Original Research Article

Comparison of the resin luting cements for the fracture resistance of endodontically treated teeth with prefabricated glass fiber posts - An in-vitro study

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Abstract

Background: This is an in-vitro study done to compare the effect of ferrule on fracture resistance of endodontically treated teeth restored with the glass fiber post cemented with two different esthetic resin modified cements

Aim: To compare the fracture resistance of endodontically treated teeth restored with prefabricated glass fiber posts luted with two different resin cements.

Materials and methods: Forty-eight freshly extracted maxillary central incisors of similar dimensions were used. The teeth were endodontically treated and decoronated to the level of the facial CEJ. The teeth specimens were divided into two groups of twenty-four each. In both the groups the Bioloren glass fiber posts were used. In Group 1 the posts were cemented with CALIBRA® esthetic resin system. In Group 2 the posts were cemented with SMARTCEM™2. Cores were built using composite resin material. The teeth were then embedded in auto polymerizing acrylic resin blocks. The specimens were subjected to loading in a universal testing machine. The data obtained was subjected to statistical analysis.

Results: The fracture resistance was higher for group 2 teeth with a mean ±SD of 2744±452.56340. The failure load observed in Group 1 was lower with a mean ±SD of 2178±452.56344. The one way ANOVA showed that in both the groups resin modified cements (Calibra® esthetic resin cement and

SmartCem™2) highly significantly influenced the resistance of the specimen to fracture under static loading (P < 0.002 and P <0.001 respectively).

Conclusion: The inherent strength of the SmartCem™2 enhanced stability and strength of the overall restoration when compared to Calibra®. Further studies should incorporate thermal cycling of the specimen and cyclic loading, stress distribution patterns, photo elastic analysis, finite element analysis and model studies to achieve better results.

Key words

Fracture resistance, Endodontically treated teeth, Glass fiber posts, CALIBRAesthetic resin, SMARTCEM™2.

Introduction

The restoration of endodontically treated teeth involves a range of treatment options of varying complexity. A post is usually placed in an attempt to strengthen the tooth [1-3]. It aids in supporting the core foundation when there is insufficient clinical crown remaining.

The first post was made of wood by Fauchard in the 18th century. Since then, many posts of various forms and materials have been made like those made of gold alloy, stainless steel etc. The most recent post, the glass fiber post has biocompatible glass fiber and fillers mixed into the resin matrix. It has the advantage over the existing posts in physical properties, esthetics, potential of root and restoration fracture, adhesive strength with the core, radio opacity, biocompatibility, chemical stability etc. It can be easily removed and retreated when needed. Its physical properties such as modulus of elasticity, yield strength and flexure strength are similar to that of dentin which reduces the possibility of root fracture [4-8].

When resin cement with a bonding agent is used to place a post, it may limit microleakage and increase retention of the prefabricated posts. The resin bonding can reinforce the remaining root structure and aids in counteracting the effects of a flared canal or poorly adapted post [9-11].

Composite resin cement/restorative material is the most recommended material to be used beneath all ceramic restorations especially for the anterior teeth. This material has relatively superior physical properties making it more esthetic, adhesive ability to the tooth structure, convenience in manipulating and setting time [12-15].

The purpose of this study was to compare the fracture resistance of endodontically treated teeth restored with prefabricated glass fiber posts luted with two different resin cements.

Materials and methods

An in-vitro study was done to compare the fracture resistance of endodontically treated teeth restored with the glass fiber post cemented with two different resin modified cements.

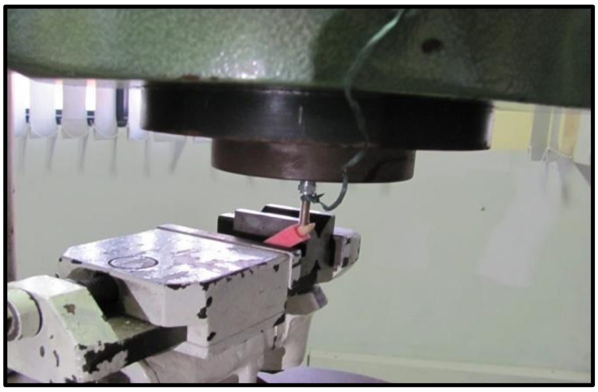
Forty-eight freshly extracted maxillary central incisor teeth of similar dimensions (Tooth length - 20-21 mm, mesiodistal width - 6.0-7.5 mm and canal diameter- Snug fit of No. 25 K file at the root apex) were used for the study. Teeth with cervical/root surface caries lesions or fissures, curved roots, fractures, previous endodontic therapy or a restoration closer than 2mm to the CEJ were discarded. All external debris (blood stains, soft tissue tags and calculus) were removed with an ultrasonic scaler (mini Peizon, EMS Piezon Systems, Nylon, Switzerland) and the teeth were stored in physiologic saline solution until the endodontic preparation. Each tooth was instrumented up to the No. 40 K file, 1mm short of the root apex, with sodium hypochlorite irrigation. The canal was dried with paper points and then filled with zinc oxide eugenol sealer (Roth Dental) and obturated (lateral condensation) with No. 40 gutta percha master cone (Dentsply, Malliefer) and four to five accessory cones. All the obturated teeth were decoronated with a carborundum disc, creating a flat surface perpendicular to the long axis. The shoulder finish lines of all the specimens were placed at the level of the CEJ.

About 09 mm of the filled gutta percha was removed from the canal using No. 2 Gates Glidden Drill (Dentsply Intl) such that 04 mm of the root remained filled with gutta percha to maintain the apical seal. Then the post space was prepared using a drill which corresponded to the diameter of the post of about 0.8 mm. The length of the post space was maintained to 9 mm. The teeth specimens were divided into two groups of twenty-four each. Each group was then subdivided into three groups of eight specimens each having ferrule of various dimensions prepared as follows:

The tooth surface and the post space were etched with 34% phosphoric acid (FROST, Ammdent Chem & Min. Ag) for 30seconds and then thoroughly rinsed with water for 20 seconds and air dried using a three way syringe. Then Adper single bond adhesive agent (3M ESPE Filtex™ Z350XT) was applied only to the specimens in group 1 with a microbrush provided by the manufacturer and cured for 30seconds. In both the Groups the Bioloren glass fiber posts (0.8 mm size & 13 mm long) were used. In Group 1 the posts were cemented with CALIBRA® esthetic resin system, Dentsply Caulk, Dentsply International, USA. In Group 2 the posts were cemented with SMARTCEM™2. Dentsply Caulk, Dentsply International, USA.

Preformed core forms (6mm in height and 5mm in width) were used to build the cores using composite resin material. The teeth were then embedded in an auto polymerizing acrylic resin blocks (1 mm × 1 mm × 3.5 mm) using a plastic/ putty former which allowed loading of the tooth at an angle of 130° to the long axis. The teeth were embedded so that the level of the auto polymerizing acrylic resin was 2mm apical to the cementoenamel junction and placed in a positioning device. The test specimens were loaded in such a way that the breaking probe formed a loading angle of 130 degrees labial to lingual surfaces. This angle simulates the average level of contact between the maxillary and mandibular incisors in class I occlusion. This loading angle more closely resembles a test of function than a test of impact. Although clinically the velocities of mandibular movements vary considerably, the impact compressive velocity maintained at a cross head speed of 0.5 mm/min was applied until failure. The tip of the breaking probe (compressive head) which applied the required load had a diameter of 5mm which simulated the dimension of the mandibular incisors. The specimens were subjected to loading at this orientation in a universal testing machine (Model no.UTE:40, Asset no 60265; Fuel Instruments and Engineering Ltd, Maharashtra, India). The load was measured in Newtons. Failure was defined as the point at which the loading force showed a dramatic reduction of applied load as either fracture of the core material with displacement from the post head or when fracture affected the core or the tooth (**Figure – 1, 2**).

Figure - 1: Specimen subjected to compressive load.



The data obtained was subjected to statistical analysis.

Statistical methods used:

Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on mean± SD.

Student paired T test – Comparison of the effect of cement on the fracture resistance of Group 1

Analysis of variance (ANOVA) – Intra-group comparison of the effect of cement on the fracture resistance within Group 1 and Group 2.

Figure – 2:

Specimens without fracture Specimens with fracture

Results

Evaluation of the difference in the fracture load (Newtons) between the two groups as per **Table – 1**. Mean failure loads and the standard deviation values were obtained for both the groups (**Table - 2**). The fracture resistance was higher for group 2 teeth with a mean ±SD of 2744±452.56340. The failure load observed in Group 1 was lower with a mean ±SD of 2178±452.56344.

The one way ANOVA (**Table - 3**) showed that in both the groups resin modified cements used Group1 (Calibra® esthetic resin cement and SmartCem™2) highly significantly influenced the resistance of the specimen to fracture under static loading ($P< 0.002$ and $P <0.001$ respectively)

Discussion

Glass fiber posts have replaced the metal posts as they have yield strength, flexural strength and lower modulus of elasticity which is closer to that of dentin thereby reduces the possibility of root fracture (Pegoretti A, et al) [16]. The glass fiber post is made up of glass fiber and fillers mixed into resin matrix. Its advantages include esthetics, adhesive strength with the core, radioopacity, biocompatibility, chemical stability and can be easily removed and retreated when needed. But the glass fiber post is not a panacea. It tends to bend when in contact with saliva and has a risk of secondary caries and dislocation of the post because it is sensitive to humidity (Dong Wook Shim, et al.) [17]. Compressive strength and tensile strength are important factors of a core material. Generally, the core replaces a great part of the tooth structure. Therefore, it must be able to bear functional and nonfunctional stress coming from many directions (Cho GC, et al.) [18]. Amalgam, glass ionomer cement reinforced with silver, hybrid glass ionomer compomer and composite resin etc are materials of choice. Glass ionomer cement reinforced with silver, hybrid glass ionomer compomer have advantages in setting time, adhesive ability to the tooth structure and resistance to decay (fluoride), but has low physical properties compared to amalgam and the composite resin. Composite resin is the most recommended material for core builds up especially below ceramic restorations. Composite resin has relatively superior physical properties, shade, adhesive ability to the tooth structure, convenience and setting time (Dong Wook Shim, et al.) [17]. The experimental use of natural teeth presents many problems due to inherent anatomic variations and the heterogeneous nature of tooth matter. These anatomic variations result in teeth with cross sectional profile not being always a true ellipse. However, for comparative studies the inaccuracies were not considered relevant. In this study the mesiodistal and labiolingual dimension of the tooth at the cementoenamel junction and the tooth length from the incisal edge to the tooth apex was measured. In order to ensure that the canal diameters were standardized, the teeth selected allowed the size 20 file to fit snugly into the apical foramen.

Table - 1: Tabulated column showing values for each specimen in Group 1 and 2 (Glass fiber posts were cemented with Calibra® esthetic resin cement or SmartCem™2 esthetic resin cement).

Specimen number	**Forces in Newtons**	
	Group 1	**Group 2**
1	654	690
2	615	640
3	710	728
4	735	793
5	742	765
6	761	782
7	676	694
8	750	772
9	681	725
10	649	692
11	743	742
12	772	810
13	778	792
14	795	790
15	712	744
16	787	782
17	737	785
18	713	749
19	809	813
20	828	872
21	844	865
22	768	848
23	852	815
24	834	858

Table – 2: T Test: Comparison of the effect of cement on the fracture resistance of Group 1.

Type of cement	**Group**	**N**	**mean**	**Standard Deviation**	**Standard Error Mean**
CALIBRA CEMENT	Group 1	24	2178	160.12118	56.61139
SMARTCEM2 CEMENT	Group 2	24	2744.25	452.56344	160.00534

Table – 3: Oneway ANOVA: Intragroup comparison of the effect of cement on the fracture resistance within Group 1 and Group 2.

Group	**N**	**mean**	**Standard. Deviation**	**Standard Error**	**95% confidence interval for mean**	
					Lower Bound	**Upper Bound**
Group 1-CALIBRA	24	3199.6667	496.42656	150.00917	2855.2626	3544.0707
Group 2-SMARTCEM2	24	3363.3333	464.21921	137.63483	3048.5892	3678.0775

ANOVA measurement		
Group	F	Significance
Group 1-CALIBRA	8.129	**0.002****
Group 2- SMARTCEM	15.565	**<0.001****

<0.05- Significant
<0.001-Highly Significant
*** Significant**
****Highly Significant**

The purpose of this study was to know the fracture resistance of endodontically treated teeth restored with glass fiber post cemented with two different esthetic resin modified cements namely Calibra® and SmartCem™2.

Endodontically treated teeth that require a crown are inherently compromised owing to loss of coronal dentin, instrumented canals and therefore increased flexure in response to occlusal forces (Sedgley CM, Messer HH) [19].

The length of the glass fiber post was standardized to 13 mm in order to have uniformity in the specimen's preparation and to avoid errors in the forces acting on the specimen when subjected to compressive load in the universal testing machine. In two specimens of Group1, the glass fiber post got fractured under the compressive forces. None of the other specimens showed fracture of the glass fiber post. This suggests that the glass fiber post has good flexural strength and lower modulus of elasticity which reduces the possibility of root fracture [4-8].

Pegoretti A, Fambri L and Zappini G. [16] stated that the modulus of elasticity of the post is important in resisting the specific type of loading. S. Abdulrazzak and E. Sulaiman [20] in their study concluded that increasing the ferrule height significantly increased the fracture resistance of endodontically treated teeth restored with glass fiber post, composite core and a crown.

The light cure composite resin (3M ESPE, A3 shade) was used to build the cores. (Gale MS, Darvell BW) [21]; Cho GC et al [14] have reported that light cure composite resin has more favorable compressive strength and tensile strength than that of auto polymerizing composite resin. This corresponds to the findings in this study which showed that in Group 1- 83.33% and in Group 2- 91.6% composite core fractured at the root core interface at a high compressive force subjected by the universal testing machine. In the present study the load on the specimen was stopped as soon as the initial drop in the load was detected. This helped to characterize the fracture resistance of the post and the core system at initial failure and allowed evaluation of the failure mode. When failure commences under compression, the most brittle fibers break due to variability in individual fiber surface defects. This leads to interfacial slip between the broken fiber and the matrix and consequently stresses magnification in the adjacent fibers. As the interfacial bond is stiff, tensile stress in the broken fiber along the bond transfer length will gradually build up. If the bond strength is exceeded, delamination of the fiber from the matrix will commence and propagate with the interfacial bond loss. Progressive fiber fracture will lead to catastrophic failure (Simone G, et al.) [22].

In most of the specimen the fracture was seen at the root core interface (Group 1 - 83.33% and Group 2 - 91.6%) within the core (Group 1 - 4.1% and Group 2 - 4.1%), within the core and root core interface (Group 1 - 4.1% and Group 2 - 4.1%) and some with part of the tooth material and post fractured along with the core (Group 1 - 8.3%). This is because of the creation of a monobloc dentine post-core system through dentine bonding would allow better distribution of forces along the root. So, if excessive loads are applied to the tooth the post will be able to absorb stresses, reducing the possibility of root fracture as has been concluded by the study done by Marcela PN, et al. [11]; Dong Wok Shim, et al. [18] who explained three types of fractures of the teeth specimen under scanning electron microscope.

The variables that influence the performance of the endodontically restored teeth are the type of post and core used and the luting cement used. The performance of a glass fiber post is chiefly attributed to the resin luting cement used and its ability to withstand horizontal shearing forces better than that of zinc phosphate cement used for metal posts (Nikolai Stankiewicz, Peter Wilson) [23]. The luting cement offers additional retention and resistance form to glass fiber post and composite core system. This is due to the dentin bonding provided by the resin luting cement. The dentin bonding also affords the root canal system additional resistance to fracture (Mendoza DB, et al.) [10]. The two resin luting cements used to fix the glass fiber posts were Calibra® and SmartCem™2. In both the groups there was positive relationship between the stability of the glass fibre post and the luting cement (Calibra® and SmartCem™2) used.However, when the degrees of significance were compared there is a higher value in Group 2 than in Group 1. This suggests that the luting cement used in Group 2 i.e. SmartCem™2 is able to withstand more static load than Calibra® used in Group 1. This means that the compressive strength and the fracture resistance of SmartCem™2 are higher than Calibra®.

The bonding agent has to be applied before the use of Calibra® esthetic resin cement. Calibra® is dispensed as a two-tube system. So, the length of the two ropes (catalyst medium and base medium) may vary depending on the operator. This may vary the ratio of the catalyst and base which may therefore alter the properties of the cement. Invitro data are variable regarding the use of Calibra® as dual cure or self-cure in conjugation with some light cured only adhesives such as Prime Bond light cured dental adhesive and Xenon IV one component light cured self-etch dental adhesive without self-cure activator (Dentsply International) [24]. SmartCem™2 does not require the use of bonding agent. It is dispensed as an auto mix barrel system thereby delivering equal amount of the base and the catalyst. This may enable to achieve better properties of the cement. As such there are no studies done to prove which of the two cements is better. Only a few laboratory trial studies comparing SmartCem™2 with other cements have been conducted by the manufacturer. They have stated that the inherent strength of the SmartCem™2 adds reinforcement to indirect materials, providing enhanced stability and strength of the overall restoration.

SmartCem™2 has exceptionally high flexural strength compared to other self-adhesive resin cements, especially in the dual cure modes. The water solubility and sorption play an important role in the lifetime of the cement. SmartCem™2 falls within the ISO standards for cements. No study data have been found so far to compare Calibra® with other cements, and as such there is no single study done to compare Calibra® with SmartCem™2. (Dentsply International) [25].

This study is first of its kind ever done to compare the two esthetic resin cements Calibra® and SmartCem™2. The results obtained in this study should be interpreted with caution. The main disadvantage of the use of human teeth is the relatively large variation in size and mechanical properties often resulting in large standard deviations. In addition, dentinal changes can be caused by different water content, pulpal condition before tooth extraction, patient's age and composition of dentine. The teeth were mounted for load testing in resin material that have limited resiliency. This takes out the viable periodontal ligament and the resilient alveolar bone out of the equation which are crucial parameters on loading. This variation can affect the fracture during loading. Finger pressure was used to maintain the posts in position during cementation which did not provide a standardized loading force. A single load to fracture (compressive force) test was used to test the fracture resistance of endodontically treated teeth. For more meaningful results further studies should incorporate thermal cycling of the specimen and cyclic loading. This can mimic the multidirectional characteristics of masticatory forces. Studies should also include stress distribution patterns, photoelastic analysis, finite element analysis and model studies to achieve more authentic results from laboratory studies.

Summary and Conclusion

- There is a definitive positive relationship between the length of the ferrule and the resistance to fracture of the endodontically treated teeth. The best results were obtained in 2 mm ferrule specimens.
- Glass fiber post may be the post of choice to reinforce the endodontically treated anterior teeth as it can withstand a greater compressive load when subjected to static force.
- SmartCem™2 cement showed a better resistance to fracture when compared to Calibra® as per the statistical analysis of the fracture loads compared in the form of means and P value.

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