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Retention of Cast Posts Cemented with Two Commonly Used Conventional and Two Resin Cements and the Mode of Root Fracture Following Their Removal

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ABSTRACT

Objectives: This study aimed to compare the retention of cast posts cemented with four types of cements and assess the mode of root fracture following their removal.

Materials and Methods: In this in vitro, experimental study, 48 upper central incisors were randomly divided into 4 groups of 12, and were endodontically treated. The fabricated cast posts in each group were cemented with zinc phosphate (Masterdent), glass ionomer (GI; Meron), Meta resin cement, and Panavia SA resin cement. A device was customized for post removal by a universal testing machine similar to WAM X pliers. The retention of cemented posts was measured by the pull-out test in a universal testing machine. Next, the teeth were macroscopically and microscopically inspected regarding the occurrence and sites of catastrophic fracture, cracks, or craze lines. Quantitative and qualitative data were analyzed by ANOVA, and Chi-square test, respectively ($P<0.05$).

Results: ANOVA showed a significant difference in the mean retention of cements ($P<0.001$). Panavia provided the highest retention (278.6±34.9 N) followed by zinc phosphate (221.9±28.88 N), GI (161.3±60.7 N), and Meta (140.4±66.54 N). There was no significant difference between the groups regarding the pattern of root fracture ($P=0.39$). However, site and extent of fractures were significantly different among the groups ($P<0.05$).

Conclusion: The conventional cements provided optimal retention and caused less root damage after post removal. Thus, cements providing adequate retention and allowing easier post removal are recommended for use in endodontically treated teeth with a possibility of requiring retreatment.

Keywords: Post and Core Technique; Endodontics; Dental Cements; Tooth Fractures

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INTRODUCTION

Root canal retreatment of teeth with intracanal posts is a challenge for dental clinicians [1]. Intracanal posts are commonly used in endodontically treated teeth to provide retention for the restorations under prosthetic crowns [1,2]. In teeth with poor-quality root canal treatment, inappropriate length or diameter of intracanal posts, or presence of caries

under the post-retained restoration, non-surgical endodontic retreatment requires intracanal post removal [3,4].
However, intracanal post removal is often associated with the risk of root perforation, root fracture, or weakening of the remaining tooth structure [1,2,5]. Root fracture may occur with different patterns and different extents [6]. The retention and stability of intracanal posts are influenced by the type of post (prefabricated or cast), its shape, length, and diameter, and type of cement [7-9]. Therefore, the required force for intracanal post removal is also influenced by the same factors [2,5,10-12].
At present, different luting cements are used for intracanal post cementation such as zinc phosphate, polycarboxylate, glass ionomer (GI), resin modified GI, and resin cements, each having advantages and disadvantages [13,14]. Zinc phosphate was the gold-standard for this purpose for a long time. Next, GI cements were introduced, with the shortcomings of moisture sensitivity, and expansion over time [13]. Polycarboxylate cements were introduced next, which form a low chemical bond to tooth structure and subsequently provide low retention. Also, they undergo plastic deformation under occlusal loads [15,16]. Resin cements were then introduced, providing higher retention [17-20]. However, they have shortcomings such as high film thickness, polymerization stress, and difficult handling [21-23].
Several techniques and instruments are used for intracanal post removal such as burs, trephines, post removal instruments, and ultrasonic instruments [4,24]. Recently, WAM X pliers were introduced for removal of cast posts; however, studies on their efficacy are limited [25].
Considering the significance of selecting an appropriate luting cement for intracanal post cementation, this study aimed to compare the retention of cast posts cemented with two conventional and two resin cements and assess the root fracture patterns following post removal.

MATERIALS AND METHODS

This in vitro, experimental study was performed on upper central incisors extracted due to periodontal disease (IR.KAUMS.MEDNT.REC.1398.098). The teeth were stored in saline until the experiment.
The exclusion criteria were teeth with cracks, fracture, root caries, restoration, curved roots, mean root length shorter or longer than 17±1mm, and root diameter considerably different from that of other collected teeth. Eventually, 48 teeth were collected, which were highly similar in terms of shape and size. All teeth were inspected under a light microscope at x10 magnification to ensure absence of craze lines and cracks.
The teeth were randomly divided into 4 groups of 12. Next, they were decoronated by a carborundum disc (Dentorium, New York, NY, USA) under air and water coolant such that the remaining root length was 17 mm. The root canals were prepared with F1, F2 and F3 rotary files (ProTaper, Dentsply Maillefer, Ballaigues, Switzerland). During preparation, the root canals were rinsed with 2.5% sodium hypochlorite. After instrumentation, the root canals were rinsed with distilled water and dried with paper points. They were then filled with gutta-percha (Meta Biomed; Co., LTD, South Korea) and AD Seal sealer (Meta Biomed; Co., LTD, South Korea) using the lateral compaction technique. To prevent the leakage of fluids through the canal orifice, it was temporarily restored with a light-cure temporary restorative material (Temp.It, Spident, Korea).
To simulate the oral environment, the teeth were incubated at 37°C and 100% humidity for 1 week. Next, the roots were coated with a thin layer of melted wax (around 0.2 mm thickness) and then each root was mounted in a cylinder of auto-polymerizing acrylic resin (Beta Dent, Iran). After setting of the acrylic resin, the root was removed and the wax was eliminated.
The wax space was then filled with light body silicone impression material (Speedex, Coltene, Switzerland), and the roots were quickly placed back in their place in the acrylic cylinder. By doing so, the periodontal ligament was simulated (Fig. 1).

Fig. 1: Simulating the periodontal ligament space by light body silicone impression material

The dressing placed on the orifice was removed by a fissure bur and high-speed handpiece under air and water coolant. To prepare the post space, #1 and #2 peeso reamers (Mani, Japan) were used to empty 12 mm of the canal length. The canals were then thoroughly rinsed with distilled water. An impression was made from the canal using pin jet and acrylic resin (Pattern Resin LS; GC, Japan). The core section was also reconstructed with Pattern Resin (Fig. 2a).

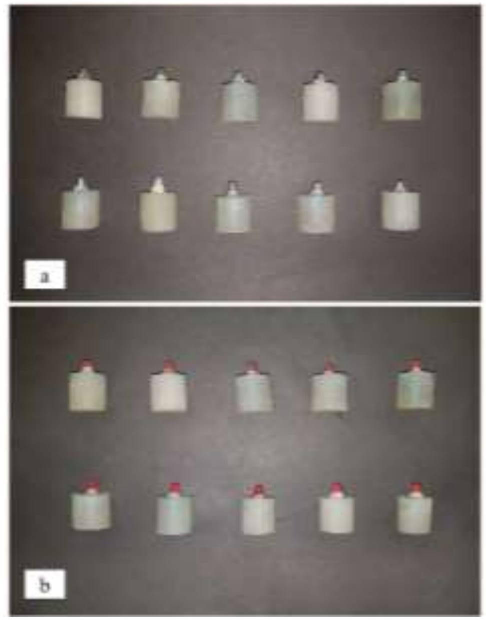

Fig. 2: (a) Preparation of acrylic pattern for cast posts. (b) Preparation and adjustment of cast posts

A cotton pellet was placed inside the canal, and the orifice was temporarily restored until the intracanal post was fabricated. Acrylic patterns of the canals were flasked and invested.

Table 1: Cementation protocols according to the manufacturers' instructions

Group	Cement	Company	Manipulation
1	Glass ionomer	Meron; Voco GmbH, Germany	P/L ratio: 1-1 Mixing time: 10s Working time: 3min Setting time: 3-5min
2	Zinc phosphate	Masterdent, USA	P/L: 32g / 17.5ml Mixing time: 20s
3	Resin cement 1	Meta; Metabiomed, South Korea	1. Surface treatment of restoration: apply a double coat of bond; air dry for 5s; light cure for 10s 2. Tooth treatment: apply 37% etchant gel for 15s; rinse for 20s; dry; apply a double coat of Meta Bond; air dry for 5s; light cure for 10s 3. Apply Metacem: dispense cement paste onto a mixing pad and mix for 20s (WT: 2min); apply cement to restoration 4. Pre-cure: 10s 5. Remove excess cement 6. Light cure all marginal areas for 40s
4	Resin cement 2	Panavia SA Cement Plus; Kuraray, Japan	No etching, bonding or other surface preparation of the tooth is necessary. Dispense cement paste onto a mixing pad and mix; apply cement to restoration; light cure all marginal areas for 10s in each surface

A phosphate-bonded investment (Bego, Bremen, Germany) was chosen for investing, and the mold was casted with Ni-Cr casting alloy (Wiron 99, Bego, Bremen, Germany). The cast posts were divested, sandblasted with alumina particles (200μm), and finished with suitable rotary instruments, and then prepared for cementation (Fig. 2b).

The canals were then thoroughly rinsed with distilled water and completely dried with paper points. Cementation of intracanal posts in each group was performed separately according to the manufacturers' instructions using Lentulo spiral (Mani Co., Tokyo, Japan). GI (Meron; Voco, Germany) was used in group A, zinc phosphate (Masterdent, USA) was used in group B, Meta dual-cure resin cement (Metabiomed; Co., LTD, South Korea) was used in group C, and Panavia SA Cement Plus (Kuraray, Japan) which is a self-adhesive dual-cure cement was used in group D. Table 1 describes the cementation process according to the manufacturers' instructions. After cementation of all intracanal posts, the teeth were incubated again at 37°C and 100% humidity for 1 week. After removal from the incubator, ultrasonic vibration was applied using ultrasonic instrument (DTE, Woodpecker, China). The tip of the ultrasonic instrument was placed at the core-tooth interface, and vibration was applied at maximum speed at four points of mesial, distal, buccal and lingual, each for 30 s, under water spray. Next, the tip of the ultrasonic instrument was moved in a circular motion around the post for 2 min [11,12]. To better simulate the clinical setting and to prevent damaging of the specimens, we had to custom design an instrument to connect it to the universal testing machine. For this purpose, we fabricated a metal piece similar to the design of the WAM X pliers with similar blades (Fig. 3). After applying ultrasonic vibration, the core-tooth margin interface was removed by 2 mm using a fissure bur and high-speed handpiece to create a space for placement of the blades. The specimens then underwent a pull-out test in a universal testing machine at a crosshead speed of 1 mm/min until the post was detached. Load at the moment of detachment was displayed by the device.

Fig. 3. Device similar to WAM X pliers prepared for universal testing machine

The designed metal piece was used for load application (Fig. 4).

Fig. 4. Placement of specimens for pull-out test in the universal testing machine with load application at a crosshead speed of 1 mm/min

After testing, the teeth were removed from the mount and inspected for catastrophic fracture. After macroscopic inspection, they were inspected under a light microscope (Olympus, Tokyo, Japan) at x10 magnification for presence of cracks and craze lines. The frequency of different root fracture patterns was also determined for statistical analysis. Differences between the retention strength values (N) were analyzed by ANOVA. Also, we used the Tukey's post-hoc test for multiple comparisons. The Chi-square and Fisher's exact tests were used for comparison of the root fracture modes and location of failure for all cement groups.

RESULTS

ANOVA revealed maximum retention in Panavia SA resin cement (278.6±34.9 N), and minimum retention in Meta resin cement (140.4±66.54 N) group.

Table 2: Mean and standard deviation (SD) of retention strength (N) of the cement groups

Group	Cement	Mean±SD	Minimum/Maximum	P *
1	Meron glass ionomer	161.3±60.7	122.7/199.8	<0.001
2	Zinc phosphate	221.9±28.88	203.5/240.2	
3	Meta Biomed	140.4±66.54	98.15/182.7	
4	Panavia SA Cement Plus	278.6±34.9	256.4/300.8	

* Analysis of Variance

A significant difference was noted regarding the mean retention among the cement groups (P<0.001, Table 2).
The Tukey's post-hoc test revealed no significant difference between Meta resin cement and Meron GI (P>0.05). However, the differences between the aforementioned two groups and zinc phosphate and Panavia SA resin cement were statistically significant (P<0.05). As shown in Table 3, 28 teeth (58.3%) had root fracture. The highest frequency of cracks and craze lines was noted in Panavia SA group (n=6, 50%) (Figs. 5a and 5b). The highest frequency of fractures was noted in Meta resin cement group (n=9, 75%). Zinc phosphate cement group had minimum frequency of fractures (n=8, 66.7%).

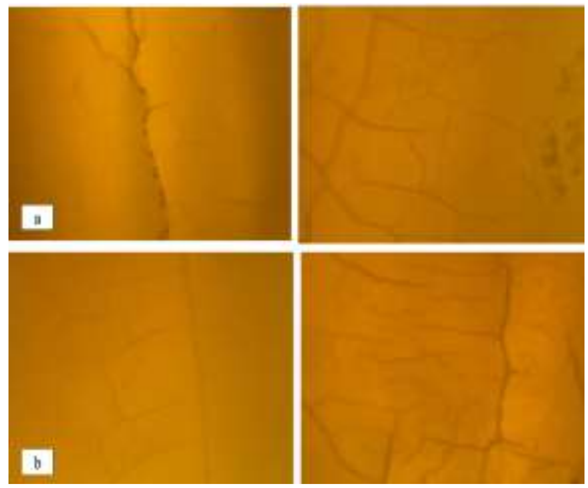

Fig. 5: (a) Inspection of cracks under a light microscope. (b) Inspection of craze lines under a light microscope

Table 3: Number (percent) of root fracture modes after pull-out test in the cement groups

Root Fracture Mode	Cement				P*
	Meron glass ionomer	Zinc phosphate	Meta Biomed	Panavia SA Cement Plus	
None	5 (41.7)	8 (66.6)	3 (25)	4 (33.3)	**0.398**
Craze line	4 (33.3)	2 (16.7)	4 (33.3)	2 (16.7)	
Craze line and cracks	3 (25)	2 (16.7)	5 (41.7)	6 (50)	
Total	12 (100)	12 (100)	12 (100)	12 (100)	

* Chi-square test

Table 4: Number (percent) of the location of failure in the cement groups

Location of failure	Meron glass ionomer	Zinc phosphate	Meta Biomed	Panavia SA Cement Plus	P*
Coronal third	2 (16.7)	0	7 (58.3)	2 (16.7)	**0.028**
Middle third	2 (16.7)	3 (25)	2 (16.7)	1 (8.3)	
Apical third	1 (8.3)	0	0	0	
Coronal and middle thirds	0	0	0	3 (25)	
Middle and apical thirds	0	0	0	1 (8.3)	
All three regions	2 (16.7)	1 (8.3)	0	1 (8.3)	
No Fracture	5 (41.7)	8 (66.6)	3 (25)	4 (33.3)	
Total	12 (100)	12 (100)	12 (100)	12 (100)	

* Fisher's Exact test

Catastrophic fracture did not occur in any tooth. Statistically, no significant difference was noted between the groups regarding the type of fractures ($P=0.398$).

As indicated in Table 3, cracks alone were not seen in any group. No significant difference was found between the groups in frequency of cracks and craze lines ($P>0.05$).

As shown in Table 4, coronal third was the most common site of fracture with a frequency of 7 cases (58.3%) in Meta resin cement group. Apical third had the lowest frequency of fractures with a frequency of 0 in Meta resin cement group. In Meta resin cement group, the fracture patterns in each tooth were exclusive to one area. In Panavia SA cement group, the diversity of fracture patterns was higher in different parts of the teeth. The maximum frequency of fractures was noted in the middle third with a frequency of 6 cases (50%) in Panavia, and in the apical third with a frequency of 3 (25%) in GI cement. Statistically, the difference in the frequency of root fractures was significant in the coronal third ($P=0.05$) but not in the middle or apical third ($P>0.05$). Nonetheless, a significant difference was noted between the cement groups regarding the site of fractures ($P<0.05$).

DISCUSSION

In this study, the mean force required for removal of intracanal posts cemented with Panavia SA, Meta, zinc phosphate and Meron GI cements was 278.6±34.9 N, 140.4±66.54 N, 221.9±28.88 N, and 161.3±60.7 N, respectively. The maximum retention was noted in Panavia SA group while the minimum retention was noted in Meta resin cement group. Zinc phosphate ranked second, and GI ranked third in this respect. Panavia SA is a new type of Panavia cement, which has easier application steps than other resin cements. According to the manufacturer, cementation of posts with this cement does not require etching and bonding of the tooth or post. Since this cement was recently introduced to the market, no similar study has evaluated its retention. Thus, we discuss studies conducted on Panavia F2 resin cement instead.

Several factors affect the retention of intracanal posts such as root canal preparation technique, adaptation of the post to the root canal walls, post design, post length, post diameter, type of cement, and surface properties of the post [26-29]. Cast posts and cores have maximum adaptation to the canal walls [30]. To date, studies on bond strength of different cements have not evaluated the fracture pattern of teeth after post removal [31]. However, knowledge about the integrity of the root after post removal is imperative for selection of an appropriate cement for cementation of intracanal posts. Previous studies created horizontal grooves on the roots to prevent their removal from the mount; however, these grooves could weaken the root structure [32]. In the current study, we custom designed a device to mount on universal testing machine to assess the pattern of root fracture after post removal, unlike previous studies. This instrument was designed according to the WAM X pliers, which have shown high success rate in removal of cast posts [25]. Also, we obtained results closer to the clinical setting by using this custom-made device. The numerical results of biomechanical parameters are absolute under such circumstances, and depend on the retention of intracanal posts. Previous studies evaluated the tensile strength of cements with teeth mounted in acrylic resin with no intermediate material. Thus, the tensile strength value was relative, not absolute, because part of the force would be spent on removing the tooth from the mount. Therefore, the obtained values were expected to be higher than the absolute retention of cements [33]. Studies that compared the retention of different cements applied tensile load to the posts after their cementation [31,32,34-36]. In the clinical setting, ultrasonic vibration is used for post removal before using the post removal instruments. Thus, in this study, the teeth underwent ultrasonic vibration after cementation of posts to further simulate the clinical setting. Considering the studies on the effect of ultrasonic vibration, ultrasonic energy should be used for 4 min [37,38]. Garrido et al. [38] measured the bond strength of Panavia F and zinc phosphate cements for luting of cast posts in three modes of using ultrasonic instrument along with water spray, using ultrasonic instrument without the water spray, and no use of ultrasonic instrument. They showed that Panavia F2 yielded higher retention than zinc phosphate cement.

Sabouhi et al. [31] compared resin cements, zinc phosphate, GC GI, and polycarboxylate in removal of cast posts. The mean retention of resin cements, zinc phosphate cement, and GI cement in their study was higher than our results. This difference was expected since ultrasonic instrument was used prior to post removal in the present study. Moreover, in the present study, the applied force was purely spent on post removal and there was no force loss at the interface of root and acrylic resin. Thus, lower mean force (retention) compared with previous studies was not far from expectation. The result of Sabouhi et al, [31] regarding higher retention of resin cement than zinc phosphate cement was in line with our findings. However, the retention of GI was higher than that of zinc phosphate and resin cement in their study, which was different from our result. Sahafi et al. [39] compared Panavia F2 and zinc phosphate cements with different film thicknesses. They used prefabricated zirconia posts in their study and reported higher retention of Panavia F2 than zinc phosphate, which was in line with our findings. Also, cements had higher retention in lower film thicknesses. Al-Omari and Zagibeh [40] compared Durelon zinc phosphate cement and Medicem GI cement for luting of nickel-titanium cast posts fabricated by the direct and indirect techniques. They also compared the retention of posts in use and no use of Lentulo. They reported higher retention of zinc phosphate cement compared with GI cement. Gavranovic et al. [35] compared the retention of cast posts cemented with zinc phosphate, Ketac-CEM GI, and hybrid RMGI, and reported higher retention of GI than zinc phosphate. This result was different from our finding, and can be due to the different cement types and in vitro design. Choudhary et al. [32] compared the retention of four different types of posts cemented with self-adhesive resin cement, and reported that cast posts had maximum retention (mean value of 434.51 N). Since Panavia SA is a self-adhesive cement, our results can be compared with those of Choudhary et al [32]. The mean retention value in our study was lower than theirs, which can be due to the use of ultrasonic vibration, and the use of custom-made device (which eliminated the effect of mounting on the results).

In this study, macroscopically visible catastrophic fracture did not occur in any tooth. Some teeth showed microscopic craze lines. Some others showed craze lines in addition to deeper cracks. The maximum frequency of cracks or craze lines in the roots was noted in the resin cement group while minimum value was recorded in zinc phosphate cement group.

A light microscope was also used to assess the extension of cracks and craze lines, and the involved areas. For better comparison, roots were hypothetically divided into three zones of coronal, middle, and apical thirds, and the extension of fracture patterns was evaluated in the three zones. In the majority of samples in the GI group, fractures were limited to one zone; but this zone was variable in different samples such that the fractures were in the coronal third in 16.7%, middle third in 16.7%, apical third in 8.3%, and all three zones in 16.7% of the samples. The fracture patterns in this group were more irregular and diverse than in other groups. In the Panavia SA group, the fracture patterns were more diverse along the roots such that in 41.7% of the teeth, fractures were noted in more than one zone. In this group, fractures mainly occurred in the coronal and middle thirds such that the fractures were in the coronal third in 50% and in the middle third in 50% of the teeth. The fractures had extended to the apical third in 16.7% of the teeth. Since no previous study has evaluated the pattern of root fracture following intracanal post removal, comparison of the results was not possible.

CONCLUSION

Considering the current results, in comparison with the available literature, it may be concluded that Panavia SA resin cement provides higher retention for intracanal posts compared with Meta resin cement and other commonly used cements. Cracks and craze lines were more common in roots in both resin cement groups after post removal. Despite higher retention, zinc phosphate cement group showed fewer cracks than GI group. Maximum fractures were noted in the coronal third in Meta resin cement group and in the middle third in Panavia SA group. Since defects in the coronal third can be repaired via crown lengthening surgery, teeth with such defects may be preserved. Also, according to the current results, WAM X pliers are suitable for intracanal post removal without damaging the root surface especially when conventional cements have been used. In use of resin cements, alternative techniques such as apicoectomy or dental implant may be considered for teeth that cannot undergo root canal retreatment.

CONFLICT OF INTEREST STATEMENT

None declared.

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