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FRACTURE RESISTANCE OF DIFFERENT FIBER POST MATERIALS (IN VITRO STUDY)

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ABSTRACT

BACKGROUND: Posts must be built of a material with optimal strength and an elastic modulus close to that of natural dentin. To date, there's no material that meets these demands.
Purpose: This study aimed to assess the fracture resistance and failure patterns of bundle glass fiber posts in comparison to conventional fiber posts.
MATERIALS AND METHODS: Eighteen extracted permanent second mandibular premolars were selected to receive fiber posts. Based on the material type, teeth were randomly allocated into two groups (n = 9). Group (RGP): bundle glass fiber post; Group (CP): conventional fiber post. Following the root canal's cleaning, shaping, and obturation. Post holes were then created, and core building was performed. The fracture resistance of the restored teeth was determined in Newtons using a universal test device acting at a speed of 0.5 mm/minute and a 45-degree inclined load. A stereomicroscope was employed to assess the mode of failure.
RESULTS: Group CP had a median score of 424.52 N, with values ranging from 102.33 N to 570.86 N, Group RGP had a median score of 394.71 N, with values ranging from 168.21 N to 827. 09 N. The Mann Whitney U test indicated that there was no statistically significant difference in fracture resistance values among the group (p value 0.691). There was no statistically significant difference between the two study groups regarding mode of failure (p value 1.00).
CONCLUSION: The findings indicate that utilizing bundle posts could serve as an effective alternative to single fiber post. Both types of posts showed similar fracture resistance.

KEYWORDS: Fiber post, Bundle post, Fracture resistance, Mode of failure.
RUNNING TITLE: Fracture resistance and failure patterns of different types of fiber posts.

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INTRODUCTION

Teeth that have been subjected to root canal treatment and have lost a significant portion of the coronal part of the tooth structure often need a post to be inserted into the root canal to support a core that will serve as the foundation for the final restoration. The main disadvantages were the presence of stress concentrations in different regions of the root, as well as the absence of attachment when employing a metallic post with a greater young modulus than the dentin. This may lead to the development of strains and potentially result in post separation or mid-root fracture. Fiber posts are proposed as an alternative to repairing endodontically treated teeth (ETT) (1).

Carbon and polyethylene fiber posts were used in the anterior region; however, the cosmetic outcomes were unsatisfactory, and corrosion responses led to allergic reactions (2, 3).

For zirconium ceramic posts, which have a high modulus of elasticity, forces may be immediately delivered to the tooth contact without shock absorption. Ceramic posts may cause more root fractures than carbon fiber posts mainly because of their rigidity (4).

Fiber posts were introduced in the late 1980s as a solution to restore teeth that undergone endodontic treatment with significant loss of tooth structure. The primary advantage lies in their similarity to dentin in terms of modulus of elasticity, making them particularly suitable for achieving good aesthetics. Furthermore, fiber posts offer additional benefits such as reducing the risk of root fracture by allowing for delicate cementation without inducing friction against the root canal walls (5).

Accessory fiber posts or newer approaches like bundle posts can be used. These posts will take up space inside the canals without requiring the removal of additional dentin, resulting in a reduction in the thickness of the luting cement needed to achieve a proper fit for the posts (1, 6).

The bundle post is a composite post that is radiopaque, transparent, and has a similar elastic modulus of dentin. Each post consists of several fine individual posts (0.3 mm in diameter) arranged in different quantities and bound together with a color-coded sleeve (7).

Placement of a bundle post within the root canal area does not require any prior preparation, and the assembling of bundle posts enables easy insertion into different root canal shapes(8, 9). Hence, the integration of bundle post into the root canal structure, without the need for further dentin removal, would be beneficial for the preservation of tissue (9).

The adhesive cement used in the cementation procedure possesses a low elastic modulus, which enables it to serve as a shock absorber, effectively reducing the root fractures. This homogeneous biomechanical unit facilitates more uniform distribution of stress, thereby preserving the weakened tooth structure more effectively (10).

There is limited agreement in the literature that one material is advantageous over another concerning its fracture resistance and mode of failure. This study aimed to evaluate fracture resistance and mode of failure of bundle glass fiber post versus conventional fiber post. The null hypothesis proposes that there will be no obvious difference in fracture resistance and mode of failure on bundle glass fiber post over conventional fiber post.

MATERIAL AND METHODS

This in vitro study was approved by the Research Ethics Committee at the Faculty of Dentistry, Alexandria University IORG 0008839. Eighteen natural extracted mandibular second premolars teeth obtained from Department of oral surgery, Alexandria University, were used to evaluate fracture resistance and mode of failure of bundle glass fiber post and conventional fiber post. The patient consented to the utilization of their teeth for this study.

To prepare the specimens for this study, all extracted teeth were selected with following criteria, intact root, fully mature single roots and examined under stereomicroscope (Olympus, Tokyo, Japan) to exclude any tooth with multiple root canals, root cracks, open apices, fractures, resorptive defects, or previous root canal treatment (11, 12). The study eradicated the roots less than 14 ± 1 mm in root canal length (cement-enamel junction to apical foramen) (13). Teeth were obtained and stored in 0.1 percent thymol solution until they were ready to be used. A periodontal curette (Nordent Manufacturing Inc., 610 Bonnie Lane, Elk Grove Village, IL 60007, T: 800.966.7336 US & Canada) was used to eliminate root surface soft tissue. Prior to root canal preparation, a diamond disc (Komet Gebr. Brasseler GmbH & Co) was attached to a straight handpiece while being continuously cooled in order to provide a consistent length for the remaining root to the level of cement-enamel junction (CEJ). The specimens were measured using insize digital caliper (Insize Co., Ltd., Binjiang District, Zhejiang, China) to verify the distance of the root from the cement-enamel junction to the root apex of 14±1 mm **(Figure 1)** (6, 14, 15).

The teeth were inserted in acrostone auto-polymerizing acrylic resin blocks with a diameter of 15 mm, and a height of 18 mm (Acrostone Dental Manufacturer, 215 El Hegaz St., Heliopolis, Cairo, Egypt) in metallic molds that are cylindrical in shape and aligned vertically along their vertical axis. Above each block, 2 mm of the coronal structure was visible **(Figure 2)**.

Pro-taper next (Maillefer-Dentsply, Ballaigues, Switzerland) was used for cleaning and shaping procedure of root canal up to full working length by using wismy endomotor (Wismy, Guangdong, China) at 250 rpm with 2 N/cm torque (7, 14).

Regarding irrigation, use a 30-gauge irrigation needle with side vents (#1707 Yinqiao Building, 58Jinxin Rd, Pudong, Shanghai 201206, China) with a 2.5% sodium hypochlorite. The drying process was done using paper points, then canals were filled with a single cone gutta-percha size F2 which is fitted at the working length with minimal resistance and endodontic sealer ADSEAL (Meta Biomed Co. Ltd, Korea). The access cavities were restored with Tetric N-ceram composite (Benderer Str. 2, 9494 Schaan, Liechtenstein) and placed in an incubator set at 37°C with 100% humidity for one week (7, 14).

The post hole was prepared for all specimen using Peeso reamer drills (MANI, INC., Tochigi-Ken, Japan) up to size no.3 which is connected to a low-speed handpiece w&h (Ignaz-Glaser-Str.53,5111 Bürmoos Austria), the length was meticulously adjusted using an endodontic ruler followed by no.2 coded glassix preparation drill with diameter 1.2 mm to achieve a standardized post hole preparation respectively (14, 16).

The specimens were allocated into two groups based on the type of post used: Group RGP: bundle glass fiber post Rebilda GT (Voco, Cuxhaven, Germany) and Group CP: conventional fiber post Galssix (Glassix, Nordin, Switzerland). (17).

For the cementation procedure, the posts underwent a cleaning process using alcohol and were subsequently air-dried to ensure optimal surface conditions. (Silano) coupling agent (Maquira Industry of Dental Products Ltd., Brazil) was coated to the post for 60 seconds and then dried using air. The post holes were irrigated with normal saline. Subsequently, they were dried completely by endodontic absorbent paper points (Meta Biomed Co.Ltd, Korea) and a bonding agent Solobond M (Voco, Cuxhaven, Germany) was applied. Bifix SE, a dual-curing composite-based luting cement (Voco, Cuxhaven, Germany) an auto-mixing tip was applied, facilitating the precise injection of the cement into the post holes and thorough application around the surfaces of the posts. The cement was light-polymerized for 20 seconds and 4 minutes for complete chemical-polymerization according to manufacture instructions. After the conventional, or bundle posts were cemented, the cores were constructed through specially designed crown former of 4mm inciso-cervically to ensure standardization using a dual-cure adhesive composite resin Charmcore ((Dentkist, South Korea) core foundation system and then finished using diamond rotary tools (7, 13, 14).

Each specimen was attached to a universal test device (5st, Tinius Olsen, England) at a speed of half millimeters per minute. The tooth within the acrylic block was attached to a special jig which is designed at 45 degree, and attached to the lower part of universal testing machine and load was applied vertically to outer cusp inclines as shown in **(Figure 3)**. The highest load at which failure occurred was measured in Newtons (N). The failure modes were examined under stereomicroscope (SZ1145TR Olympus; Japan 1990) and categorized into favorable fracture and unfavorable fracture or any form of interface debonding. (18, 19).

Normality of fracture resistance was assessed using Shapiro Wilk test and Q-Q plots. Non-normal distribution was confirmed for all variables thus median, minimum and maximum were used for data presentation in addition to mean and standard deviation (SD). Mode of failure was presented using frequency and percentage. Comparison between groups regarding fracture resistance test was done using ***Mann Whitney U test*** while ***Chi Square test*** was used to assess differences in mode of failure between groups. Significance level was set at *p* value<0.05. Data were analyzed using IBM SPSS 23.0.

RESULTS

(Table 1) showed the comparison of the fracture resistance between the two study groups, Group CP had a median score of 424.52 N, with values ranging from 102.33 N to 570.86 N, Group RGP had a median score of 394.71 N, with values ranging from 168.21 N to 827.09 N. No significant difference between the two study groups regarding the fracture resistance values (p value 0.691). (**Figure 3)**

Table 1: Comparison of fracture resistance among the two studied groups.

	Group I (RGP) (n=9)	Group II (CP) (n=9)	U Test (*p* value)
Mean ±SD	447.70 ±188.67	396.42 ±154.47	0.397 (0.691)
Median	394.71	424.52	
Min - Max	168.21 – 827.09	102.33 – 570.86	

U Test: Mann Whitney U test

No significant difference between the two study groups regarding the mode of failure (p value 1.00) as illustrated in **(Figure 4),** none of the specimens showed post fracture. **(Figure 5 &6)**

Figure (1): Showing the distance of the root from the cement-enamel junction to the root apex of 14±1mm

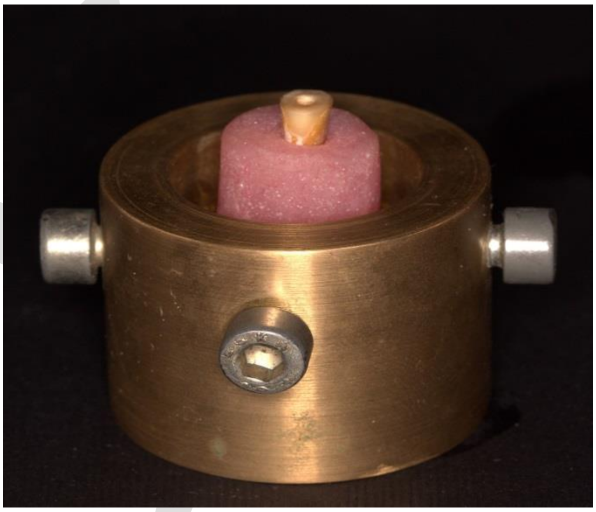

Figure (2): Showing specimen in metallic molds with 2mm of the coronal structure visible.

Figure (3): Showing specimen under universal test device.

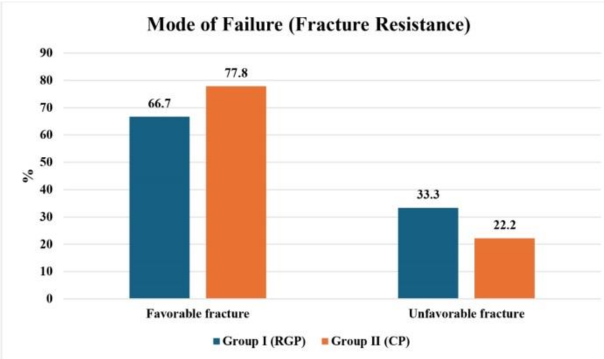

Figure (4): Showing mode of failure (fracture resistance).

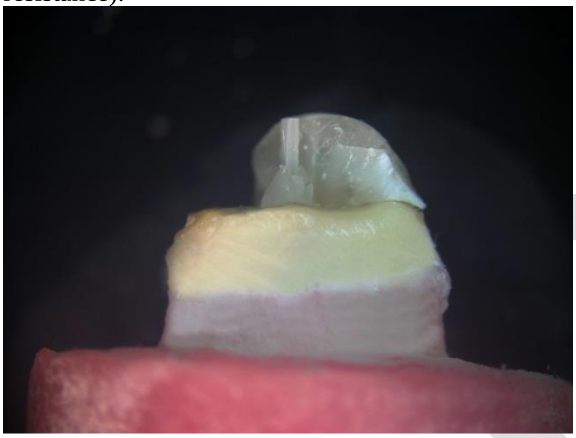

Figure (5): Showing failure mode of fractured of bundle post (favorable fracture).

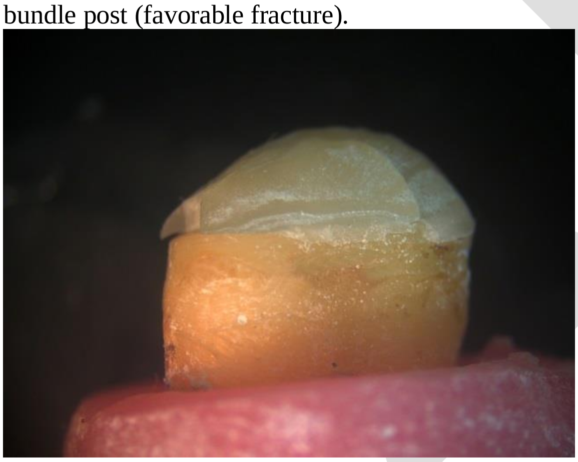

Figure (6): Showing failure mode of fractured of conventional post (favorable fracture).

DISCUSSION

Restoring teeth after endodontic therapy is a highly important aspect of dental practice. Using a post and core is a frequently employed method for repairing damaged teeth. To achieve successful repair, it is necessary to provide particular concern to the structural, functional, and aesthetic aspects. This involves offering enough support for a core, which acts as the essential foundation for the final restoration (20).

This study exclusively employed natural extracted mandibular second premolars due to their established susceptibility to fracture under occlusal loading subsequent to endodontic treatment. Additionally, the application of loading forces at a 45-degree angle introduces extra-axial forces onto the restored tooth, generating unfavorable stress during functional tasks. According to **Wandscher et al.,** an oblique load represents the most imperative condition for evaluating resistance of fracture of endodontically treated teeth (ETT) (10, 21).

All of the specimens were canal prepared to a standard length of 10 mm to retain 4 mm of endodontic filling material at the apex and to provide an excellent apical seal and endodontic treatment integrity. Which is in accordance with **Amarnath GS et al**, who stated that extending the post length more than two-thirds of the root length results in increased stress concentrations at apical part , potentially jeopardizing the integrity of the root's apical seal (22). According to research by **Chuang et al.,** increasing the length of posts might reduce root strength (23).

The above study examined the fracture resistance of endodontically treated mandibular second premolars, which were restored using two different post systems in respect to 1.2 mm post hole diameters. **Merve Özarslan et al.** showed that the diameter of the post is a more critical determinant of fracture strength than the length of the post. Increasing the post diameter can enhance its resistance, but it may also necessitate the removal of excessive intact tooth tissue, thereby weakening the overall structure. On the other hand, if the diameter of the post is too small, the layer of cement becomes thicker, causing stress to be distributed disparagingly at the interface between the post, cement, and dentin (14).

Bundle glass fiber post was chosen as it represents an innovative class of glass fiber dental posts characterized by a bundled configuration. (7). The Rebilda GT post was used, which is compatible with all drill systems (8). Bundle fiber post was chosen over other materials in this study owing to first, this post different from conventional posts because once open the sleeve it will occupy the canal space and adapted well to the canal walls, and second it can be used in conditions where strongly curved root canals (7). According to **Alkhalidi EF,** (7) showed that fracture resistance increased when the post adapted closely to the canal walls.

The resin cement used in this study was the same for both groups to eliminate any significant variations. **Naumann et al.** showed that Bifix SE exhibits superior retention levels and retaining excellent mechanical properties despite prolonged exposure to stress (24).

In this study, constructing a crown would have potentially skewed the results related to fracture resistance, as it would redirect the compressive forces into tooth directly rather than post. Since the primary focus was on evaluating the fracture resistance of the post restoration, it was crucial to apply the load directly to the core. This approach ensures that the majority of the forces are transmitted directly to the core then post, allowing for a more accurate assessment of the post's structural performance under load (25).

The null hypothesis of this study, which posited no significant difference in fracture resistance among the groups examined, is accepted. Group CP had the highest median score in fracture resistance test followed by Group RGP. This might be due to the force was directed on the core and the coronal third of the root, no force was transmitted into post itself (26), or it might be due to the minimal elastic modulus aids in the distribution and absorption of forces along the lengths of both bundle and fiber posts. Additionally, their ability to bond effectively with tooth dentin contributes to the creation of a monoblock effect (26).

The results of this study were similar to those obtained by **Alhanoof Aldegheishem et al.** (27)**, Esra Kul et al.** (26) and **Ranjkesh B et al.** (28) they examined the fracture resistance of bundle posts and conventional fiber posts in teeth that have undergone endodontic treatment. The experiment showed that there was no significant difference in fracture resistance between the tested groups. Both bundle posts and fiber posts exhibited equal fracture resistance values, which align with the results of this study.

This result was incompatible with **Alkhalidi EF,** who found that the bundle fiber post exhibited more significant fracture resistance compared to the single glass fiber post. The author explained this to the superior bond between the bundle fiber post and the resin matrix, which facilitated better stress distribution compared to a single post (7).

In regarding mode of failure, this study showed the highest value of favorable mode of fracture in group CP was 77.8% followed by group RGP was 66.7%. The explanation for this result could be due to the same elastic modulus, the fiber post roughly matches that of dentin. (26). This was in contrast to the findings of a study by **Alhanoof Aldegheishem et al.,** who revealed that the incidence of tooth fractures is higher in the bundle post group (77.7%) compared to both the control and fiber glass post groups (66.6% and 33.3% respectively) (27).

The present findings suggest that the fracture resistance of endodontically treated teeth (ETT) is improved by the placement of either post system; however, this in vitro study did not completely replicate clinical conditions, such as the thermal fluctuations and masticatory forces present in the oral cavity. Future research involving simulations of clinical conditions, including dynamic load applications and extended duration clinical trials, will be pivotal to comprehensively evaluating the efficacy of the bundle post system in restoring ETT.

CONCLUSION

Drawing from the results of this study, it can be shown that:

The findings indicate that utilizing bundle posts could serve as an effective substitute to single fiber post. Both types of posts showed similar fracture resistance.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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