bonding efficiency was comparable to total etch and sefl etch techniques. Thus neccositating for these in-vitro and in-vivo investigation before routine clinical usage of these materials and techniques.

CONCLUSION

Within the limitations of the study, it was concluded that Posts cemented to endodontically treated roots using (self-adhesive resin cement) SmartCem2 have highest fracture resistance, whereas, posts cemented with PermaFlo® DC using a self-etch technique showed unfavourable fracture resistance and finally the posts cemented with Calibra resin cement using a most acceptable total etch technique showed improved fracture resistance compared to PermaFlo® DC cement. Thereafter with careful attention to diagnosis and treatment planning, the self-adhesive resin cement SmartCem2 might be considered as an economical, practical and time saving alternative to the more extensive and expensive resin cements and cementation techniques.

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