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RESEARCH ARTICLE

A COMPARATIVE EVALUATION OF THE FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH RESTORED WITH THREE DIFFERENT TYPES OF FIBRE-REINFORCED COMPOSITE POST SYSTEMS USING TWO DIFFERENT TYPES OF LUTING CEMENTS- AN IN-VITRO STUDY

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ABSTRACT

Aim: The aim of this in-vitro study was to evaluate and compare the fracture resistance of endodontically treated teeth restored with three different types of fibre-reinforced composite post systems using two different types of luting cements. **Settings and Design:** This was an in vitro study. **Materials and Method:** Ninety extracted intact human maxillary central incisor teeth were selected for the study. All the teeth were decoronated 2 mm above the cemento-enamel junction, root canal treatment was performed, post space was prepared and the samples were divided into 3 groups (n= 30); Group 1: prefabricated glass fibre post (Reforpost), Group 2: customized polyethylene woven fibre post (Ribbond) and Group 3: customized Everstick post (GC). Two types of luting cements, dual cure resin cement Paracore (COLTENE) and self-etch/self-adhesive resin cement Maxcem Elite (KERR) were used for post cementation. The core was standardized to 4mm. Prepared samples were subjected to compressive load of 5mm/min at 135o anguation using an universal testing machine. The load at which fracture occurred was analysed statistically by one way ANOVA and post-hoc tukey test. **Result:** The findings showed statistically significant difference between failure loads. Group 3 showed highest mean fracture resistance value (54.77±1.65 Kgf), followed by group 1 (Reforpost) with mean value (42.47±2.24 Kgf) and group 2 (Ribbond) with mean value (24.12±1.91 Kgf). **Conclusion:** Teeth restored with Everstick post showed highest mean fracture resistance value regardless of luting agent.

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INTRODUCTION

Restoration of the mutilated endodontically treated tooth is a subject that has been evaluated and discussed widely in dental literature (Hegde *et al.,* 2011). It represents a key factor during treatment planning because of its impact on the long-term prognosis of the tooth. The presence of reduced circumferential dentin, loss of moisture and coronal destruction from dental caries weaken the tooth structure, leading to reduced load carrying capacity making it susceptible to fracture under normal masticatory forces. Hence, posts are often indicated to restore these teeth to provide resistance and retention for a core material and coronoradicular stabilization.
An ideal post and core material should have optimal physical properties similar to those of dentin to achieve the best results (Piovesan *et al.,* 2007). Until 1980, the cast metal post and core was considered the standard option to rebuild an endodontically treated broken tooth.

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However, these conventional posts have biological and mechanical disadvantages, such as high modulus of elasticity, lack of retention, root fracture and are prone to corrosion (Hegde *et al.,* 2011). The restoration of endodontically treated teeth with metal free, physiochemically homogenous materials that have physical properties similar to those of dentin has become a major concern in dentistry (Makade *et al.,* 2011). Fibre-reinforced composite (FRC) posts have been described and discussed in the literature for 20 years (Bolay *et al.,* 2012). Fibre-reinforced composites advocated for use as post and core systems can be classified into two categories: prefabricated posts and customized posts. Reforpost (Fiber post, Angelus, Londrina, PR, Brazil) a commercially available prefabricated glass fibre-reinforced composite post embedded in an epoxy resin matrix having serrations on the surface, is said to exhibit favourable biomimetic properties (Ramesh *et al.,* 2016). When the post's diameter differs from that of the canal, the luting technique creates a thick layer of cement between the root dentin and the post and this interface becomes the weakest point. Customized post and core systems were introduced to overcome this problem, leading to the advent of individually formed FRC posts. (Ramesh *et al.,* 2016). An example of the customized fibre post–core system is Ribbond (Ribbond Inc., Seattle, WA, USA), which is commercially available and was first introduced as a splint material. The material has a three-dimensional structure due to the leno weave or triaxial braid, and this provides mechanical interlocking with composite resin at different planes. In addition, microcracking is minimized during polymerization of the resin (Ramesh *et al.,* 2016). Attempts to develop alternative polymer matrices of FRC posts have been made and results of a multiphase polymer matrix, consisting of both linear and cross-linked polymer phases (semi inter-penetrating polymer network, IPN resin matrix), have been promising (Makarewicz *et al.,* 2013), leading to the introduction of Everstick Posts (Stick Tech Ltd, Turku, Finland) in the market. The type of luting material used contributes in part to the clinical success of fiber post and core restorative procedures. Studies have shown that use of resin cement significantly increases retention and fracture resistance of tooth by providing adhesive bonding (Acharya *et al.,* 2014) Hence, the purpose of this study is to evaluate the fracture resistance of endodontically treated teeth restored with Fiberpost, Ribbond and Everstick post cemented with resin luting cements i.e. Paracore and Maxcem elite.

MATERIALS AND METHOD

Ninety human non-carious permanent maxillary central incisors extracted for periodontal reasons, free of caries and fracture were selected for the study. All external debris was removed with an ultrasonic scaler and the teeth were stored in normal saline until use. The teeth were decoronated 2 mm above the cemento-enamel junction with a diamond disc at low speed under water cooling. The root canal of all the specimens were instrumented upto ISO K-file size no. 40 until 0.5 mm short of the apex and irrigated with sodium hypochlorite at each change of file and stepping back with progressively larger instruments to an ISO size of 70. After complete preparation, the root canals were finally irrigated with 5% sodium hypochlorite followed by normal saline. The smear layer was removed using 17% liquid ethylene-diamine-tetraacetic acid (EDTA) followed by final irrigation with normal saline. Obturation was done with gutta-percha cones and AH Plus root canal sealer using cold lateral condensation technique. Post space was prepared using Peeso reamers upto a length of 7 to 10 mm from the CEJ depending on the tooth. At least 4-5 mm of gutta-percha was left apically to preserve the apical seal.

Prepared teeth were randomly divided into three groups (as per the post used) and two subgroups (as per the luting cement used):

- Group 1- prefabricated glass fibre post.
- Group 2- customized polyethylene woven fibre post (Ribbond).
- Group 3- customized glass fibre inter-polymerizing network (IPN) post (Everstick post, GC).
- Subgroup A- Paracore (COLTENE) (dual cure resin cement).
- Subgroup B- Maxcem Elite (KERR) (dual cure self-etch/self-adhesive cement).

Post preparation

Group 1: Reforpost: Glass fibre post was cut with a diamond disc to desired length with an excess of 3 mm to retain core.

Group 2: Ribbond: A piece of Ribbond fibre 2 mm wide was cut a little in excess of twice the length of the post space. The fibre was then folded to create two stems in the root canal.

Group 3: Everstick post: The Everstick post with a diameter of 1.2mm was placed inside the root canal, both ends were cut for a perfect fit using a sharp scissor (the apical end diagonally and the coronal end leaving 4mm of fiber above the canal opening) and then light-cured for 20s inside the canal. After that the post was removed from the canal and further light-cured for 40s from all sides outside the canal. Then the surface of the post was activated using light curing resin adhesive for 3 to 5 min, dried and light-cured for 10sec.

Post cementation

In groups 1A, 2A, 3A, Paracore was used as a luting agent. Non-rinse conditioner was applied onto the prepared post space preparation of the root canal using a brush, massaged for 30s and dried using gentle stream of air for 2s. One drop of adhesive A and adhesive B was mixed and applied into the prepared post space preparation of the root canal and massaged for 30s. ParaCore was dispensed directly from the syringe into the prepared root canal using the root canal tip. The root canal post was thoroughly coated with ParaCore material. In group 1A and 3A the posts were inserted into the canal to a full depth using gentle finger pressure (Fig. 1 and 2). The samples were then subjected to light curing for 60 s i.e 20 s each on occlusal, buccal and lingual surfaces.

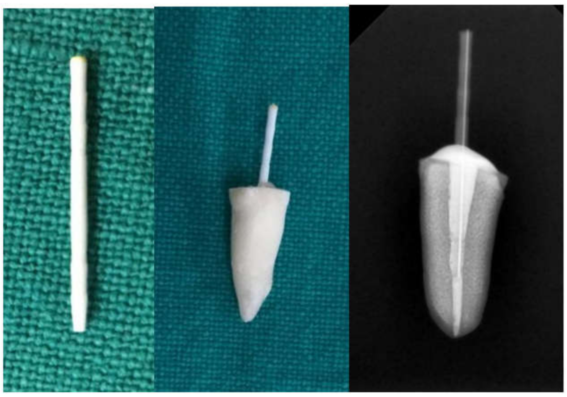

Fig. 1. Cementation of fibre post

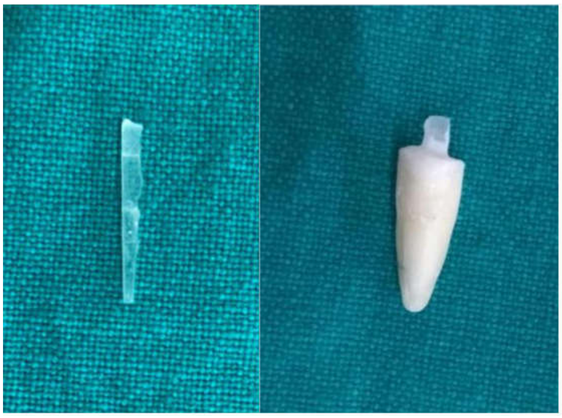

Fig. 2. Cementation of everstick post

In case of group 2A, the Ribbond fibres were inserted into the pretreated post space filled with luting cement and compacted using an endodontic plugger in a way that 3 mm post was available above root canal to retain composite core (Fig. 2).

The samples were then cured as described above. In groups 1B, 2B, 3B, where Maxcem elite was used as a self-adhesive luting agent, no pretreatment of dentin with the phosphoric acid or application of bonding agent was required. The cement was dispensed onto the post or directly into the canal space using the root-canal tips. The posts were seated into the canal followed by light curing all the surfaces with the LED light for 20s.

Core formation

Nanohybrid composite Z350 (3M ESPE) was used to build up the cores of all specimens. For the purpose of standardization of the core, an inciso-cervical height of 4 mm was kept for all the specimens.

Procedure for testing fracture resistance

Fracture resistance was measured using a stainless steel rod with a diameter of 2 mm mounted on a Universal Testing machine (Fig. 4). All test samples were mounted in an acrylic block and subjected to a compressive force exerted by the stainless steel rod. The force was applied at the centre of the core on the palatal surface, at 135 degree angle to the long axis of root, at a cross head speed of 5mm/min until fracture (Fig. 5). Descriptive data was collected and analysed using one way ANOVA and post-hoc tukey.

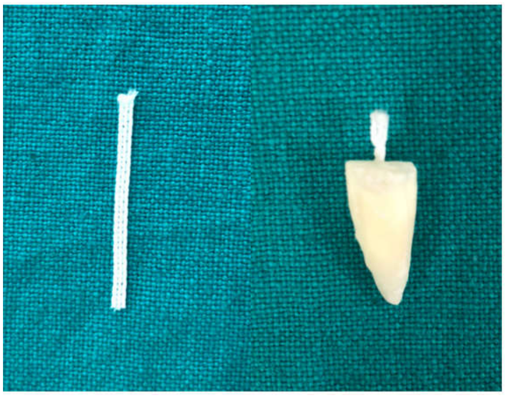

Fig. 3. Cementation of ribbond

Fig. 4. Universal testing machine used for measuring fracture resistance

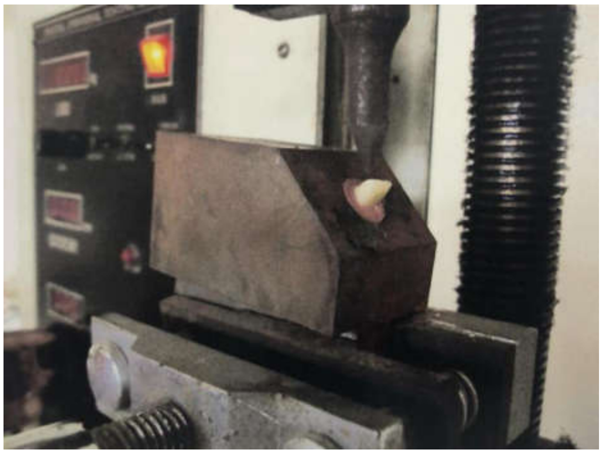

Fig. 5. Specimen mounted on universal testing machine

RESULTS

Following analysis, Group 3 (Everstick) showed significantly highest mean fracture resistance value (54.77±1.65 Kgf), followed by Group 1 (Reforpost) (42.47±2.24 Kgf) and Group 2 (Ribbond) (24.12±1.91 Kgf) (p <0.001). (Table 1). test was used to compare the mean fracture resistance of the three Groups (1,2 and 3) with respect to subgroup A and B shown in table 2, 3 and 4. It was seen that the difference within Group 1 was highly significant (p <0.001) while the intragroup difference in Group 2 and Group 3 was significant with p-value 0.03 and 0.02 respectively.

Table 1. Showing the mean fracture resistance of Group 1, Group 2 and Group 3

Group	N	Mean (Kgf)	SD	minimum	maximum
1	30	42.47	2.24	38	47
2	30	24.12	1.91	20.38	28.6
3	30	54.77	1.65	50.9	58.3
Total	90	40.45	1.28	20.38	58.3

Table 2. T- test showing the comparison of mean fracture resistance of Group 1 with respect to subgroup A (Paracore) & subgroup B (Maxcem elite)

	Mean (Kgf)	S.D	P value	Significance
Group 1A	44.1000	1.55196	<0.001	HS
Group 1B	40.8533	1.54959		

Table 3. T- test showing the comparison of mean fracture resistance of Group 2 with respect to subgroup A (Paracore) & subgroup B (Maxcem elite)

	Mean (Kgf)	S.D	P value	Significance
Group 2A	25.4000	1.67625	0.03	S
Group 2B	22.8467	1.71381		

Table 4. T- test showing the comparison of mean fracture resistance of Group 3 with respect to subgroup A (Paracore) & subgroup B (Maxcem elite)

	Mean (Kgf)	S.D	P value	Significance
Group 3A	55.3800	1.55159	0.02	S
Group 3B	54.1706	1.58539		

DISCUSSION

The success of endodontic therapy depends on adequate post endodontic restoration to make pulpless teeth function as an integral part of the masticatory apparatus (Das *et al*., 2015). The endodontically treated tooth must be restored such that it will resist masticatory forces acting in vertical and lateral direction without being prone to fracture (Chandran, Noushad and Balan 2017). One of the common methods of restoration of such broken down teeth is with the use of intra-radicular posts (Jayasenthil *et al*., 2016). Custom made cast post and core technique has been advocated as the gold standard restoration for decades (Aggarwal *et al*., 2013). Rigidity due to its high modulus of elasticity is the major drawback of metal posts. The choice of post materials later changed from very rigid materials to materials that have mechanical characteristics that more closely resemble dentin (Ozcopur *et al*., 2010). Fibre-reinforced composite posts provided a viable alternative to traditional rigid post materials mostly because of their similar biomechanical properties to that of dentin. In this way, a monoblock unit could be created, and fracture risk of the roots could be reduced. Glass fiber posts integrally bond to the composite core and provide a natural hue improving the aesthetics without compromising much on the strength and they also require less dentin removal during treatment procedures, with single-appointment direct build-up cores being the most popular (Dua, Dua and Wali 2015). In the current study, fracture resistance of endodontically treated incisors was evaluated using Fibrepost, Ribbond and Everstick post and two luting cements i.e. Paracore (dual cure resin cement) and Maxcem elite (dual cure self-etch/self-adhesive cement). The use of self-cure or dual cure resin cements is recommended because of limited penetration of light into depths of root canal. Human maxillary central incisor was selected as it is more susceptible to trauma and receive more angular forces and thereby, require maximum restoration in terms of post and core. (Makade *et al*., 2011 and Aggarwal *et al*., 2013). The loading angle of 135 degree from palatal to labial was selected on the basis that it simulates the average angle of contact between maxillary and mandibular incisors in Class I occlusion and is a test of function (Chandran *et al.,* 2017). From the data it is observed that irrespective of the luting cement used, specimens restored with Everstick post (Group 3) showed highest resistance to fracture than the other two groups. The specimens restored with Ribbond (Group 2) showed the least resistance to fracture.

Similar findings were reported by Chandran *et al.,* 2017 where use of Everstick post showed highest mean fracture resistance regardless of luting agent..Everstick post is a recently introduced FRC post containing polymethylmethacrylate (PMMA) as a linear phase and poly bis-GMA as the cross-linked phase of the polymer matrix (Maiti, Desai and Das 2016). The monomers of the adhesive resins and cements can diffuse into the linear polymer phase and form inter-diffusion bonding. Improved bonding allows transfer of loads from the crown-core system to the root through the root canal post (Makarewicz *et al*., 2013). In custom-made FRC posts (Everstick), the fiber volume at the coronal part of the root canal is high and it fills the entire available root canal space. This increases the stiffness and strength of that part of the post and forms strong support for the core. (Makarewicz *et al*., 2013). Toksavul *et al.,* 2005 compared fracture resistance of zirconia posts, glass fiber reinforced post and Everstick posts. The results showed that Ever Stick post gave better fracture resistance values. Lassila *et al.,* 2004 determined the flexural properties of different types of non-metallic posts when combined with composite cores for comparison with the ever Stick fibre-reinforced post. The greatest flexural strength was exhibited by the novel fibre-reinforced post. These results are in concurrence with the present study. The result of this study echoed the finding by Bell *et al.,* 2004 that demonstrated higher bond strengths of an individually formed IPN post compared to a prefabricated fiber post. Newman *et al.,* 2003 compared the fracture strength of three composite posts, namely FibreKor, Luscent anchors and Ribbond in narrow and flared canals. It was found that the fracture strengths of Luscent anchors and FibreKor were significantly higher than Ribbond in narrow canals, while Ribbond fared better in the flared canal group. The authors attribute it to the fact that the flared canals allow the placement of more fibre and more composite compared to the narrow Canals. Thus, the lower amount of Ribbond fibre and composite placed could have contributed to the reduced fracture resistance obtained by Ribbond as compared to Reforpost in the present study. In the present study, all the three experimental groups with Paracore luting system showed considerably higher mean fracture loads than those with Maxcem elite luting cement. Aleisa *et al.,* 2013 determined the effect of luting agents on the tensile bond of glass fiber posts. Fiber posts luted with Paracore demonstrated significantly higher mean tensile bond strengths than other cements. This is in accordance with the present study. One can speculate that the application of a dentine bonding agent before the application of the luting cement allows the dentine bond to form before the contraction of the luting composite takes place. This may reduce the risk of gap formation. The results of the present study are encouraging and clinically significant as the endodontically treated maxillary central incisors restored with Everstick, Fiber post and Ribbond were able to resist normal occlusal forces in the incisor region (9.07 Kgf to 11.31 Kgf) (Anusavice 11th edition).

Conclusion

Within the limitations of this present study, it can be concluded that Everstick post provided highest resistance to fracture among the three experimental groups regardless of the luting cement used and it is suitable for restoration of endodontically treated anterior teeth. Long term clinical observations of the performance of these posts should be studied to arrive at any definitive conclusions.

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