ECRONICON OPEN ACCESS

EC DENTAL SCIENCE
Research Article

Evaluation of Compressive Strengths of Vertical Root Fractured Teeth Restored Using Different Fiber Posts and Ferrule Design

Zuhal Gorus[1] and Devrim Deniz Üner[2]*

[1]Department of Prosthodontics, Harran University, Faculty of Dentistry, Sanliurfa, Turkey

[2]Department of Periodontology, Harran University, Faculty of Dentistry, Sanliurfa, Turkey

***Corresponding Author:** Devrim Deniz Üner, Department of Periodontology, Harran University, Faculty of Dentistry, Sanliurfa, Turkey.

Received: November 20, 2018; **Published:** December 31, 2018

Abstract

Objective: The objective of this *in vivo* study is to investigate the compressive strengths of vertical root fractured teeth, reattached through different fiber applications and the ferrule effect along with resin-based cement.

Materials and Methods: Forty central teeth were randomly divided into four groups (n = 10). Regardless of the groups, a vertical fracture was formed on the root and divided into two equal parts. The separated fragments were restored by applying Variolink to the root canal with a glass-fiber post (Exacto) and glass-fibers (Tescera, Bisco), and/or creating a ferrule design in the cervical region. The core structures were formed with composite resins. A continuous force at the rate of 0.5 mm/min was applied to the samples vertically until a fracture occurred. The fracture values were recorded as Newton (N). Statistical analyses were performed with ANOVA and Duncan's multiple range tests.

Results: The samples restored with resin cement and Exacto fiber post showed the lowest average fracture resistance (871.9 N) ($P < 0.05$) compared to all the other test and experimental groups. The samples restored with resin cement, glass fibers and a 2 mm ferrule design showed the highest fracture resistance among all the experimental groups, and there was a statistically significant difference between them and the control group.

Conclusions: To reinforce vertical root fractured teeth, applying fibers to the root canal and creating a 2 mm ferrule design along with using Variolink may be a sound treatment option.

Keywords: *Fracture Resistance; Fibers; Reattachment; Vertical Root Fracture*

Introduction

Many complicated tooth problems in our day can be effectively treated thanks to root canal treatment. However, vertical root fracture is still a hopeless problem for dentistry. Its chances to be treated are generally low, and tooth extraction is proposed [1-3].

According to the American Association of Endodontists, vertical root fracture (VRF) is defined as a fracture initiated from the apex and progressing through the coronal portion of the tooth, stretching along the long axis of the root [4-6]. Reasons for vertical root fractures generally include a weakened tooth structure and the excess of received forces over the elasticity limit of the remaining dentin. The most common reason for tooth extractions is vertical root fracture [7-10].

In previous years, metal posts were used due to their fine physical features in restorations of endodontically treated teeth. But the developments in resin technology and the use of esthetic materials for restorations in the tooth color have increased. Along with the approaches to preserve the remaining tooth structure, the use of fiber-reinforced post systems has become common [11-13]. In dentistry, there is an increasing interest in fiber-reinforced composite posts, which, apart from endodontics, can also be used in prosthetic restorations, periodontology, and orthodontics as splints. Two different fiber material types come to the forefront in the reinforcement of roots in endodontics; namely, prefabricated rigid fiber posts and moldable fiber posts [14-16].

Exacto Angelus is a type of rigid glass-fiber. Tescera glass-fiber bundles can be described as pre-silanated fiber ribbons independent of each other. The silanization of this product enables the adhesion between resin and glass-fibers to increase. Moldable fiber post systems have more elastic structure than rigid fiber posts and their characteristics of elasticity are very close to natural tooth structure [17-19].

The idea to create a ferrule effect in restored teeth was first suggested by Rosen in 1961 [4], who suggested that the metallic collar circling the core along the gingival seat be used. Besides changing the recommended altitude level and design of the ferrule effect, numerous researchers have recommended a ferrule effect going in parallel with dentin walls for at least 1 - 2 mm and covering the tooth completely in the same level of altitude [20-22].

Objective of the Study

The objective of this study is an *in vitro* comparison of the compressive strengths of five different reattachment methods performed using resin-based cement, different fiber posts and two ferrule effect methods, in the reattachment of vertical root fractured teeth.

Material and Methods

100 similarly sized central teeth were collected from extracted human teeth. While picking the teeth to be used in the study, the points taken into consideration were whether the tooth was decayed, contained restoration, or had any fractured or cracked line. Canals affected by internal-external resorption or calcified canals were left out of the study as a result of the radiographic results obtained from these teeth. The selected teeth were left idle in 4°C distilled water until used. Immediately before being used, the teeth were cleansed of tartars and other residuals with the aid of ultrasonic tips and a scaler. For the experimental groups, the crowns of the teeth were moved in a way so that they had a root length of 14 mm from the apex with the aid of a carbon-made separator (ZumSeparieren, Germany).

Endodontic access cavities were prepared with a round dental bur (Horico, Berlin, Germany). The root canal preparation of the teeth was performed with the crown-down technique using a cordless endodontic micromotor (Endo Mate TC2, NSK, Japan) and NiTi files (S1-S2-F1-F2-F3, ProTaper Universal, Dentsply, DeTrey, Konstanz, Germany) in a way so that its study length was 0.5 mm shorter than the apical foramen. In every file change, the root canal was cleaned with a physiological saline filled injector. Afterward, the canal was cleaned with 0.5% sodium hypochlorite for 1 minute and bathed in distilled water.

Vertical root fractures in the experimental groups were created by applying mechanical force with the aid of a hammer after vertically placing an angular nail on the center of the root canal; exactly like the method described by Wenzel., *et al.* as to how a vertical root fracture should be created (Figure 1). The roots, divided into two equal parts as a result of the applied force, were selected to be used in the experimental groups (Figure 2). The roots that were not fractured as desired or had multi-part fractures were left out of the study.

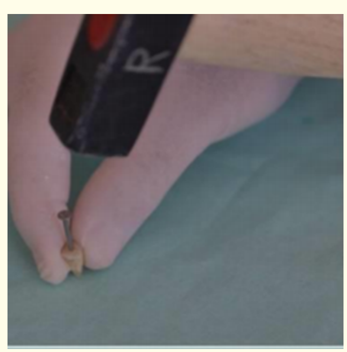


Figure 1: *Application of mechanical force by using a hammer and angled nails to roots.*

Figure 2: *Obtaining of standard vertical fracture of roots.*

50 teeth to be used in our study were divided into groups as can be seen in table 1.

Group 1 (n =10)	Variolink II
Group 2 (n = 10)	Variolink II ve Exacto cam post
Group 3 (n = 10)	Variolink II ve 1 mm ferrula +Tescera fiber lifleri
Group 4 (n = 10)	Variolink II ve 2 mm ferrula+Tescera fiber lifleri

Table 1: *Classification of experimental groups.*

Group 1: The fragments of the roots, divided into two equal parts after the vertical fractures were created, were only attached with Variolink II (Ivoclar Vivadent, Schaan, Lichtenstein). Afterward, a 4 x 3 x 3 mm sized core was formed with composite resin materials (G-ænial, GC Corporation, Tokyo, Japan) (n = 10, control group).

Group 2: The fragments of the roots, divided into two equal parts after the vertical fractures were created, were attached with Variolink II (Ivoclar Vivadent, Schaan, Lichtenstein) and by placing Exacto glass-fiber post, a rigid fiber post (Exacto, Angelus, Brazil), in between the fractured fragments. Afterward, a 4 x 3 x 3 mm sized core was formed with composite resin materials (G-ænial, GC Corporation, Tokyo, Japan) (n = 10).

Group 3: The fragments of the roots, divided into two equal parts after the vertical fractures were created, were attached with Variolink II (Ivoclar Vivadent, Schaan, Lichtenstein) and by placing Tescera fiber post, a moldable post (Bisco Dental Products, Schaumburg, IL, USA), in between the fractured fragments. Afterward, 1 mm wide and 1 mm deep grooves were created around the cervical region of the root with a standard dental bur. Dual-hardening composite (Tesceraflo, Bisco Dental Products, Schaumburg, IL, USA) was placed in the grooves and fiber bundles were polymerized in a way so that they could completely cover the tooth (40 s, 500 mW/cm2). With this method, a 1 mm wide ferrule effect was constituted around the tooth with moldable Tescera fiber post systems (Bisco Dental Products, Schaumburg, IL, USA). Afterward, a 4 x 3 x 3 mm sized core was formed with composite resin materials (G-ænial, GC Corporation, Tokyo, Japan).

Group 4: The fragments of the roots, divided into two equal parts after the vertical fractures were created, were attached with Variolink II (Ivoclar Vivadent, Schaan, Lichtenstein) and by placing Tescera fiber post, a moldable fiber post (Bisco Dental Products, Schaumburg, IL, USA), in between the fractured fragments. Afterward, 2 mm wide and 1 mm deep grooves were created around the cervical region of the root with a standard dental bur. Dual-hardening composite (Tesceraflo, Bisco Dental Products, Schaumburg, IL, USA) was placed in the grooves and fiber bundles were polymerized in a way so that they could completely cover the tooth. With this method, a 2 mm wide ferrule effect was constituted around the tooth with moldable Tescera fiber post systems (Bisco Dental Products, Schaumburg, IL, USA). Afterward, a 4 x 3 x 3 mm sized core was formed with composite resin materials (G-ænial, GC Corporation, Tokyo, Japan) (n = 10).

Group 5: The fragments of the roots, divided into two equal parts after the vertical fractures were created, were attached with Variolink II (Ivoclar Vivadent, Schaan, Lichtenstein) and by placing Tescera fiber post, a moldable fiber post (Bisco Dental Products, Schaumburg, IL, USA), in between the fractured fragments. Afterward, a 4 x 3 x 3 mm sized core was formed with composite resin materials (G-ænial, GC Corporation, Tokyo, Japan) (n = 10).

All the samples were left idle in 37°C distilled water for 24 hours. The circumferences of the reattached and restored samples were covered with 0.2 mm silicon impression material with the aid of a fine brush in order for them to imitate periodontal ligament. Afterward, all the teeth were put into autopolymerizing acrylic trays in a way so that 5 mm of the root would be in acrylic (Figure 3). Following the complete hardening of acrylic resins, acrylic blocks were placed on the panel of a universal testing system (Instron Corp., Canton, MA, USA). A steel round bit 3 mm in diameter was placed on the tip of the testing system. A force increasing with the rate of 0.5 mm/m was applied to the long axis of the root until parallel fractures were formed on the teeth, with the steel round bit arranged so that it could touch the whole of the coronal surface of the tooth. The force values required for each sample to be fractured were measured and recorded as Newton.

Data analysis was performed using the Statistical Package for the Social Sciences version 23.0 (SPSS Inc., Chicago, IL, USA). The statistical analysis of the obtained compressive strengths was carried out using One-Way ANOVA and Duncan's multiple range test ($\alpha = 0.05$).

Figure 3: *Embedding of teeth in the acrylic molds.*

Results

Following the statistical evaluation of the obtained results, statistically significant differences were observed between the groups ($P < 0.05$) (Table 2).

Groups	Average (N)	Std Deviation	Std Data	Maximum	Minimum	Median
Group 1	941.84[b]	50.77	16.05374	870.40	1045.50	967.65
Group 2	871.89[c]	62.30	19.69988	791.90	996.50	864.60
Group 3	965.70[b]	57.47	18.17217	846.40	1036.80	963.55
Group 4	981.56[ab]	82.46	26.07669	862.10	1086.90	986.10
Group 5	958.82[b]	85.36	26.99359	838.70	1087.20	943.35

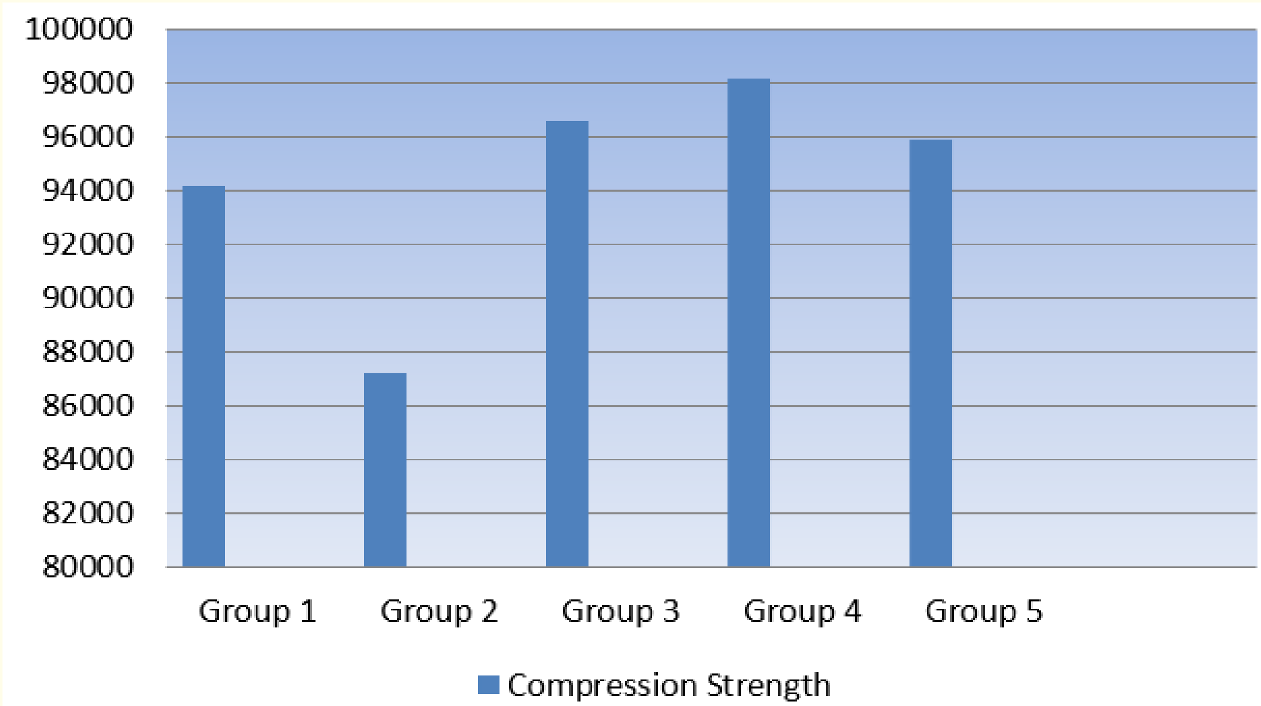
Table 2: *The average compressive strength of teeth and descriptive statistic values.*

The group reattached using Variolink resin cement and Exacto glass-fiber post (Group 2) represented significantly lower values statistically than all the other test and experimental groups ($P < 0.05$). The compressive strength obtained in the group reattached with moldable glass fibers (Group 5) presented a statistically significant difference from that of the group reattached with Exacto glass fiber post ($P < 0.05$) (Table 2).

The group in which a 2 mm ferrule design was created using Variolink resin cement and moldable glass fibers (Group 4) showed a greater fracture resistance than all the other test groups ($P < 0.05$). In addition, the compressive strength obtained from this group presented a statistically significant difference from that of the control group (Group 1) (Table 2).

The difference between the group with the 1 mm ferrule design (Group 3) and the group with the 2 mm Ferrule design (Group 4) was statistically significant ($P < 0.05$).

The compressive strength values of the groups are presented in graph 1. The greatest compressive strength level belonged to Group 4.



Graph 1: *Compression strength values of groups.*

Discussion

The objective of this study is to evaluate the use of different fiber post systems and the ferrule effect in the reattachment of vertical root fractured teeth.

In this study, all the controllable factors were standardized. The samples were selected on a similar mesiodistal width basis. Crown structures were moved, through which root lengths were obtained (14 mm). In addition, a type of dual-hardening cement, found to have the highest level of adhesive strength in previous studies, was used to attach the fragments. The variables of the study were determined as the use of different fiber systems and the ferrule designs.

Standard vertical root fractures were created by applying mechanical force using a hammer and angular nails, just as described by Wenzel., *et al.* in their study [23-25]. The reason why we used this method in our study was our objective to completely match the fractured areas while reattaching the teeth on which vertical fractures were formed.

Variolink resin cement was preferred in the reattachment of the teeth since it had a superior adhesive strength compared to other types of cement according to the body of literature.

Composite materials were preferred for the upper core structure due to their high adhesive strength, controllable and rapid hardening characteristic, fine elasticity and suitable compressive strength

Cagidiaco., *et al.* found the success levels of the teeth restored using D.T. Light post to be 90.9% for three years. In the same study, according to the three-year observation results from the teeth restored using D.T. Light, displacement of crown restoration and the risk of root fracture formation were reported to be lower. In addition, this study also acknowledged the crowns with the ferrule effect to have a longer intraoral lifespan [14]. Likewise in our study, the core structures with the ferrule effect were witnessed to have a greater compressive strength.

Performed studies have shown that Exacto fiber post has a high level of fracture resistance [15-17] However, in spite of the studies revealing its high compressive strength levels, it caused a statistically significant inferiority of fracture resistance in our study. The fact that it caused a new fracture on the reattachment area due to its rigidity shows that it conducts the force in a way that creates a dowel action. In our study, Exacto fiber post showed a low level of compressive strength. In addition, the rigid post group had a lower fracture resistance than the moldable post group in our study. In accordance with the results of our study, we are of the opinion that moldable posts are convenient to use in reattachment cases, while rigid fiber posts are not.

In their clinical study, Da Costa., *et al*. found the use of moldable glass fiber posts within the root to be successful following their three-year observation of teeth, and recommended them to be used in teeth within the scope of endodontic treatments [22]. Yoshino., *et al*. recommended that moldable fibers be preferred to rigid ones especially in extremely wide canals [24]. Researchers have suggested that prefabricated fiber posts create more stress on the dentin than moldable fiber posts. The use of moldable posts has been witnessed to provide a sufficient homogeneity under masticatory forces [18,19,25]. Likewise in our study, rigid posts showed a low level of fracture resistance.

In the finite element analysis study of Genovese., *et al*. prefabricated fiber posts were reported to create more stress on the dentin than moldable fiber posts [21].

Stankiewicz., *et al.* reported that post and core crown restorations without any ferrule design bore the most disappointing results in terms of their intraoral lifespan under smaller forces. In our study, the Ferrule effect enhanced the fracture resistance, supporting the conclusions of Stankiewicz., *et al* [20].

In their clinical studies, Ferrari., *et al.* and Crysanti Cagidiaco., *et al.* acknowledged the ferrule effect to have positive effects on the clinical success levels of premolar teeth that are endodontically treated and reinforced with fiber posts [19].

In our study, the extents to which the 1 mm and 2 mm ferrule effects created using fiber materials affected the fracture resistances of vertical root fractured teeth were evaluated. Ultimately, creating a 2 mm ferrule effect has been acknowledged to be the best method to increase the fracture resistance of teeth with post and core restorations.

Conclusion

1. Creating a ferrule effect using moldable fiber materials has a positive effect on the reinforcement of vertically fractured teeth that are reattached.
2. The use of rigid fiber post systems in vertically fractured teeth that are reattached (Group 2) has a negative effect on the fracture resistance.
3. The average fracture resistances obtained by reinforcing vertically fractured teeth that are reattached with moldable fiber post systems are significantly greater than the average fracture resistances obtained by reinforcing the teeth with rigid fiber posts.
4. Reattaching vertically fractured teeth with Variolink cement and moldable fiber posts and creating a 2 mm ferrule design with moldable fiber systems (Group 4) is considered to be the optimal treatment method for such teeth.

Bibliography

1. Touré B., *et al*. "Analysis of reasons for extraction of endodontically treated teeth: A prospective study". *Journal of Endodontics* 37.11 (2011): 1512-1515.

2. Tamse A. "Iatrogenic vertical root fractures in endodontically treated teeth". *Dental Traumatology* 4.5 (1988): 190-196.

3. Wang P., *et al*. "Detection of dental root fractures by using cone-beam computed tomography". *Dentomaxillofacial Radiology* 40.5 (2011): 290-298.

4. Rosen H. "Operative procedures on mutilated endodontically treated teeth". *Journal of Prosthetic Dentistry* 11.5 (1961): 973-986.

5. Madfa AA., *et al*. "Diagnostic accuracy of conventional, digital and cone beam computed tomography in vertical root fracture detection". *Iranian Endodontic Journal* 6.1 (2011): 973-986.

6. Metska ME., *et al*. "Detection of vertical root fractures in vivo in endodontically treated teeth by cone-beam computed tomography scans". *Journal of Endodontics* 38.10 (2012): 1344-1347.

7. Rosen E., *et al*. "Medico-legal aspects of vertical root fractures in root filled teeth". *International Endodontic Journal* 45.1 (2012): 7-11.

8. Rivera EM and Walton RE. "Longitudinal tooth cracks and fractures: an update and review". *Endodontic Topics* 33 (2015): 14-42.

9. Pereira JR., *et al*. "Effect of a crown ferrule on the fracture resistance of endodontically treated teeth restored with prefabricated posts". *Journal of Prosthetic Dentistry* 95.1 (2006): 50-54.

10. Chang E., *et al*. "Cone-beam Computed Tomography for Detecting Vertical Root Fractures in Endodontically Treated Teeth: A Systematic Review". *Journal of Endodontics* 42.2 (2016): 177-185.

11. Talwar S., *et al*. "Role of Cone-beam Computed Tomography in Diagnosis of Vertical Root Fractures: A Systematic Review and Meta-analysis". *Journal of Endodontics* 42.1 (2016): 12-24.

12. Pradeep Kumar AR., *et al*. "Diagnosis of Vertical Root Fractures in Restored Endodontically Treated Teeth: A Time-dependent Retrospective Cohort Study". *Journal of Endodontics* 42.8 (2016): 1175-1180.

13. Walton RE. "Vertical root fracture: Factors related to identification". *Journal of the American Dental Association* 148.2 (2017): 100-105.

14. Guldener KA., *et al*. "Long-term Clinical Outcomes of Endodontically Treated Teeth Restored with or without Fiber Post-retained Single-unit Restorations". *Journal of Endodontics* 43.2 (2017): 188-193.

15. Chan CP., *et al*. "Cutaneous sinus tract caused by vertical root fracture". *Journal of Endodontics* 23.9 (1997): 593-595.

16. Santos AFV., *et al*. "Can fiber posts increase root stresses and reduce fracture?" *Journal of Dental Research* 89.6 (2010): 587-591.

17. Verma D., *et al*. "Photoacoustic FTIR spectroscopic study of undisturbed nacre from red abalone". *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 64.4 (2006): 1051-1057.

18. Ferrari M., *et al*. "Post placement affects survival of endodontically treated premolars". *Journal of Dental Research* 86.8 (2007): 729-734.

19. Cagidiaco MC., *et al*. "Placement of fiber prefabricated or custom made posts affects the 3-year survival of endodontically treated premolars". *American Journal of Dentistry* 21.3 (2008): 179-184.

20. Stankiewicz N and Wilson P. "The Ferrule Effect". *Dental Update* 35.4 (2008): 222-228.

21. Genovese K., *et al*. "Finite element analysis of a new customized composite post system for endodontically treated teeth". *Journal of Biomechanics* 38.12 (2005): 2375-2389.

22. Da Costa RG., *et al*. "Three-year follow up of customized glass fiber esthetic posts". *European Journal of Dentistry* 5.1 (2011): 107-112.

23. Souza RO., *et al*. "Resin bonding to root dentin: influence of the alveolar bone level and thickness of the cement layer". *Minerva Stomatologica* 63.7-8 (2014): 239-248.

24. Yoshino K., *et al*. "Prevalence of vertical root fracture as the reason for tooth extraction in dental clinics". *Clinical Oral Investigations* 19.6 (2015): 1405-1409.

25. Fernandes AS and Dessai GS. "Factors affecting the fracture resistance of post-core reconstructed teeth: a review". *International Journal of Prosthodontics* 14.4 (2001): 355-363.

Volume 18 Issue 1 January 2019