

Fracture Resistance of Endodontically Treated Teeth Restored Using Three Different Esthetic Post Systems

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ABSTRACT

Aim: To compare and evaluate the fracture resistance of endodontically treated teeth restored with Rebuilda post GT, EverStick post and prefabricated glass fiber post at 90-degree vertical load and 45-degree oblique load.

Materials and methods: Eighty freshly extracted single-rooted mandibular premolars were selected, and after root canal preparation and obturation, standardized post spaces were prepared. Samples were randomly divided into four groups ($n = 20$) depending on the type of restorative technique used: group I restored with Rebuilda post GT system (bundled glass fiber reinforced composite post), group II restored with EverStick post (Individually formable glass fiber root canal post), group III restored with prefabricated glass fiber post, group IV restored with direct composite resin restoration without a post (control). Using a universal testing machine, 90-degree vertical and 45-degree oblique load was applied to the restored teeth with a crosshead speed of 0.5 mm/minute. Fracture loads and mode of fracture was recorded.

Results: The results of the analysis of variance (ANOVA) and *post hoc* Tukey HSD test revealed that the fracture resistance was significantly affected by different post systems ($p < 0.001$).

Conclusion: Rebuilda post GT samples showed maximum fracture resistance followed by the EverStick fiber post group, prefabricated post, and least in the control group.

Keywords: Endodontically treated tooth, Fiber post, Fracture resistance, Rebuilda post GT.

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INTRODUCTION

Restoration of the mutilated endodontically treated tooth (ETT) is a subject that has been evaluated and discussed widely in dental literature. Esthetic, functional, and structural rehabilitation of a pulpless tooth is critically important to ensure a successful restorative outcome. Endodontically treated teeth present with dehydration, altered esthetic, and change in physical characteristics.¹ These include decreased proprioception and moisture, leading to reduced dentin fracture resistance.² According to Dietschi et al.,³ the consequences of these changes are negligible. The major issues of ETT are related with the coronal destruction resulting from caries, dentin loss due to the removal of the roof of the pulp chamber,⁴ and the weakening of the pericervical dentin during access preparation.⁵ As a result of the compromised structural integrity, an increased fracture tendency during normal function is noted.⁶ Thus, in most ETT with inadequate coronal tooth structure, the use of intraradicular posts is recommended to encourage the retention of the final restoration and to biomechanically buttress the remaining tooth structure, thereby providing a coronoradicular stabilization.^{7,8} Development and use of fiber-reinforced composite (FRC) root canal posts have increased rapidly over the past few years.⁹

Glass fiber posts have an elastic modulus similar to that of dentin,¹⁰ consequently reinforcing the tooth structure.¹¹ This property has been reported to reduce catastrophic root fracture and provide better stress distribution.¹² Glass fiber post provides the most esthetic results and transmits light,¹³ require less dentin removal, and can be bonded to dentin.⁸

To overcome the difficulties that irregular root canal forms pose, an elastic FRC post (EverStick post, GC Europe, Leuven) was introduced to the market in 2011. This post is individually adaptable glass fibers, and its bonding and flexural properties (flexural strength: 1145 MPa, Young-modulus: 15 GPa)¹⁴ appear to be superior to commercially available, prefabricated FRC posts.⁹

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Rebuilda post GT (VOCO GmbH, Germany) is a bundled glass FRC post. It consists of a bundle of fine individual posts (0.3 mm in diameter) in varying numbers. Once the sleeve is removed, the bundle is spread, and the fine individual posts are distributed in the entire root canal. In contrast to conventional root posts, this provides homogeneous reinforcement of the entire core buildup.

This study hence attempts to evaluate the fracture resistance of endodontically treated teeth restored with Rebuilda post, EverStick post, and prefabricated post at 90-degree vertical and 45-degree oblique load (Fig. 1).

MATERIALS AND METHODS

Freshly extracted intact human mandibular premolars (for orthodontic purpose) without caries, with anatomically similar roots were selected. The teeth were examined with a stereomicroscope under 10× magnification to detect craze lines or cracks, which were excluded from the study, resulting in 80 specimens. Teeth were stored in 0.1% thymol solution and were decoronated at the cemento-enamel junction (CEJ) with a diamond-coated saw (Isomet 2000; Buehler

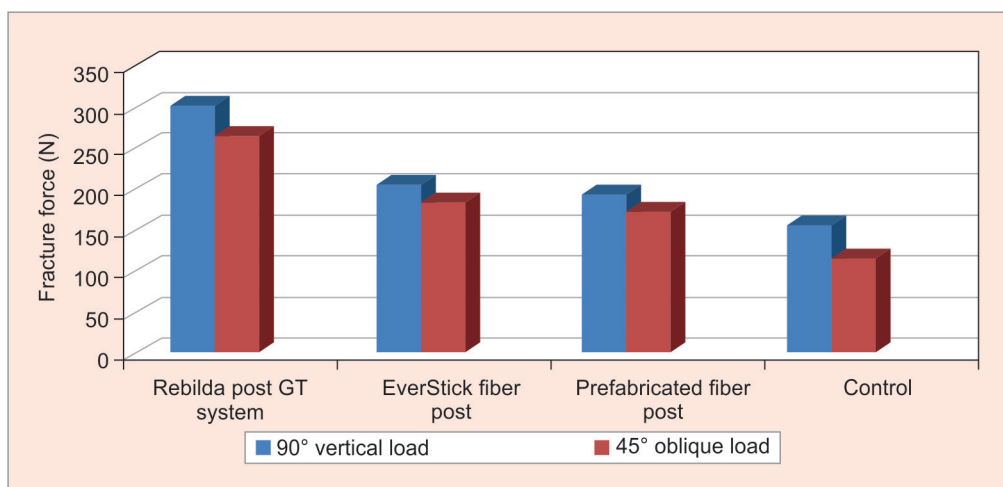


Fig. 1: Comparison of fracture resistance of different post systems at 90-degree vertical load and 45-degree oblique load

Ltd., Lake Bluff, Illinois, USA). The roots were adjusted to 16 mm in length, and the working length was established 1 mm short of the apex. All the root canals were instrumented using Protaper Universal rotary instruments till sizes F3 using crown-down technique under copious irrigation with 5 mL of 2.5% sodium hypochlorite (NaOCl). Canals were rinsed with 1 mL of 17% aqueous ethylene diamine tetraacetic acid (EDTA) for 1 minute followed by distilled water as the final irrigant, to remove any traces of remnant sodium hypochlorite and dried using paper points (Protaper® Universal Paper Points) sizes F3 matching the final finishing file, and obturated with gutta-percha using cold lateral condensation technique and AH Plus sealer (DeTrey Dentsply, York, Pennsylvania, USA). The root access was temporarily sealed with Cavit (3M ESPE, Seefeld, Germany). Samples were later stored in an incubator at 37°C and 100% humidity for 1-week.

After 1-week of incubation, post space was prepared with size 2 Peeso Reamer burs and fiber post drill to a depth of 10 mm. During preparation of the canal, 5 mm of endodontic filling was left at the apex of each canal. All samples received a final rinse with 5 mL of distilled water, and the excess was removed using paper points (Protaper® Universal Paper Points).

Samples were randomly divided into four groups ($n = 20$).

Group I

Restored with Rebilda post GT. Post space was prepared by Rebilda post drill (1.0 mm), and 1.0 mm apical diameter with 6-single posts under the red sleeve was selected. The post was pretreated with silane for 60 seconds and then air-dried. After irrigation and drying of the root canals, they were treated by Futurabond U (VOCO America Inc.) dual-cure universal adhesive for 20 seconds using an intraoral tip. The adhesive bond layer was dried using paper points. Rebilda post GT was coated with Rebilda dual-cure luting composite cement (VOCO America Inc.) and then inserted into the root canal filled with the cement. Prior to polymerization of the luting composite, the sleeve was removed, so that the individual posts can be fanned out throughout the canal using a suitable instrument. After the post reached the regulated length, cement was light-cured from above the post for 20 seconds. Light curing was performed using a light-emitting diode unit (Bluephase polywave LED, Ivoclar Vivadent, Schaan, Liechtenstein).

Group II

Restored with EverStick post. Post space was prepared by size 2 Peeso Reamer burs. After irrigation and drying of the root canals,

they were treated by Futurabond U (VOCO) for 30 seconds. The fibers of EverStick post were bundled according to the thickness of the root canal using the lateral condensation method. This post was gently removed from root canal, and then light-cured. The light-cured post was cemented using Rebilda dual-cure luting composite. After the post reached the regulated length, cement was light-cured from above the post, perpendicular to the fiber for 20 seconds.

Group III

Restored with prefabricated post. After the preparation of the root canal same as group I and II, single prefabricated glass fiber post was cemented according to the manufacturer's instructions. Glass fiber post was slowly inserted into the cement-filled root canal and light-cured for 20 seconds.

Group IV (Control)

Restored with a composite core.

In order to ensure the uniformity of the specimens, the composite resin core build-ups were standardized using cellulite core-forming matrices of the same size. All the specimens were maintained in 100% humidity, for 24 hours, at 37°C.

Mechanical Testing

Fracture Resistance test was carried out by applying a load using the Instron Universal Testing Machine (Zwick, Germany). A 90-degree vertical and 45-degree oblique load was applied with a cylindrical plunger of a crosshead speed of 0.5 mm/minute until fracture, and the fracture loads were recorded. The vertical load was applied to the center of the occlusal surface, while the oblique load was applied to the center of the cusp beneath which the post was located. Mode of fracture was observed by visual inspection with the aid of transillumination.

STATISTICAL ANALYSIS

Descriptive statistics were expressed as means and standard deviation (SD) for each group (Tables 1 and 2). The effect of different post systems on the fracture resistance of the tooth was assessed by comparison of groups using ANOVA test and *post hoc* Tukey HSD test (Tables 3 and 4). In the above tests, $p \leq 0.05$ was taken to be statistically significant. All analyses were performed using Statistical Package for the Social Science software, version 17.

Table 1: Comparison of force required to cause fracture under 90° vertical load

Group	Mean + standard deviation	p value
Rebilda post GT system	302.69 ± 3.76	0.000
EverStick fiber post	205.63 ± 2.83	0.000
Prefabricated fiber post	194.97 ± 2.70	0.000
Control	157.90 ± 3.83	0.000

Since *p* value for the ANOVA test is less than that of 0.05 indicates significance of difference

Table 2: Comparison of force required to cause fracture under 45° oblique load

Group	Mean	Standard deviation
Rebilda post GT system	265.65	4.67
EverStick fiber post	183.73	5.34
Prefabricated fiber post	175.34	3.61
Control	116.63	5.26

Since *p* value for the ANOVA test is less than that of 0.05 indicates significance of difference

Table 3: *Post hoc* Tukey HSD test to evaluate significance of difference under 90° vertical load

Group I	Group II	Mean difference (I–J)	Std. error	p value
Rebilda post GT system	EverStick fiber post	97.05700	1.48511	0.000
Rebilda post GT system	Prefabricated fiber post	107.71500	1.48511	0.000
Rebilda post GT system	Control	144.78600	1.48511	0.000
EverStick fiber post	Prefabricated fiber post	10.65800	1.48511	0.000
EverStick fiber post	Control	47.72900	1.48511	0.000
Prefabricated fiber post	Control	37.07100	1.48511	0.000

p value less than that of 0.05 indicates significance of difference and positive value in mean difference indicates higher fracture loading average in group I than group II

Table 4: One-way ANOVA with *post hoc* Tukey HSD test to evaluate the significance of differences under a 45° oblique load

Group I	Group II	Mean difference (I–J)	Std. error	p value
Rebilda post GT system	EverStick fiber post	81.91600	2.13376	0.000
Rebilda post GT system	Prefabricated fiber post	90.31300	2.13376	0.000
Rebilda post GT system	Control	149.01300	2.13376	0.000
EverStick fiber post	Prefabricated fiber post	8.39700	2.13376	0.002
EverStick fiber post	Control	67.09700	2.13376	0.000
Prefabricated fiber post	Control	58.70000	2.13376	0.000

A *p* value less than that of 0.05 indicates significance of difference and positive value in mean difference indicates higher fracture loading average in group I than group II

RESULTS

The samples were evaluated by subjecting them to two different loads, 90° and 45°. Under the 90° vertical as well as 45° oblique loads, group I—Rebilda post GT samples fractured at a force of 306.29 N and 265.65 N respectively, showing maximum fracture resistance, followed by the EverStick fiber post group, prefabricated post and least in the control group.

DISCUSSION

It is well established that dentin exhibits a fracture toughening mechanism, thereby reducing the possibility of crack progression.⁴ For these reasons, a minimally invasive post space preparation protocol was performed. The results of the study revealed that the fracture resistance of the tooth differed significantly between different prefabricated glass fiber post systems. In general, improvements in the fracture resistance values (*N*) were found in

the following order: Rebilda post GT > EverStick > Prefabricated glass fiber post > Control.

Rebilda post GT (VOCO GmbH, Germany) (group I) system showed the maximum resistance against vertical as well as oblique load. This could be attributed to a better chemical bond between the glass fiber and the resin matrix. Also, increase in number of fibers in the coronal aspect leads to better bonding to the core and thus better stress distribution.¹⁵ In addition, Maceri et al.,¹⁶ investigated single, double, and triple prefabricated composite post under several loads and indicated multi-post solution induces a significant reduction of stress levels into the residual dentin and therefore the root fracture risk decreases as well as the expected polymerization shrinkage effects. This could be accounted for the higher resistance exhibited by Rebilda post GT.

EverStick post (group II) showed better fracture resistance than Prefabricated post. EverStick post system allows the additional number of unpolymerized posts to be added according to the canal

morphology, which leads to better adaptation and better stress distribution. The results of the current study are in accordance with Sorensen et al., who concluded that a significant increase could be measured in the fracture resistance of restored teeth when the posts are adapted closely to the canal walls.¹⁷ The root canal completely filled with fibers is a more effective reinforcement than one post only when compared under the same polymerization procedure.¹⁸

Through the use of a multi-post technique utilizing small diameter posts, one is able to fill large and irregular root cavities more efficiently than with a single, centrally positioned post.¹⁷

Single prefabricated glass fiber post (group III) showed the least fracture resistance in comparison to other glass fiber post systems. As stated by Hatta et al., this could be attributed to the thick cement layer resulting in weakened reinforcement.¹⁸ Prefabricated post with poor adaptation to oval canals undergoes flexure to functional stress and produce micro-movement of the core.¹⁹

Fracture of the post(s) or the restored tooth itself is among the most common failures of ETT restoration.²⁰ In the present study, no difference was found between the study groups regarding the fracture pattern. The results of the present study revealed no catastrophic root fractures and were in agreement with Sirimai and Sidoli demonstrating no root fractures in teeth restored, with fiber posts, i.e., restorable fractures (above CEJ).²¹

The tested specimens received a vertical and oblique load (90-degree and 45-degree to the long axis of the tooth, respectively). From the present study, it could be concluded that posts significantly contributed to the reinforcement and strengthening of decoronated pulpless teeth by supporting the remaining tooth structure against vertical compressive force. As described by Wandscher et al., oblique load appears to be the worst-case scenario in terms of the fracture resistance of ETT.²² Applying this angle of force to teeth without a dental ferrule resulted in significant stress on the cervical aspect of the restored tooth²³ and heavy shear forces on the post/luting agent/radicular dentin interfaces.

The data demonstrate low fracture loads across the samples that can be attributed to the compromised tooth structure (no ferrule), unfavorable loading forces, and a lack of crown restoration. This highlights the importance of these three factors in the clinical success of restored, endodontically treated teeth and the importance of further investigations to achieve meaningful information about the best way to restore these teeth clinically.

CONCLUSION

- The decoronated endodontically treated teeth without post-core system showed the least fracture resistance demonstrating the need to reinforce the tooth.
- Use of Rebuilda post GT and EverStick post reinforce the tooth structure better as compared to Prefabricated post.
- No root fractures were seen any of the teeth restored with glass fiber posts, making them more amenable to retreatment.

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