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Effect of Surface Treatment on the Bond Strength of Fiber-Reinforced Composite Posts

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ABSTRACT

Background: Bond strength of fiber-reinforced composite (FRC) posts can be influenced by the post surface treatment method. The aim of the present study was to evaluate the effect of surface treatment method on the bond strength of FRC posts.

Methods: 40 extracted mandibular premolars with minimum root length of 14 mm were cut from 1 mm above CEJ and root canal treatment was performed on them. Randomly divided into 2 groups: Group 1 surface treatment with hydrogen peroxide (H2O2) 24%, group 2 surface treatment with hydrofluoric acid (HF) 10% and posts in 2 groups cemented with Luxacore cement. The push-out test was performed on 2 mm sections from cervical, medial and apical areas of roots in universal testing machine with speed of 1 mm/min. Bond strength was calculated in megapascal. The failure mode of the specimens was analyzed under stereomicroscope at ×40 magnification. The data were statistically analyzed with SPSS 21 and the results were evaluated by ANOVA, chi2 tests at the significance level of p<0. 05.

Results: Bond strength was 22. 13 ± 10. 12 and 21. 27 ± 9. 45 megapascal in group HF and H2O2 respectively. There was no significant difference between two surface treatment methods and bond strength. The most mode of fracture was in cementum-dentin.

Conclusion: Based on the result of the present study, surface treatment can affect the bond strength of FRC posts. Further studies are recommended.

Keywords: surface treatment, fiber post, compressive bond strength, push-out, composite post

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Introduction

The endodontically treated teeth may be at risk due to caries, fractures, previous restorations, and access cavity for endodontic treatment. Moreover, the endodontically treated teeth are more prone to biomechanical fracture rather than teeth with vital pulp (1).

Various materials and restorative methods have been recommended to improve the integrity of tooth structure with a high volume missing of the crown (2). Restoration of a root canal-treated tooth using a crown covering can prevent the fracture of the root and remained crown walls (3).

Nowadays, different posts and core materials are used to restore endodontically treated teeth. Fiber-reinforced composite posts (FRC) is a type of material bringing good clinical outcomes. These materials have been used in many types of research (4, 5).

Regarding their modulus of elasticity and aesthetic properties, FRC posts are preferable compared to metal posts (6, 7).

Adhesive restorations can pass and distribute stresses through bonding to tooth; therefore, occlusal forces caused by micromechanical adhesion can be spread over a wide area to strengthen the structure of weakened tooth structures (2). Post debonding from the dentin is the most common reason for clinical failure of application of fiber posts in endodontically treated teeth (8, 9).

Adhesive cement in conjunction with fiber post can form an integrated set with dentin in terms of mechanical structure. Cement-to-dentin adhesion has been introduced as the weakest bonding loop in post-cement-dentin (9). The quality of the created bond between post-cement-dentin is the most substantial factor for retention of fiber posts (10).

There have been many attempts to increase the lifetime of the interface between canal dentin and FRC posts. Adhesive treatment, sandblasting, tribomechanical treatment are some of the strategies in this field (11-13).

Surface preparation strategies increase the strength of resin posts bonding to the dentin. According to relevant studies, phosphoric acid, hydrogen peroxide, and silane enhance the post bond strength (14).

Ahmet et al. found no significant relationship between surface preparation and Micro push-out bond strength of constructed posts with CAD-CAM to the dentin (15).

Franca *et al.* (16) reported that the application of 2% Chlorhexidine and 100% Ethanol could enhance push-out bond strength to intraradicular dentin, while Chlorhexidine indicated better results.

Mishra *et al.* indicated that in light of the current evidence, surface treatment strategies increased the bond strength of glass fiber post to dentine (14).

Regarding the conflicting results of studies conducted on the effect of surface preparation on bond strength of FRC posts, the present study was conducted to examine the effect of two preparation techniques of hydrofluoric acid (HF)10% and hydrogen peroxide (H_2O_2)24% with a type of resin cement -existing in the market that is used by dentists- on compressive bond strength of FRC posts.

Materials and Methods

The present study is an in vitro research performed on 40 sound mandibular first premolars extracted due to orthodontic reasons or periodontal problems. The selected teeth had straight roots, without caries, fractures, history of root canal treatment, and a minimum root length of 14 mm. The teeth were thoroughly rinsed after extraction and placed in sodium hypochlorite solution 5. 25% (Golrang, Iran) for 24 hours to be disinfected, and then, kept at room temperature in physiological serum until the test. The crowns of the teeth were cut perpendicular to the longitudinal axis of the tooth from 1 mm above CEJ. The access hole was drilled by round dental diamond bur (Teezkavan, Iran) using a high-speed turbine and water. Passive step-back method was employed using hand files (Mani, Japan) up to No. 35 and rinsed with normal saline. The samples were filled with lateral condensation using Gutta Percha points (Meta Biomed, Korea) and AH 26 resin-based root canal sealers (Dentsply, UK). All procedures were conducted by a single operator who had previously been trained and skilled (17).

Teeth after root canal treatment were kept in physiological serum at ambient temperature for one week, then, for all teeth, 10 mm long dental canals were prepared using Gates Drills and Peeso Reamers (Mani, Japan), so that at least 4 mm of gutta-percha would remain at the end of the canal (18).

Moreover, 37% phosphoric acid was placed inside the canal for 15 seconds. The canal was rinsed with water for 30 seconds, and then, dried with a paper point. Bonding was ultimately performed. 40 samples were divided into two groups based on the type of surface treatment. Group 1: The fiber posts were drenched for 1 minute with 24% H_2O_2, rinsed with water, dried, and placed on the silane treatment for 1 minute. Group 2: The fiber posts were drenched for 1 minute with 10% HF, rinsed with water, dried, and applied silane for 1 minute. All posts were cemented with LuxaCore cement (DMG, Germany) using Lentulo No. 30 (Mani, Japan). The cement was also applied on post. And after placing the post inside the channel, cement and post were cured for 40 seconds using the light cure device.

After the cementation process, the posts were cut from CEJ to be tested in the universal testing machine and all samples were filled with composite (Diadent, Netherlands), then, kept in physiological serum at room temperature for one week. The teeth were then buried in autopolymerized acrylic and cut into three 2-mm pieces (one piece in the apical, one in the medial, and one in the coronal) by a cutting machine. To test the compressive strength, the specimens were placed in a universal testing machine and a force of 1 mm/min was applied until the post piece was removed. The maximum force required to separate each post piece (N) was recorded and converted to MPa through dividing the force (F) by the cross-section (A). Due to the difference in post diameter in different sections, the cross-section was calculated using the following formula:

$$A = \pi(R + r)((h)^2 + (Rr)^2)^{0.5}$$

Where, R (mm) is the radius of the post in the coronal section, r (mm) is the radius of the post in the apical section, and h (mm) is the thickness of the post in each sample.

Fractured specimens were also observed under a stereomicroscope with a magnification of 40 to determine the type of fracture. Data were recorded in a checklist and analyzed in SPSS 21 statistical software by ANOVA and Chi-square test. Statistical significance level was considered at $P \leq 0.05$.

This project was approved by Oral and Dental Disease Research Center of Kerman University of Medical Sciences with proposal code #97000781 and Ethical code: IR.KMU.REC.1397.425.

Results

The average fracture strength in HF and H_2O_2 preparation techniques was 22.13±10.12 and 21.27±9.45 MPa, respectively. The highest fracture strength was seen in the coronal area while using the HF preparation technique. However, there was no significant difference between the two preparation methods regarding fracture strength in apical, coronal, and middle areas (Table 1).

Table 1. The relationship between compressive strength of various areas based on the surface preparation methods

Variable		Number	Mean	Standard Deviation	P-value
Apical bond	H_2O_2	20	21. 40	10. 18	0. 622
	HF	20	19. 69	11. 55	
Median bond	H_2O_2	20	22. 00	11. 36	0. 902
	HF	20	21. 59	8. 72	
Coronal bond	H_2O_2	20	21. 76	6. 83	0. 225
	HF	20	25. 12	10. 09	

The most frequent fractures were seen in the middle cement-dentin area, while surface preparation was done using H_2O_2. The lowest numbers of fractures were cohesive type in cement in the middle area using the surface preparation technique of H_2O_2. The surface preparation technique of HF led to the highest number of adhesive fractures in cement-post and apical areas.

There was no significant difference between types of fracture in the middle area and the applied preparation technique. There was a significant difference between fracture sites in the apical area (P=0. 021), coronal area (P=0. 024), and preparation techniques (Table 2).

Table 2. The relationship between mode of fracture in various areas based on the surface preparation methods

Variables		**H_2O_2**	**HF**	**P-value**
	Cement-Dentin	14	7	
Coronal	Cement-post	2	10	0. 024
	Cement cohesive	4	3	
	Cement-Dentin	17	13	
Middle	Cement-post	3	4	0. 307
	Cement cohesive	0	2	
	Cement-Dentin	10	3	
Apical	Cement-post	7	15	0. 021
	Cement cohesive	3	2	

Discussion

The strong bond between resin post and dentin is the key factor for successful post-core restorations (19).

The fracture pattern of fiber posts differs from the pattern of metal posts. Debonding usually leads to a fracture in fiber posts (20-22). The gaps and defects seen in the thick layers around the post also have a negative effect on post retention (23).

In the present study, there was no significant difference between surface preparation technique and post bond strength. This finding is consistent with the results reported by Ahmet *et al.* (15) who found no significant relationship between surface preparation and bond strength of post. Aksornmuang *et al.* (24) concluded that different preparation techniques of the post, including HF with various concentrations and times and 24% H_2O_2, did not affect bond strength.

In the present study, the average value of compressive strength was lower while H_2O_2 was applied for surface preparation compared to HF. Valdivia *et al*. (25) found that 24% H_2O_2 led to a significantly higher bond strength compared to HF and 70% ethanol, which is inconsistent with the results of the present study.

According to the results of surface preparation using HF and silane techniques, these methods led to higher bond strength rather than control group (26).

Another study indicated less bond strength by glass fiber posts prepared by HF compared to the control group and sandblasting plus silane (27).

Another study by Kırmalı *et al.*, reported the push-out bond strength values of hydrofluoric acid treated glass fibers post followed by silane application and showed the non-significant difference with the control group (28). The reason for these differences may be in the method of study.

Majeti *et al.* found that using H_2O_2 for 60 seconds contributed to higher bond strength on glass fiber post rather than using H_2O_2 for 15 and 30 seconds and control group (12).

According to the findings of the present study, the highest bond strength occurred in the coronal area.

The results were matched with the findings obtained by Gençoglu *et al.* (29) and Garcia *et al.* (30) who reported the highest bond strength in the coronal area. According to the results of a systematic review, the highest bond strength of FRC posts occurred in the coronal area (14).

In this research, the highest number of fractures occurred in the dentin-cement area without consideration of the surface preparation technique.

This finding is consistent with studies conducted by Shiratori *et al.* (17) and Fonseca *et al.* (31) that reported more fractures in the dentin-cement area.

Amižić *et al.* (32) conducted a study on bond strength of FRC and constructed posts. They reported that all fractures occurred in the dentin-cementum area.

However, this finding is inconsistent with the results obtained by Amini *et al.* (33) who found the highest fracture in cement and post areas, this difference may be related to fiber post preparation technique.

Limitations

One of the limitations of this study is the lack of access to other surface preparation methods such as laser and their comparison with fracture resistance of FRC posts.

Conclusion

According to the findings of the present study, HF technique had the highest bond strength. However, there was no significant difference between the two surface preparation techniques of H_2O_2 and HF regarding the bond strength of FRC posts. The highest bond strength occurred in the coronal area in both preparation techniques. Most fractures were seen in the cementum-dentin area in both preparation methods.

Conflict of Interests

The authors declare that they have no conflict of interests.

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