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FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH RESTORED WITH DIFFERENT FIBER POST LENGTHS

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ABSTRACT

Purpose to compare fracture resistance of endodontically treated teeth restored with different lengths of fiber posts.

Materials and methods: Thirty- two freshly extracted sound mandibular premolars of approximate sizes, were mounted centrally and vertically in 12 x 12 x 20 mm acrylic block. Then, decoronated 2 mm above the cemento-enamel junction and were endodontically treated.

Teeth were randomly divided between 4 main groups (n= 8). For all groups, post holes were prepared (group A; post hole less than the crown length (3 mm), group B; post hole equal to the crown length (5 mm), group C; post hole half of the root length (7 mm), group D; post hole 2/3 of the root length (9 mm). Posts were cemented using self-adhesive resin cement. Using core former and light-cured core composite, cores for all specimens were built. A 0.5 mm finish line was prepared with 2 mm ferrule, to receive metal coping. Using universal testing machine, axial loadwas applied at crosshead speed of 0.5 mm/min, parallel to long axis of the tooth until failure.

Results: Group D scored the highest mean fracture resistance values (2670 ± 597.37 N) followed by Group A (2668 ±316.67 N) and Group B (2609 ±523.15 N). Group C scored the lowest fracture resistance values (2517 ±464.35 N). One-way ANOVA revealed no significant difference between groups (P=0.9). Chi-squre test also revealed no significant difference in restorability between the studied groups. (P=0.2).

Conclusions: The tested post lengths had no significant effect on fracture resistance of endodontically treated teeth. Posts having radicular lengths equal to half of the root, showed the most non-restorable fracture pattern among all tested groups.

KEY WORDS: fiber post, length, fracture resistance.

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INTRODUCTION

Structurally compromised teeth (SCT) are still considered as a restoration dilemma for both clinician and patient. It is well known that endodontically treated teeth are much weaker than vital teeth because of considerable loss of valuable tooth structure[1]. Restorations of such teeth usually need more structural resistance features that may be derived from intra-radicular posts to add more retention of the restorative material to the root portion[2].

Nowadays, many post and core systems are available in the dental field. They may be classified into two basic types; custom-made and prefabricated posts.

Prefabricated posts were first constructed from metallic materials such as stainless steel, titanium, or precious alloy. Later, due to increased demand on esthetic prosthesis, fiber reinforced composite posts were introduced in the beginning of 90s. They started with the introduction of carbon fiber posts, which had black color and did not solve the esthetic problem[3]. Later on, glass fiber posts were introduced which solved both the esthetic and biological downsides of metal.

Recently, many types of fiber posts are available for restoring SCT, they have many shapes, lengths and diameters. They are mainly composed of resin matrix strengthened by fibers, which may be zirconia, glass, carbon or quartz[4]. The use of fiber posts offers many advantages, including biocompatibility, esthetic properties, dentin-like rigidity, resistance to corrosion, and better mechanical properties that closely match those of natural teeth[5].

The most important feature of glass fiber post is its chemical adhesion with bonding cement and composite resin cores[6]. This advantage gives the ability for more conservative post space preparation.

A wide range of recommendations have been suggested, regarding cast post length needed to best serve its purpose without compromising its strength, which included the following: (a) The post should be equal to the clinical crown, (b) The post should be longer than the clinical crown, (c) The post should be half of the root length, (d) The post should be two-thirds the root length, (e) The post should be four-fifths the root length, and (f) The post should be as long as possible without disturbing the apical seal[7,8,9].

In 2015, A study by Latrash et al[10], demonstrated that nayyar core restored premolars had more fracture strength than fiber post restored ones. In addition, it has been reported that, using a short FRCP rather than a longer one improved both fracture resistance and restorability of tooth upon fracture of post/core/crown assembly[11].

The recommended length of the post was passed automatically from the metal post to fiber post, without bearing in mind different biomechanical and fractographic behavior of both, and without studies conducted covering that area.

A question worth asking; does the length of fiber post really affect the fracture resistance of the structurally compromised teeth?

The null hypothesis of the study was that; there will be no difference in fracture resistance between tested fiber post lengths.

MATERIALS AND METHODS

Specimens preparation

Thirty-two sound freshly extracted mandibular premolars of approximate sizes were collected from surgery clinics at the Faculty of Dentistry, Beirut Arab University. They were randomly divided into 4 equal groups of 8 teeth each. (Table 1)

TABLE (1) Samples grouping

Group	Post length	Number of samples
A	Less than the crown length (3 mm)	8
B	Equal to the crown length (5 mm)	8
C	1/2 of the root length (7 mm)	8
D	2/3 of the root length (9 mm)	8
Total		32

Teeth were cleaned using air-scaler and brass wire brush to remove any remnants. Then sterilized in an autoclave at 121°C, 15 psi for 40 min, and stored in distilled water for 72 hrs[12].

A small access hole was drilled through the occlusal surface allowing access to the pulp chamber and root canals for treatment. Canals were disinfected using 5.25% sodium hypochlorite, then root length was confirmed visually by locating the tip of the file from the apical foramen.

Teeth mounting

Teeth were mounted centrally and vertically at the level of 2mm below the cement-enamel junction (CEJ) in an auto-polymerized resin blocks (Vertex, Netherland) with a size of 12×12×20 mm.

Teeth preparation

Teeth were endodontically treated using eugenol-free root canal sealer. Then crowns were amputated horizontally 2 mm above cemento-enamel junction.

The recommended post space diameter was 1.3 mm consequently; fiber post size 2# was chosen which had 1.35 mm diameter[13].

Gates Glidden drills size #1 followed by #2 were used to the planned depth (according to groups) to create a path way for Peeso-reamers to straighten up canals and remove remaining gutta percha on the walls. After each drill, root canals were irrigated using NaOCl. Finally post-matched drill was used to create final post hole channel. All samples were irrigated using distilled water with endo-tip and dried using air jet then paper points to prepare them for cementation.

Each post was then inserted into canal and tried for fit and corresponding length. (Fig. 1)

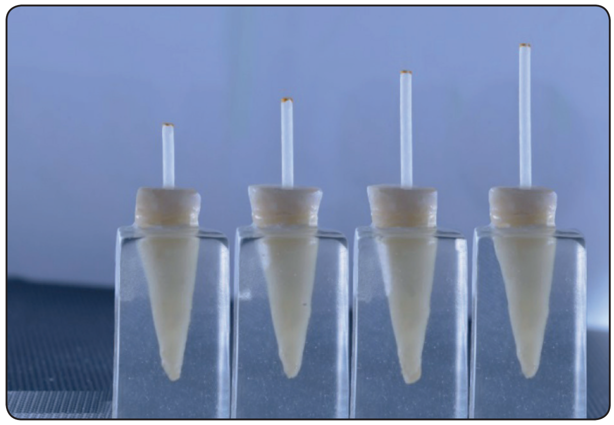

Fig. (1) Post try in

Using intracanal tip, self-adhesive dual cure resin cement (Rely X U 200, 3M ESPE, USA) was injected into each canal, in an apical-coronal direction to minimize any void formation. All posts were then cleaned using alcohol, dried with oil-free air, and inserted into corresponding canals. Each fiber post was held under pressure of curing tip, and the cement was cured for 20 sec. After full polymerization each post was shortened using metal disc to have a 2 mm coronal part.

Standardization of teeth preparation

The Teeth were prepared using a paralellometer surveyor to standardize design. A 0.5 mm finish line was prepared at the cemento-enamel junction with ferrule of 2 mm to receive a metal crown.

The coronal core portion was built with a light-cured core composite for one sample to duplicate it for all samples to standardise its form. An impression was taken with C-silicon material then poured with stone. The base block of stone die was trimmed to allow vacuum celluloid sheet to have all details of the core form. This custom-made core former, was used to standardized all cores.

All specimens were scanned using Extra-oral Scanner (EOS) and Standard Trangulation Language (STL) file was exported to Selective Laser Sintering machine (SLS) where all crowns were printed and laser sintered from CoCr powder.

Finally, metal crowns were cemented using resin cement, under load of 5 Kg. All specimens were stored in distilled water for 48 h before testing. Then thermo-cycled for 1000 Cycles between 5°C and 55°C with dwell time of 30 seconds.

Fracture resistance testing

To simulate the occlusal contact points, metal rod was fabricated with an end simulating occlusal surface of maxillary premolar. All specimens were axially loaded,

at cross head speed of 0.5 mm/min, in the central fossa parallel to the long axis of the tooth until failure.

Fracture load of each specimen was recorded in Newton (N).

Fracture mode analysis

The results were classified according to the mode of failure into restorable or unrestorable.

RESULTS

A) Fracture resistance:

Group D scored the highest fracture resistance mean values (2670 N) followed by Group A (2668 N) and Group B (2609 N). Group C scored the lowest fracture resistance values (2517 N).

One-Way ANOVA test revealed no significant difference between the studied groups.

B) Failure mode:

Failure mode was analysed in table 2

Although most fractures were restorable, group A scored the highest percentage of restorability followed by Group B and D and the lowest percentage was for Group C (Fig.6).

Chi-squre test also revealed no signicant differences in restorability between the studied groups.

TABLE (2) Failure mode

	No.	Failure mode*					Total	
		I	II	III	IV	V	Restorable	Non-restorable
Group A Less than the crown length (3 mm)	8	2	5	1	0	0	8	0
Group B Equal to the crown length (5 mm)	8	1	2	4	1	0	7	1
Group C 1/2 of the root length (7 mm)	8	0	1	4	3	0	5	3
Group D 2/3 of the root length (9 mm)	8	1	3	3	1	0	7	1

**I (Debonding of the post), II (Fracture above the cement-enamel junction), III (Fracture at the level of cement-enamel junction), IV (Fracture at coronal 1/3 of the root), V (Vertical fracture).*

DISCUSSION

This in-vitro study investigated the effect of fiber post length on fracture resistance of structurally compromised RCT teeth.

In this study, extracted mandibular premolars were chosen because it's a single rooted tooth with a single canal[14].

Teeth were preserved immediately after extraction and were cleaned to prevent the changes in the dentine compositions and were sterilized in an autoclave, and stored in distilled water without using any fixation materials which may affect the bonding protocols[12].

Eugenol-free root canal sealer was used to prevent interference with resin polymerization. Many researchers investigated the effect of phenolic substances (e.g. eugenol, wintergreen oil) and they found an effect of these materials in polymerization of resin[15].

Dual-cure self-adhesive resin cement was used to minimize problems related to curing light not reaching the most apical portions of the root canal, and to avoid technique sensitivity that is associated with multiple-step adhesive systems[16].

All the specimens received full metal crowns. Because, the presence of a prosthetic restoration generates a different biomechanical effect[17], full metal was used to avoid the false reading from fracture of ceramic crown if used.

Increasing post length improves retention; however, in the apical region of the canal, the bonding between the post and dentin is unpredictable[18]. The use of adhesive resin cement resulted in increased tensile strength between short FRC posts and root dentin, and improved fracture resistance[19]. It has been reported that using a short FRC post rather than a long post may yield to a higher fracture resistance with more restorable fracture pattern[11].

Moving through results, no significant differences were detected between studied groups which could suggest that fiber post length may not have an impact on the fracture strength of the tooth. On the other hand, favourable fracture patterns were observed in all studied groups. Most of specimens showed failure pattern at the coronal part above the CEJ which suggests stress concentrates in the same area. This may be due to the 360° ferrule of 2mm height in all the specimens that distributes the applied forces and concentrates them at the narrowest point around the circumference of the tooth[20].

These results are in agreement with previous studies which revealed that fiber post length did not contribute to fracture strength of teeth[21] and those with ferrule showed more satisfactory stress distribution and more fracture resistance[22].

It should be noted that groups A, B and D showed from 0 to 1 non-restorable failure patterns which may be due to the minimal ability of short fiber post to bend in its middle portion in group A and B. Regarding group D, the length of the post may dissipated the force along the root. On the other hand, group C showed the highest non-restorable failure pattern may be due to bending of the post in a weak area of the root.

As these studies were in vitro, it is difficult to achieve standardization with regard to functional age of teeth, morphologic variations of the pulp, and abnormalities in dentin composition before tooth extraction (Meng et al. 2009). Differences in dentin composition may affect the resilience of the dentin and thus, change the fracture pattern during compression. These variations were not controlled in this study which probably constitute a limitation of the present analysis[23]. Hence, it is suggested to carry out similar researches in more simulating conditions to obtain more realistic clinical results.

CONCLUSIONS

Within the limitations of the present in vitro study, the following can be concluded:

1- The tested post lengths had no significant effect on fracture resistance of endodontically treated teeth.

2- Posts having radicular lengths equal to half of the root, showed the most non-restorable fracture pattern among all tested groups.

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