Effect of Nanoparticle Calcium Hydroxide Dressing on the Push-out Bond Strength of Fiber Posts

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Abstract

Introduction: Calcium hydroxide is used as the medication of choice to eliminate microorganisms from the root canals and dentinal tubules. The present study aimed to evaluate the effect of nanoparticle calcium hydroxide dressing on the push-out bond strength of fiber posts.

Materials and methods: Fifty-four single-rooted premolar teeth were decoronated at CEJ, and the root canals were instrumented. The samples were randomly assigned to two case groups (nanoparticle calcium hydroxide and calcium hydroxide)and one control group in terms of the dressing material used (n=18). After irrigation of the intracanal medicaments, the root canals in all the three groups were obturated with gutta-percha and sealer. A post space was prepared, measuring 9 mm in length. The fiber posts were placed in the prepared post spaces after placing the resin cement within the root canals. The resin cement was light-cured with an LED light-curing unit. Disk-shaped cross-sections, measuring 1 mm in thickness, were prepared from all the samples for the push-out test. The data were analyzed with SPSS 20 using one-way ANOVA and Kruskal-Wallis test.

Results: In all the three groups (calcium hydroxide, nanoparticle calcium hydroxide, and control), the push-out bond strength decreased from the coronal third to the apical third of the root. The mean push-out bond strength at and cross-sections A and C were similar in all the three intracanal dressing materials. However, in the cross-section B of the calcium hydroxide group, it was significantly higher than that in the control group (P=0.20). The push-out bond strength was similar in the calcium hydroxide and nanoparticle calcium hydroxide groups.

Conclusion: Under the limitations of the present study, nanoparticle calcium hydroxide did not increase the push-out bond strength of fiber posts.

Key words: Calcium hydroxide, fiber post, nanoparticles.

Introduction

Bacteria are the chief etiologic agent for pulpal and periapical inflammation; a successful endodontic treatment depends on a significant decrease or elimination of bacteria (1). Although biomechanical preparation and shaping of the root canal decrease the microbial population significantly, these procedures do not eliminate bacteria from the root canal completely, especially in its inaccessible areas (2). Therefore, many researchers have proposed the use of intracanal medicaments from the root canals (2, 3). One of the dressing agents widely used as an intracanal medication is calcium hydroxide (4).

Calcium hydroxide has been used by dentists as a choice intracanal medication to eliminate microorganisms from the root canals and dentinal tubules for many years (5-8). Calcium hydroxide has a high pH and is disintegrated into hydroxyl ions (-OH) to penetrate the dentinal tubules and accessory root canals to eliminate microorganisms from these areas. The bacterial cell membranes are destroyed due to these ions' release and alkali effects (9-11). Komabayashi et al (2009) evaluated the size and shape of calcium hydroxide particles and reported 1-10 µm particle size for the commonly used calcium hydroxide particles, while the diameter of dentinal tubules is approximately 2-2.5 µm at pulp proximity. They concluded that due to the large particle size of calcium hydroxide, the conventional calcium hydroxide particles could not properly penetrate the dentinal tubules. Therefore, Roy and Bhattacharya produced nanoparticle calcium hydroxide by modifying the production procedure (13).

However, studies showed that it is impossible to completely remove calcium hydroxide from the root canal space (2,3). Lee et al reported that the bond strength of resin cements to dentin decreased after the use of calcium hydroxide (14). However, Zare Jahromi et al (2016) reported that calcium hydroxide, as an intracanal medication, increased the bond strength of fiber posts to radicular dentin (15).

Since the penetration depth of nanoparticle calcium hydroxide is different from conventional calcium hydroxide particles (16), their effect on the bond strength of fiber posts to the root canal dentin might be different. Smaller particles and a higher surface-to-volume ratio in nanoparticle calcium hydroxide result in differences in the physical properties and an increase in its chemical activity compared to conventional calcium hydroxide particles (17), with a different effect on radicular dentin. Therefore, the present study aimed to evaluate the effect of calcium hydroxide nanoparticles on the push-out bond strength of fiber posts.

Materials and Methods

The present in vitro study was carried out in the Dental and Periodontal Research Center of Tabriz Faculty of Dentistry on human extracted teeth in terms of inclusion and exclusion criteria. Fifty-four extracted single-rooted premolar teeth were stored in 0.5% chloramine T solution after mechanical elimination of calculi remaining on their surfaces until used in the study. A diamond disk was used to remove the tooth crowns at CEJ to leave a root length of 14 mm.

The root canal patency was evaluated with a Mani #10 K-file (Mani, Inco., Tochigi, Japan), and the working length (WL) was determined 1 mm short of the apical foramen. The root canals were prepared with RaCe rotary files up to #40, 4%. The root canals were irrigated with 2.5% sodium hypochlorite (NaOCl) solution between the instruments during root canal preparation. The final

irrigation of the root canals consisted of 5 mL of 5.25% NaOCl for 5 minutes, followed by 3 mL of 17% EDTA for 5 minutes to remove the smear layer. Finally, the root canals were irrigated with 10 mL of distilled water and dried with paper points.
The samples were randomly assigned to three groups in terms of the intracanal dressing used (n=18). In groups 1 and 2, calcium hydroxide nanoparticles and conventional calcium hydroxide (Master Dent) were used as an intracanal dressing, respectively. In group 3, no intracanal dressing was used (the control group). Calcium hydroxide nanoparticles were transferred into the prepared root canals. The samples were stored in 100% relative humidity at 37ºC for one week. The intracanal dressing was then removed with 5 mL of NaOCl, followed by irrigation with 5 mL of EDTA. The root canals were obturated with gutta-percha (Gapadent, China) and AH26 sealer using the lateral compaction technique. Then the samples underwent a radiographic examination to evaluate the obturation quality. The samples were stored for 72 hours for the final setting of the AH26 sealer.
In the next step, post spaces were prepared, and the resin cement was placed within the root canal, followed by curing with an LED light-curing unit for 20 seconds. The samples were stored in an environment with 100% relative humidity at 37ºC for 24 hours. The root samples were connected to the arm of a low-speed saw (Isimet, Buehler Ltd, Lake Bluff, IL) and cut perpendicular to the root long axis under water cooling. Three segments, measuring 1 mm in thickness, were prepared from each root. The push-out force was determined with the cylindrical tip of a rod measuring 1.1 mm in diameter, connected to a universal testing machine (Instron, Model 1334, Instron Corp., Cauton, MA). In the push-out test, the cylindrical rod was placed on the fiber post surface, and a force was applied in the crono-apical direction at a crosshead speed of 1 mm/min. The maximum force required to dislodge the post from the samples was recorded as the bond failure force.

Results

Table 1 shows no significant differences in cross-sections A and C in the mean push-out bond strength between the three intracanal dressing agents. However, in the cross-section C, there were significant differences between the three groups. Post hoc Tukey tests showed that the mean push-out bond strength values in the nanoparticle calcium hydroxide group were similar to other groups. Group 2, i.e., conventional calcium hydroxide, exhibited significantly higher push-out bond strength than the control group (P=0.20).

Table 1. Comparison of the mean push-out bond strengths between the three groups

Section	Intracanal dressing			P-value
	NC	$Ca(OH)_2$	Control	
A	19.17±11.85	28.53 ±13.5	21.28 ±9.99	0.058*
B	12.94 ±8.60	21.23 ±15.6$^{\neq}$	9.84 ±3.97	0.008*
C	11.57 ±6.75	17.52 ±16.1	10.84± 2.94	0.811**

*one-way ANOVA; **Kruskal –Wallis test; #significance in the Tukey test

Discussion

The present study evaluated the push-out bond strength of fiber posts in three cross-sections (A, B, and C) measuring 1 mm in thickness from the roots' coronal area. In each cross-section, the dentinal tubules' diameter and the number of tubules in root dentin affected the push-out bond strengths. Since the mean dentinal tubule diameter in the coronal area of the root was 4.32 mm, with a mean 46789 dentinal tubules in $1mm^2$ of the root dentin, the tubular space available for the penetration of the dressing in a cross-section, measuring 1 mm in thickness, was 1.04 mm^3 (18).

The mean diameter of the dentinal tubules and their number decreased from the coronal area toward the middle third of the root; the mean diameter of the tubules in the middle third was 3.74 mm, and their mean number in a 1-mm^2 area was 30940. In the middle third of the root, the space available for dressing agent penetration decreased to 0.2 mm^3 (18). The evaluations above showed that from the most coronal cross-section (A) to the most apical cross-section (C), the tubular space decreased. Since the diameter and number of dentinal tubules decreased from the coronal area to the apical area, the fiber post push-out bond strength decreased from the coronal area to the apical area with the use of conventional and nanoparticle calcium hydroxide intracanal dressing agents.

A comparison of different intracanal medicaments showed a significant difference only between the calcium hydroxide group and the control group (P=0.02). No significant difference was detected between the nanoparticle calcium hydroxide group and the control and conventional calcium hydroxide groups. Therefore, calcium hydroxide positively affected the push-out bond strength and exhibited favorable properties for use as an intracanal dressing agent. Also, the nanoparticle calcium hydroxide group was not significantly different in push-out bond strength from the control group, with no significant effect on the push-out bond strength. Therefore, this dressing agent, too, can be considered a favorable material for intracanal dressing.

In all three groups, i.e., conventional calcium hydroxide, nanoparticle calcium hydroxide, and control, there was a decrease in push-out bond strength from the coronal to the apical area. Since the effect and ability of irrigation solutions to eliminate dressing agents from the root canals decrease from the coronal area to the apical area (19), the push-out bond strength in the present study decreased from the coronal to the apical areas.

Zare Jahromi e al (2017) reported that calcium hydroxide, as an intracanal medicament, increased the bond strength of fiber posts to root dentin, consistent with the present study (15). However, Barbizam et al (2008) reported results that are different from the present study. They showed that in groups in which calcium hydroxide was used, the bond strength of resin-based endodontic sealers was lower (20).

Besides, studies by Akcay et al (2014) and Brleato et al (2013) showed that the bond strength of fiber posts to the root canal dentin was similar in the control and calcium hydroxide paste groups (21,22), different from the present study, which might be attributed to differences in the thicknesses of the samples, concentration and type of the irrigation solution, and the temperatures.

Concerning the reason for an increase in push-out bond strength of calcium hydroxide compared to the control group in the present study and the difference from other results, differences in the procedural steps, including the technique used to remove the dressing from the root canal and the brand of the materials can be mentioned. Previous studies also determined the bond strength of resin sealers to the root canal walls with the use of calcium hydroxide, while the present study determined the bond strength of fiber posts to root canal dentin.

Under the limitations of the present study, nanoparticle calcium hydroxide did not increase the push-out bond strength. However, due to the differences in particle size and greater tubular penetration of nanoparticle calcium hydroxide compared to conventional calcium hydroxide, it might be associated with more potent antimicrobial effects in endodontic treatment. In addition, considering no adverse effect on the push-out bond strength, it might be suggested as a proper intracanal medicament.

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