Comparison of Fracture Resistance between Prefabricated and Fabricated Fiber Reinforced Post Systems on Different Post Canal Width

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Abstract

Background: Endodontic treated teeth are more susceptible to fracture. Correct restoration can minimize fracture risk, for example crown and post-core systems. Based on its manufacturing, Fiber Reinforced Composite (FRC) Post was divided into prefabricated and fabricated. The objective of this study was to evaluate the differences of fracture resistance between Prefabricated and Fabricated FRC Post systems on different post canal width. **Method:** The samples of this study were 28 premolars that were cut with 15 mm in length. The samples were treated with conventional endodontic method using gutta percha and resin sealer. The samples were divided into two groups and two sub-groups. The first two group was based on canal width consisting of 14 teeth each group with two different canal width (1.4 mm and 2.1 mm). Then, the first group was divided again into two subgroups based on the dowel use (Prefabricated post and Fabricated Post). Universal Testing machine was used to test the samples resistance. **Result**: This research showed that there were differences in fracture resistance on different post canal width. However, there were no fracture resistance differences between prefabricated post and fabricated post.

Keywords: post canal width, prefabricated FRC post, fabricated FRC post, fracture resistance

1. Introduction

In necrotic teeth, frequent fractures occurred due to loss of integrity, moisture, and strength of dentin. Dental necrosis can be maintained in the mouth if one does not take appropriate root canal treatment and restoration [1]. Trauma that occurs in young permanent teeth can stop root growth until the apical portion of the root canal is open and become wide. Root canal preparation may also lead to the thinning of canal walls. The tooth strength to resist mastication pressure decreases when there is less remaining hard tissue. In addition, post root canal treatment increase the risk of fracture because the teeth become more brittle and fragile. It is necessary to have post core restoration and crown to ensure that the teeth continue to function normally[3]. The post is an object made of metal or nonmetal that is inserted into the root canal to increase the retention of the crown and continued pressures received evenly throughout the root of teeth. The post can be divided into several kinds. Based on the manufacturing, the post is divided into Pre-fabricated and Fabricated with the use of metal or non-metal post. Some non-metal posts include post resin composites, ceramics, and fiber reinforced polymers[3].

Generally, root canal treated teeth by using posts core restorations castings made by the laboratory; however, this restoration has a high vertical fracture risk due to the huge pressure on the apex. Non-metal restoration posts that are often used as options are mainly made of fiber.

FRC (Fiber Reinforced Composite) was chosen because it has some properties that almost resemble dentine[4]. Fabricated FRC systems are made by the operator by entering a form of polyethylene fibers woven fiber and resin composite into the post canal and simultaneously build up a full point [2]. The required amount of woven fiber (polyethylene fibers) will depend on the major post canals. Fabricated FRC system can adjust the shape of the canal posts; thus, even though the canal has very wide posts, it can be filled with wicker fiber (fiber polyethylene fibers).

Prefabricated FRC posts consist of various shapes and sizes. Based on its tapered post, prefabricated consists of parallel and tapered post (tapered); while based on the configuration post, prefabricated consists of smooth and grooved post[3]. Prefabricated FRC posts are usually made of unidirectional glass fiber encapsulated by the matrix resins (epoxy resins). Each manufacturer made prefabricated FRC posts with different composition of the matrix and fiber[5]. The volume on the prefabricated FRC fiber varies between 40-65% vol. Prefabricated FRC posts are more widely used by practitioners, because the use on the procedure is easier and faster; however, the prefabricated FRC has a weakness that it cannot adjust the shape of the root canal. The resistance to fracture is the ability of the teeth to resist masticatory pressure to prevent fracture [6]. The research was conducted on fracture resistance by using posts different materials (metal and non-metal) to the width of a different root canal (1.4 mm and 2.1 mm)[2].

The purpose of this study was to determine the difference between the resistances of tooth fracture by using prefabricated and fabricated fiber reinforced composite posts on a different canal width post. The results of this study were expected to provide scientific information on the selection of fiber reinforced composite posts and post based on the width of canal in order to minimize the risk of tooth fracture.

2. Methods

2.1 Root canal treatment

The research subjects used 28 premolar teeth that had been stored in saline solution. Teeth that were used should be qualified in some criteria such as did not develop cavities, cracks, or micro fractures. Each tooth root canal treatment was performed by using conventional preparation techniques. The first step was the determination of working length of 15 mm. The first file entry was # 15 by stopper with a length of 14 mm. Preparation was done by using K-Files from # 15 to # 50 file with a working length of 14 mm. Each turn of the file irrigation used a solution of 2.5% NaOCl and 15% EDTA intermittent and ended with irrigation by using 15% EDTA. The canals were dried by using paper points. Root canal preparation was derived from master apical file (MAF) # 50. Obturation of root canals was done by using lateral condensation of root canal filling Guta patchwork and Siler resin (AH 26). Razorblade was inserted into the root canal by using paste filler. The main Guttapercha (# 50) was conducted with a working length of 14 mm, after apical third smeared Siler was inserted into the root canal. Spreader was inserted between gutaperca and canal walls, condensed apical direction, the main gutaperca would move laterally. The space available after spreader was taken, filled with additional gutaperca, press apical again, and the process was repeated until the spreader could not enter the coronal third of Guta patchwork. The cutting gutaperca limited coronal with plugger, then covered with zinc phosphate cement. Each dental research subject was stored in an incubator at 37 ° C for 1 week and kept moist[2].

2.2 Post Preparation

In all of the study subjects (28 lower premolars), the researchers made post canal preparation by using gutaperca taken using a heated plugger, then continued Peesoreamer stopper fitted with a 10 mm. The remaining of gutaperca was 4 mm. The length of the post derived two-thirds of the tooth root length (15 mm) was 10 mm. The teeth were divided into two treatment groups, each of 14 teeth which were on Group I: the canal width of 1.4 mm post, and group II: Post canal width of 2.1 mm. After that, the teeth were prepared in accordance with the group.

The first group (I): Post canal preparation was performed by using Peesoreamer that had been marked with a stopper ranging in size from the smallest to the size no.4, followed by precision drills. The canals were cleaned by using sterile distilled water followed with 15% EDTA, and then dried with paper points.

The second group (II): Post canal preparation was performed using a Peesoreamer that had been marked with a stopper ranging in size from the smallest to the size no.6, then continued by using Long parallel fissure bur with first time round. The canals were cleaned by using sterile distilled water followed 15%EDTA, and then dried with paper points.

2.3 Post Insertion

Each group in group I and II were further divided into two; therefore, each sub-group consisted of seven dental research subjects, which were subgroup A (prefabricated FRC) and subgroup B (fabricated FRC). In subgroup B, the previously prepared tube (pipe) made of celluloid plastic with a length of 5 mm and width (1.4 mm and 2.1 mm) was used to equalize the coronal area posts.

a. **Group I A.** (The canal width 1.4 mm with prefabricated FRC posts)

The subject of research (7 teeth) resin cement was applied at post canal by using paste filler duly stopper 10 mm. Prefabricated FRC was inserted to fill the canal posts. Irradiation was performed for 20 seconds with a direction parallel to the tooth.

b. **Group I.B.** (The canal width of 1.4 mm to the article fabricated FRC)

The subject of research (7 teeth) performed the laying of a plastic tube with a 1.4 mm coronal area. Fabricated FRC shaped polyethylene fiber sheets with a width of 3 mm was cut by using a special scissors for 30 mm in length. Afterwards, the researchers applied with flowable composite slabs laid. Resin cement was inserted into the post canal using paste filler which had been given stopper 10 mm. The sheets were taken using tweezers and placed in the canal post then condensed apical direction. Irradiation for 20 seconds with a direction parallel to the teeth was performed.

c. **Group II A.** (canal width of 2.1 mm article with prefabricated FRC posts)

The subject of research (7 teeth) applied resin cement at post canal by using paste filler which had been given stopper 10 mm. Prefabricated FRC was inserted to fill the canal posts. Irradiation was performed for 20 seconds with a direction parallel to the teeth.

d. **Group II B.** (the canal width of 2.1 mm to the article fabricated FRC)

The subject of research (7 teeth) performed laying plastic tube with 2.1 mm in the coronal area. Fabricated FRC shaped fiber sheets with a width of 3 mm and was cut using a special scissors along the 40 mm. after the sheet was put on the glass plate, it was smeared with flowable composite. Resin cement was inserted into the post canal by using paste filler which had been given stopper 10 mm. Gazette polyethylene fiber was taken by using tweezers and placed in the canal post. The sheets were condensed by using a plugger along the post canals. Irradiation for 20 seconds with a direction parallel to the teeth was performed.

2.4 Sample fixation

The fixation was made by stirring acrylic resin powder and liquid with a ratio of 1: 1 in a Stellon pot. Each research subject was planted in the pipeline by acrylic resin. Cementoenameljunction (CEJ) was 1.5 mm above the acrylic resin that served as alveolar crest. After that the research subjects were kept for 48 hours so that the polymerized acrylic resin was perfect [2].

2.5 Universal Testing for Resistance.

The subject of research that had been planted in the resin block was placed in the mounting jig. Type the burden of a given static load on the load application area, namely the middle teeth. The frequency of the applied load was 1.3 Hz. Jig circular loaded with 1mm tip. Given the speed of load application was a crosshead speed of 0.05 cm / min. Angle of load application was at 45° to the longitudinal axis of the teeth. The intensity of the applied load ranged from 0 N to the root of teeth was fractured, broken posts, and the loss of the post due to the failure of cementation[2].

The data derived from the value of the resistance to fracture of four groups for treatment of teeth were tested. The results of calculation of the average fracture resistance were shown in Table 1.

Table 1. The mean and Standard deviation fracture resistance between the use of prefabricated and fabricated FRC on a different canal width post (N)

Type post	Root canal width 1.4 mm	Root canal width 2.1 mm
Prefabricated FRC	519.75+ 58.89	333.42 + 19.61
Fabricated FRC	500.14+ 78.45	333.43 + 98.06

Data normality was tested by using the Kolmogorov-Smirnov test to determine the normalcy of data distribution. The results showed the probability value was 0.973 and the value of Kolmogorov Smirnov (KS-Z) was 0.485, which meant that the data were classified as normal distribution ($p > 0.05$). The research data also tested for its homogeneity (Levene test). The results obtained were shown in Table 2.

Table 2. Homogeneity test the fracture resistance of FRC using prefabricated and fabricated on a different canal width post

The treatment group	LS	Probability
The width of the root canal	0.156	0.696
type post	0.278	0.602

Note: LS : *Levene Statistic*

Table 3. The result of two-way anova between the fracture resistances of FRC by using prefabricated and fabricated on a different canal width post

Category	Probability
Posts canal width (A)	0.000*
Type post (B)	0.445
Interaction canal width post to post type (A * B)	0.394

Note : ** : meaningful

3. Discussion

Restoration after root canal treatment should be of particular concern to ensure that the teeth remained intact and not fractured. Types of restorations used depend on the extent of the remaining tooth structure. Restoration by FRC is often used, because the FRC modulus of elasticity is almost similar to the elastic modulus of dentin.

In this study, the results of Two-way Anova analysis of two lanes showed that there was no difference between the value of tooth fracture resistance that used prefabricated FRC posts and fabricated FRC. This was consistent with the research data on the flexural strength of various types of fiber, namely the flexural strength of fiber unidirectional (prefabricated FRC) amounted to 240.61 + 37.54 MPa; while the flexural strength polyethylene fiber braided (fabricated FRC) was 246,71+ 31.09 Mpa. The study used a resin containing fiber as a reinforcement of the polymer matrix. Resin containing this fiber served to forward the pressure from the polymer matrix to fiber and as a pressure reducer. Fiber must be fully coated by resin, so that the polymer resin must be in contact with each surface of the fiber in order to achieve adequate adhesion between the fibers with the polymer matrix.

A good process of adhesion and coating resin would produce a pressure distribution of the polymer matrix to fiber[8]. The study stated that the ideal width of the root canal tooth fracture resistance that used prefabricated FRC (Luscent anchor) was greater than the fabricated post (ribbond)[2]. This was because the process of prefabricated FRC at the plant was more structured. Prefabricated FRC posts are made from unidirectional fibers that are incorporated into the polymer matrix in a high degree of conversion. Conversion of a high degree serves to protect and secure the fiber, during the process of distributing the pressure[9]. The percentage of fiber volume on a prefabricated FRC increased 45-65%[8]. Previous study showed that the unidirectional fibers could provide increased strength and rigidity in the direction of fiber and minimal changes in the properties of the polymer matrix[7].

The results of the analysis of the two-way Anova (Table 3) showed that there were differences in fracture resistance of teeth on a different canal width post. In the group of canal width of 2.1 mm the post resistance to fracture was smaller than the width of the canal group post of 1.4 mm. This was consistent with several studies that proved that the canal width of the post then the less dentin remaining, which would heighten the risk of tooth fracture. Increased canal width of the post would increase the risk of fractures. Some studies also stated that the number of remaining dentin would affect the stiffness and resistance to fracture[3]. Large posts that were too large could cause a decrease in post retention and may increase the risk of fractures[7]. In general, an ideal post canal width was no more than a third of the width of the root[3].

Based on the results two-way Anova that there was no interaction between the types of posts and posts of different canal width to tooth fracture resistance. This indicated that the selection was not based on the FRC canal width post. FRC mechanical ability was affected by fiber orientation, the amount of fiber, fiber inclusion in the polymer matrix, strong adhesion between the fiber with the polymer matrix, type, and nature of the fiber. Therefore, in choosing FRC, we must know the characteristics of FRC that was going to be used[7].

LSD result of test showed that there were significant differences between the groups post the canal width of 1.4 mm and prefabricated FRC with groups post the canal width of 2.1 mm either using prefabricated or fabricated FRC. The significant differences also occurred in the group of canal width of 1.4 mm post and fabricated FRC with a group of canal width 2.1 mm post either using prefabricated or fabricated FRC. The characteristic properties of FRC affected the comparison between fiber with resin composites, fiber width, and the strength of the relationship between the composite resin and fiber had an influence on the mechanical properties possessed by FRC[10]. Fabricated FRC required higher adaptation to the tooth structure because fiber that was inserted into a canal post were not always the same and could cause dissimilarity to the volume of fiber. The position of fiber affected the strength so that it could affect the mechanical properties of the post. The resistance to fracture was affected by fiber orientation. Besides the things that influenced the effectiveness of FRC include a resin used, the amount of resistance to fracture was also affected by fiber orientation[7].

4. Conclusions

Based on the results of the study it could be concluded that:

1. There were no differences between the fracture resistance of prefabricated and fabricated fiber reinforced composite posts used. Resilience fracture between the uses of prefabricated fiber reinforced composite post was equal to the use of fabricated fiber reinforced composite posts.
2. There were some differences in fracture resistance of the canal width of different post. Teeth with a canal width of 1.4 mm post were more resistant to fracture than teeth with posts canal width of 2.1 mm.
3. There was no interaction between the types of fiber reinforced composite posts and posts of different canal width of the fracture resistance.

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