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RESEARCH ARTICLE

EFFECT OF FERRULE ON THE FRACTURE RESISTANCE OF TEETH RESTORED WITH PARAPOST XP AND PARAPOST FIBER LUX UNDER TANGENTIAL LOAD-AN IN VITRO STUDY

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ABSTRACT

Introduction: Endodontically treated teeth are at higher risk of fracture than vital teeth due to the decreased moisture content in dentin and most of the times, compromised structural integrity. The cast post and core technique has been advocated as the gold standard restoration for decades, but the traditional technique is time consuming and involves great laboratory and material costs. Introduction of prefabricated metallic post systems and esthetic post systems such as fiber-reinforced and zirconia ceramic posts have improved the results significantly. A dental ferrule is an encircling band of cast metal around the coronal surface of the tooth. The availability of 2.0 mm of coronal tooth structure between the shoulder of the crown preparation and the tooth/core junction has been shown to enhance fracture resistance and preventing fracture and dislodgement of the post. **Objective:** To assess the effect of ferrule on the fracture resistance of teeth restored with Parapost XP and Parapost Fiber Lux under tangential load. **Methodology:** Forty Human maxillary central incisors extracted within three months were stored in saline solution. Coronal sections of teeth to be restored were sectioned with carborundum discs 2mm occlusal to cementoenamel junction. Forty maxillary central incisors specimen collected were divided into two groups. Group 1 included 20 central incisors without ferrule and were further divided into two subgroups, 'a' with Parapost XP and 'b' with Parapost Fiber Lux. Group 2 included 20 central incisors with 2mm ferrule and were further divided into two subgroups, 'a' with Parapost XP and 'b' with Parapost Fiber Lux. The teeth were then endodontically instrumented and root canals were obturated using gutta percha. After root canal treatment, teeth were prepared for post space by means of preparation drills. Self adhesive resin cement was used to cement these posts. After removal of excess cement, resin cement was allowed for 5 minutes to polymerise followed by core build up using Paracore, followed by full coverage crowns. Finally, all the specimens were embedded in the acrylic resin block to a depth of 2mm below the cementoenamel junction. The mounted specimens were secured in a universal testing machine and a force was applied at a crosshead speed of 1mm/min until fracture occurred. The fracture load was recorded in Newtons. **Results:** When tangential loads were applied to the samples, it was seen that the teeth restored with posts having ferrule withstood higher amounts of force before fracture when compared to those without ferrule. **Conclusion:** Within the limitation of the present study, it can be concluded that the ferrule effect plays a key role in increasing the fracture resistance of teeth restored with post and core.

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INTRODUCTION

When most of the sound tooth structure is lost, the restorative options may include restoring the tooth with multiple involved procedures or extracting the tooth (Jotkowitz, 2010). When restoring these cases, the long term success depends on the capability of the restoration to brace on to sound tooth structure (Cheung, 2003).

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The endodontically treated tooth is a unique category of teeth that requires restoration due to the loss of the tooth structure, the changed physical characteristics by the altered collagen cross linking, the dehydration, the altered esthetic characteristics of the residual tooth and the impaired neurosensory feedback mechanism. If the coronal portion of the tooth is lost then it is restored with the use of post and core onto which a full coverage crown is cemented (Jotkowitz, 2010). Previously posts were believed to reinforce and strengthen weakened endodontically treated teeth against intraoral forces by distributing twisting forces within the root dentin and then to the underlying supporting tissue along their roots (Zhi-Yue *et al*., 2003). Currently, posts are not believed to function as a reinforcing component of prosthodontic treatment but rather as an element supporting a core foundation when there is an insufficient clinical crown (Pareira *et al*., 2006). The cast post and core technique has been advocated as the gold standard restoration for decades, but the traditional technique is time consuming and involves great laboratory and material costs (Aggarwal *et al*., 2013). Introduction of prefabricated metallic post systems and esthetic post systems such as fiber-reinforced and zirconia ceramic posts have improved the results significantly (Abduljabbar Tariq, 2012). Compared with the cast post and core technique, use of prefabricated post systems with direct core build-ups is less invasive, less time consuming and can simplify the restoration procedure (Aggarwal *et al*., 2013). A ferrule is nothing but an encircling band of cast metal around the coronal surface of tooth. It helps to improve the integrity of endodontically treated tooth (Sorensen, 1990). Ferrule improves the structural integrity as it counteracts a] the functional lever forces (Caputo, 1987), b] wedging effect of tapered dowels (Standlee, 1972) and c] lateral forces exerted during insertion of dowels [21].Several studies show that there should be atleast 2mm of tooth structure beyond the tooth-core junction to ensure a protective ferrule effect (Eissmann, 1987; Trabert *et al*., 1985).

MATERIALS AND METHODS

Specimen Collection: Forty caries free, intact human maxillary central incisors extracted within three months were stored in saline solution. These forty maxillary central incisors specimen collected were divided into two groups. Group 1 included 20 central incisors without ferrule and were further divided into two subgroups, 'a' with Parapost XP and 'b' with Parapost Fiber Lux (a and b, n=10). Similarly, Group 2 included 20 central incisors with 2mm ferrule and were further divided into two subgroups , 'a' with Parapost XP and 'b' with Parapost Fiber Lux (a and b, n=10).

Sample preparation: Coronal sections of teeth to be restored were sectioned with carborundum discs 2mm occlusal to CEJ. The teeth were then endodontically instrumented to a size of 60K-file and root canals were obturated using No 60 gutta percha point. After letting the root canal sealer to set for 48 h, gutta percha was removed from the root canals using Peeso Reamer no.4 leaving at least 4-5 mm of root canal filling in the apical third of the root (Fig 2a). For cementing the posts, self adhesive dual polymerising resin cement Relyx U200 was used (Fig 2b). After removal of excess cement, resin cement was allowed for 5 minutes to polymerise. After posts cementation, core portion was built up using Paracore. The core preparation was completed obtaining a chamfer finish line. Wax patterns were fabricated using type I inlay wax and then these patterns were sprued and invested using phosphate bonded investment and casted. After the castings cooled, castings were tried on the teeth and checked on for its proper fit and marginal adaptation. The castings were finished and polished and luted using GIC.

Evaluation of fracture resistance: To simulate the periodontal ligament, first, 200µ thickness Bausch articulating paper was stuck to the root surface of restored tooth and the assembly was placed in to a small container into which modelling wax was poured. The articulating paper was coated with a thin layer of petroleum jelly before pouring the liquid wax, which helped in easy removal of tooth after wax was set and this set wax acted as a mould. Once the wax was set, tooth was removed from wax mould and articulating paper was scraped off. The space created by articulating paper was replaced by polyvinyl siloxane material. Finally, all the specimens were embedded in the acrylic resin block (2.5x1.5x1.5cm) to a depth of 2mm below the CEJ. The mounted specimens were secured in a universal testing machine and load was applied with a specially made device that allowed loading of the tooth at the middle point of palatal side of the incisal edge 135° to the long axis (Wheelers, 1974; Moyers, 1977) (Fig 3a). At a crosshead speed of 1mm/min specimens were loaded until fracture occurred. The fractures were observed by means of visual inspection with the help of transillumination. The data of the fracture loads in Newtons, obtained were statistically analysed using one way ANOVA test.

RESULTS

A total of 40 samples were fabricated and divided into 2 major groups. Twenty samples in group 1 and 2, which were further subgrouped into and b having 10 samples each. Among the groups, fiber post with ferrule (Group D) showed the greatest fracture resistance of 441.26N, while the fiber post group without ferrule (Group B) showed the least resistance to fracture of 91.45N. There is no significant difference between the prefabricated metallic (Group C) and fiber post when the ferrule is present. But there is quite a difference when the no ferrule preformed metallic (Group A) and fiber posts groups are compared.

DISCUSSION

Root canal treated teeth are very well subjected to high risk of fracture under occlusion than normal vital teeth. But in spite of every method possible to restore the tooth, vertical fractures are a common occurrence in the root canal treated teeth. Endodontic therapy when used alone on a grossly decayed tooth doesn't save the tooth rather it saves only the root of the tooth involved (Makade *et al*., 2011). To restore back the strength of a fractured endodontically treated tooth, a dowel and core serves as the gold standard, protecting the weakened tooth (Makade *et al*., 2011; Aggarwal *et al*., 2013; Wadhwani *et al*., 2003). Initially, cast post and core were the ones only available. But considering the fact that the cast post and cores take more time and fail twice compared to preformed metallic posts and causes unrepairable root fractures (Standlee, 1972; Torbjorner *et al*., 1995). The ferrule effect or the protective effect helps to improve the structural integrity of the tooth by counteracting the functional lever forces, wedging effect of tapered dowels and lateral forces exerted during insertion of posts (Caputo, 1987; Standlee, 1972; Standlee, 1984). Several studies have been conducted as to see how much of tooth structure be present to act as a ferrule and it was found out that 2mm of coronal tooth structure provided necessary ferrule effect (Eissmann, 1987; Trabert, 1984; Trabert, 1985). In the present study utmost care was taken to provide even distribution between the specimens with respect to size. Teeth were randomly distributed into the four test groups. Standard protocol was followed during the study, yet it is impossible to achieve uniformity in the study. The main disadvantage of natural teeth is that there will always be variations in the sizes of the teeth resulting in large SD (Heydecke, 2001).

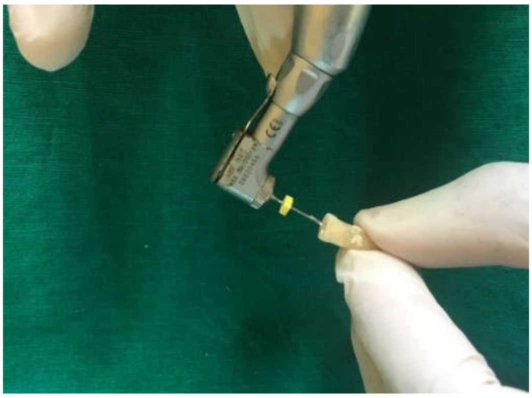

Fig. 2a. Post space preparation

Fig. 2b. Post cementation

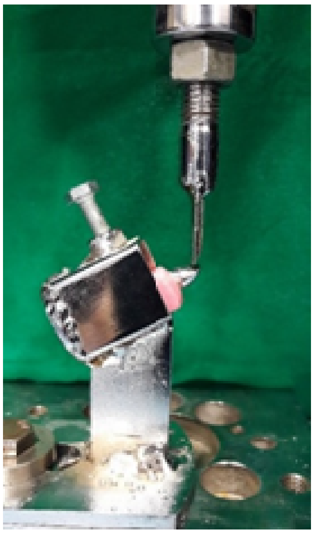

Fig. 3a. Loading at 135° to the long axis of tooth

Table 1. Descriptive statistics comparing the mean fracture loads of all posts under tangential loading

	Minimum	Maximum	Mean	Std. Deviation
Group A	147.90	121.41	108.162	92.60
Group B	91.45	130.49	109.80	12.35
Group C	246.80	398.21	325.91	65.67
Group D	263.40	441.26	354.40	78.49

The variables in the human teeth include tooth age, tooth conditions prior to extraction, tooth storage conditions, root anatomy and root dimensions (Maccari *et al*., 2003). In this study maxillary central incisor was selected because it is the most vulnerable tooth to trauma because of its position and it receives more angular forces thereby, requiring maximum restoration in terms of dowel and core (Makade *et al*., 2011; Dikbas *et al*., 2007; Sirimai *et al*., 1999). Also in the current investigation, crowns were placed over the specimen teeth before subjecting them to fracture loading. This helps us to accurately simulate the clinical intraoral environment. When the forces are applied directly on the core, there is a wedging effect on the root (Assif *et al*., 1993). However when the core is covered by a complete crown the wedging effect disappears with a shift of stress concentration to the CEJ. The loading angle selected was 135° from palatal to labial as this simulated the angle of contact between maxillary and mandibular incisors in Class I occlusion (Kraus *et al*., 1969). A crosshead speed of 1.5mm was used so as to allow distribution of force from the point of force applied to throughout the post (Butz, 2001).

According to the results of the present study, it is seen that group D i.e teeth with ferrule restored with Parapost Fiber Lux showed the highest value of fracture resistance whereas group B i.e teeth without ferrule restored with Parapost Fiber Lux showed the least value of resistance to fracture. These results are in accordance to the studies conducted by Lovdahl and Nicholls (Lovdahl, 1977), Sorensen (Sorensen, 1984) and Sidoli (Sidoli *et al*., 1977). These results are in contrary to what stated by Wadhwani *et al*., (2003) and Newman *et al*. (2003).

From the data obtained it is seen that the values of resistance to fracture is more in Group C and D when compared to Group A and B. This shows that 2mm of ferrule adds to the structural integity of the tooth increasing its resistance to fracture under tangential load. This is in accordance to the studies conducted by Sorensen (Sorensen, 1990) and Idil Dikbas (Dikbas *et al*., 2007). Teeth restored with preformed metallic posts showed cervical and middle third root fractures. While teeth restored with preformed fiber posts showed core fractures. This results are in accordance with the studies conducted by Sirimai

(Sirimai, 1999) and Sidoli (Lovdahl, 1977) demonstrating no root fractures when teeth are restored with fiber posts. When two substances have same modulus of elasticity, it is always advantageous. In the current study, fiber post has a modulus of elasticity of about 54,000 MPa which is close to that of dentin which has a modulus of elasticity of 20,000 MPa. This is considered to be more favorable for stress distribution. Whereas for a metallic post whose elastic modulus is 220,000 MPa, when stress is applied, post will not follow elastic deformation and creates a stress peak inside the radicular dentin leading to root fracture (Makade *et al*., 2011). In the present study it is seen that the fracture resistance of fiber posts in group D showed greater values when compared to that of group C consisting of metallic posts. This is in accordance to the studies conducted by Chetana S Makade (Makade *et al*., 2011) when the fiber posts possess the same elastic modulus to that of dentin forming a mono-bloc dentin-post-core system allowing equal stress distribution along the length of post and root allowing loads to be absorbed. Since the metallic posts show more modulus of elasticity compared to that of fiber posts as mentioned by Chetana S Makade (Makade *et al*., 2011), leads to stress concentrations in root causing irrepeairable fractures in the root.

Conclusion

Within the limitations of this study the following conclusions were drawn.

- The presence of ferrule increases the fracture resistance of tooth restored with post and core.
- The teeth restored with fiber post showed more resistance to fracture when compared to metallic posts.

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