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Research Article

A Comparative Evaluation of Fracture Resistance of Endodontically Treated Teeth Restored with Two Different Post and Core Systems and Two Different Luting Agents - An *In vitro* Study

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Abstract

Introduction: The longevity of endodontically treated tooth has been greatly improved by continuing developments made in endodontic and restorative procedures. One of such developments is prefabricated post and core.

Purpose: To compare fracture resistance and primary mode of failure of endodontically treated teeth with two different posts systems and two variant luting agents.

Materials and Methods: Endodontic treatment was performed on 30 maxillary incisors with proper protocol. The samples were allocated into 3 groups. For two experimental groups post space preparation was done and teeth were restored with prefabricated glass fibre post (EverStick post) with composite core (Group B) and prefabricated zirconia posts with composite core (Group C). Samples with intact coronal structure were selected as control group (Group A). In all samples post space preparation was done. Two type of luting cements dual cure resin cement (Luxacore Z) and glass ionomer cement (Fuji I, GC) was used for post cementation. The standardization of core was fixed to 4mm × 5mm. Prepared samples were subjected to compressive load of 0.5 mm/min at 135º angulation. The load at which fracture occurred and fracture mode were analysed statistically by one way ANOVA, post-hoc tukey test and chi-square test.

Results: The findings showed statistically significant difference between failure loads. The mean load required to fracture glass fibre was highest (711MPa) and least for control group (231MPa). The glass fibre posts and zirconia posts showed favorable fracture.

Conclusion: The results concluded that, endodontically treated teeth without post core system showed least fracture resistance signifying need to reinforce tooth. Use of glass fibre post (everStick post) showed highest mean fracture resistance regardless of luting agent.

Keywords: *Cast Post Core; Glass Fibre Post; Zirconia Post; Fracture Resistance*

Introduction

The restoration of endodontically treated tooth is a challenging task that involves treatment of significant tooth structure loss [1]. 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. To reinforce treated tooth, post and core are preferred which also ensures coronoradicular stabilization [2].

The choice of the post is dependent on external configuration and morphology of root; diameter, surface, geometrical configuration of dowel and materials used to fabricate these systems [3]. The endodontic posts can be of various types whether metallic and non-metallic or stiff and flexible [4].

The cast post-and-core has been considered as the gold standard because of its superior success rate [5]. The choice of restoring endodontically treated tooth is guided by strength and esthetics [6]. A variety of tooth colored posts like zirconium coated carbon fiber post, all zirconium post, FRC post and glass fibre post are available [4]. The reports state that prefabricated dowels are more flexible than cast metal dowel and permit enhanced distribution of forces resulting in smaller number of root fractures.

The basic factor for post retention is the quality of cement. However, no literature has stated the superiority of one cement over the other. There are several luting agents such as zinc phosphate, GIC, resin cement [7]. The effect of the cement type on the retention of post and on fracture resistance of endodontically treated teeth has been investigated extensively. The use of resin cement has been found to significantly increase retention of posts and fracture resistance of the tooth compared with other cements.

In this study, two types of post have been used to restore endodontically treated teeth namely individually formable and unpolymerized glass fiber post (GC everStick) and zirconia post.

Purpose of the Study

The purpose of this study is to evaluate the fracture resistance of prefabricated zirconia post and prefabricated glass fibre posts cemented with varying luting agents such as resin cement and GIC.

Materials and Methods

A total of thirty single rooted maxillary central incisors were collected from the Department of Oral and Maxillofacial Surgery, Kannur dental college and placed in formalin solution for disinfection. After disinfection the samples were maintained in normal saline solution to prevent dehydration. Endodontic treatment was performed on all specimens. 60-size gutta-percha (Dentsply, Addlestone, Surrey, UK) was used as master cone for obturation lateral condensation technique. The selected teeth were randomly assigned into three groups of ten teeth each and two subgroups of five teeth each.

- Group A: Control Group (10 Teeth)
- Group B: Prefabricated Glass Fiber Post
- Resin (5 Teeth)
- GIC (5 Teeth)
- Group C: Prefabricated Zirconia Post
- Resin (5 Teeth)
- GIC (5 Teeth)

The specimen teeth in group B and C were decoronated with a fine grit diamond disc. The root length was standardized to approximately 16 mm. Gutta percha was removed using no. #2 Gates Glidden drill until depth of 10 mm in all the experimental groups except group A (control group). The post preparations were standardized through flaring with Peeso reamer upto no # 4.

Post cementation

Prior to cementation, try in of the posts were done to make sure the complete seating to a depth of 10 mm. In group B, prefabricated posts were cut with a scissor to desired length (i.e. with an excess of 4 mm to retain the core). In group B the posts were cut with a diamond disc. Each post space were then irrigated with 5 ml of saline and dried with paper points.

For samples in Group B and Group C luted with dual cure resin cement, etching of the post space was done with 37% phosphoric acid (Total Etch; Ivoclar Vivadent) for 15 seconds, rinsed with distilled water for 15 seconds and dried with paper points. Bonding agent was applied within the canal with micro brush and cured for 20 seconds. The resin cement (Luxacore Z, DMG, America) was applied with a lentulospiral. The post was placed into the canal. Excess cement was removed using a sable brush. The cement was then light cured for 40 seconds. In group C, as the post is supplied in a pre-polymerised form, post and the cement were light cured for 40 seconds by directing the light perpendicular to the post.

In those samples luted with GIC, the cement was applied within the post space with lentulospiral. The post was then seated and finger pressure was maintained. For the samples in group C, the posts were light cured before cementation with GIC.

Core build up

The core was standardized to 4mm length from incisal edge to cervical region and 5mm width. In group A, straight fissure bur was used to standardize the core. The coronal portion of the samples in group B and C were fabricated with dual cure resin cement (Luxacore Z, DMG America) and polymerized.

Procedure for testing fracture resistance

Each specimens were mounted in an acrylic block of size 19 mm. The acrylic block with specimens were mounted on a Universal Testing Machine. The compressive load was applied with 1 mm diameter compressive head at an angle of 135° to the long axis of the tooth. The force was applied on the palatal slope at a rate of 0.5 mm/min until visible or audible evidence of fracture was shown. The force at which fracture occurred was measured in MPa. Descriptive data were collected and analysed. The results were evaluated statistically using one way ANOVA, post- hoc tukey and Chi-square test.

Results and Discussion

The analysis of variance test (Table 1) was used to compare the mean differences between the groups to evaluate fracture resistance. The P value calculated is < 0.05 which indicates the statistical significance. In all the tested samples control group exhibited the lowest fracture resistance. The glass fiber post luted with resin cement exhibited highest fracture resistance among the all four groups. Among the experimental groups lowest fracture resistance was recorded for group C subgroup B with zirconia post luted with glass ionomer cement.

	Number of values	Mean	Std. Deviation	F	P Value
Control	10	231.00	14.674	3.083E3	< 0.05
Glass Fibre - Dual Cure Resin	5	711.00	3.808		
Glass Fibre - GIC	5	685.40	5.771		
Zirconia - Dual Cure Resin	5	623.60	4.393		
Zirconia - GIC	5	574.40	4.827		

Table 1: *ANOVA test.*

The chi square test (Table 2) were used to compare the four groups and two subgroups for the mode of failure. Here the probability value is less than 0.05 and it indicates the highly significant statistical result. The results showed that all samples in Group B and Group C had restorable fractures than remaining groups.

	Restorable Fracture	Non-Restorable Fracture
Control	0	10
Zirconia - Dual Cure Resin	5	0
Zirconia-GIC	4	1
Glass Fiber - Dual Cure Resin	5	0
Glass Fiber - GIC	5	0

Table 2: *Chi square test.*

Discussion

To restore the strength of badly broken root canal treated teeth, an ideal solution is the use of a post and core which protects the weakened tooth [8]. The evaluation of whether a post is needed depends on how much natural tooth substance remains to retain a core buildup and support the final restoration after caries removal and endodontic treatment are completed [9]. The criteria for an endodontically treated tooth requiring a post is that the minimum length of remaining solid tooth equal the sum of the biologic width (2.5 mm), the ferrule length (2 mm), the apical seal (4 mm) and the post length (i.e. 8.5 mm + post length) [10].

The post/dowel selection is influenced by several factors which includes amount of coronal tooth structure, tooth anatomy, position of the tooth in the arch, root length, root width, canal configuration, functional requirements of the tooth, torquing force, stresses, development of hydrostatic pressure, post design, post material, material compatibility, bonding capability, core retention, retrievability, esthetics and crown material [11].

Recently, the material of choice for restoration of root filled teeth has changed from very rigid materials to materials with mechanical characteristics similar to dentine [12]. These newer systems have paid attention on physical properties, such as modulus of elasticity (rigidity) to reduce stress concentrations within the root canal and reduce the incidence of fractures. An additional feature of the newer posts has been the esthetics with composite core materials.

EverStick post is a recently introduced glass fiber post consisting of unidirectional E-glass and unpolymerized Bis-GMA matrix, and it has elastic modulus similar to dentin. This post is composed of glass fibres embedded in an unpolymerized resin matrix. The post is available in a soft form and hardens on polymerization with light. An enamel bonding agent without solvent like acetone can penetrate into and partly solve unpolymerized resin matrix monomers, thus allowing to bond with resin cements. In addition, EverStick Post can be bonded each other and trimmed suitably for adaptation to root canal [13].

In the current study, the fracture resistance of endodontically treated incisors was evaluated when using two post systems and two luting agents. Prefabricated glass fibre post with composite core, and prefabricated zirconia post with composite core were used with two different type of luting agents i.e. resin cement and glass ionomer cement. These cements were chosen as G.I.C. bonds chemically to tooth structure and resin cement is gaining recognition as various investigators have reported advantages related to their use [14]. The resin cements are highly resistant to moisture and therefore become highly durable cements.

Maxillary central incisor was selected as it is the most vulnerable tooth to trauma because of its position and thereby, requires maximum restoration in terms of post core. The loading angle of 135º 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 [15].

From the data it is observed that group A i.e. control group demonstrated the least mean fracture resistance values as compared to experimental groups. The results of this study are consistent with Kantor and Pines [16], Robbins [17] who recommended post and core to increase the fracture resistance. Among the experimental groups, group B (EverStik posts) exhibited the highest mean fracture load. This could be explained as fibre posts and composite cores possess a modulus of elasticity much better matched to that of dentin. This creates a mono-block of dentin-post-core system through the dentin-bonding. This inturn allows better distribution of applied forces evenly along the length of the post and root. Therefore, the excessive loads would be absorbed [18]. The above results are also consistent with Omar Ahmed [19] who demonstrated the highest mean fracture resistance values for everStick post. However, these results are contrary to the findings of Dayalan M., *et al.* [20] who compared the fracture strength of the zirconia oxide posts and prefabricated glass fiber post and concluded that zirconium oxide posts showed higher fracture strength when compared to glass fibre posts.

This study concluded that the fracture resistance of zirconia post is lower than Everstick post. This may be because the modulus of elasticity in FRC posts is similar to tooth tissue; hence, post failure under critical loads should occur before root fracture. This result is in agreement with the *invitro* study by Abduljabbar T, which concluded that fracture resistance of zirconium custom posts was higher than fiber posts and the cast post-cores [21]. The number of repairable fractures in group B (fibre posts) and Group C (zirconia posts) was significantly greater than that of any other group, as the type of failure that occurred were primarily post and core fractures that potentially allow retreatment of the tooth. This may be because the individually formed posts provide fibre location closer to the outermost surface of the root where the highest functional stresses are located [22].

The results of present study are consistent with Sirimai and Sidoli demonstrating no root fractures for fibre post i.e. restorable fractures [6,23]. In this study the fibre post showed core fracture. Makade., *et al*. found that teeth restored with cast post and core found to have root fracture whereas glass fibre posts demonstrated only core fracture [4]. Akkayan and Gulmez in an *in-vitro* study concluded that zirconia posts induced more catastrophic root fractures, while teeth restored with fibre posts were less prone to fracture than teeth restored with zirconia posts [24].

In the present study, groups with the resin luting system showed considerably higher mean fracture loads than those with glass ionomer cement. The statistical analysis also revealed significant difference between the groups with different luting cements. The results indicate that adhesive composite resin luting systems provided additional fracture resistance to metallic post.

Among two types of nonmetallic posts used in this study, the Ever Stick post luted with resin cement was associated with the highest fracture forces. This could be due to the multiphase polymer matrix of these types of posts consisting of both linear and cross-linked polymer phases (semi interpenetration polymer network, semi-IPN). The monomers of the adhesive resins and cements can diffuse into the linear polymer phase, swell it, and by polymerization, form interdiffusion bonding resulting in monoblock effect. This will result in reduced stress formation at post/dentin and post/cement interfaces. The zirconia posts were supplied in a hardened form (with pre-polymerized monomer), which might have reduced their potential for bonding to the resin cement and thus might have allowed relatively lower fracture forces than Everstick posts.

Therefore, from the above studies it can be concluded that the fibre post has characteristics simulating natural dentinal structure than any other previously used post and it acts as a shock-absorber, dissipating much stresses on the finished restoration with small fraction forces to dentinal walls thus demonstrating restorable fractures. The composite core has exceptional adaption and forms strong bond to remaining tooth structure, bondable posts, resin cements, and eventually the final restoration creating the monoblock. In addition, it is esthetic, simple and predictable.

Conclusion

According to the findings and within the limitations of the study, it was concluded that:

1) The endodontically treated teeth without post core system showed the least fracture resistance demonstrating the need to reinforce the tooth.
2) Teeth restored with glass fibre post showed highest fracture resistance.
3) A more favorable mode of failure, through composite cores, was observed in teeth restored with glass fibre posts and zirconia posts making them more amenable to retreatment.

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