

RESEARCH AND EDUCATION

Effect of length of LOCATOR abutment and cement type on retention to intraradicular dentin in overdentures



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A complete removable overdenture (CRO) is a prosthesis that is supported by the residual alveolar ridge and the remaining teeth or oral implants.¹ Improved retention and stability can be provided with the use of attachments.²

Various attachments are available to provide retention between the abutment and a CRO. A common approach is the use of an intraradicular LOCATOR abutment (LOCATOR Root Attachment; Zest Anchors Inc), for which a supraradicular design is used and a LOCATOR abutment is cemented to the retentive insert. The retentive insert is composed of the abutment and its post, which is made of titanium with a titanium-

ABSTRACT

Statement of problem. Limited information is available on the effect of LOCATOR abutment length and luting cement type on retention to intraradicular dentin in overdentures.

Purpose. The purpose of this in vitro study was to evaluate the effect of the length of a commercially available LOCATOR abutment and cement type on retention in the root canal.

Material and methods. Eighty LOCATOR abutments with a standard length of 6 mm were obtained. Half of them were shortened to 3 mm. Eighty recently extracted single-rooted teeth were divided into 2 groups. The post space was prepared to 6 mm in the first group and 3 mm in the second. After preparation, the LOCATOR abutments were luted with one of the following cements: dual-polymerized glass-reinforced resin cement (Parapost Paracore), dual-polymerized resin cement (Variolink II), self-adhesive resin cement (RelyX Unicem), and conventional cement (zinc phosphate). The tensile force required for the removal of the LOCATOR abutments from their corresponding roots was recorded. Data were statistically analyzed with 2-way ANOVA and the Tukey multiple comparison test.

Results. Both the cement type ($P < .001$) and the length of the LOCATOR abutment ($P < .001$) significantly affected the mean tensile forces. Dual-polymerized glass-reinforced resin cement (Parapost Paracore) presented significantly higher mean tensile forces for the LOCATOR abutment retention among all cements ($P < .05$).

Conclusions. Regardless of the length, LOCATOR abutments luted with Parapost Paracore resin cement presented higher mean resistance to tensile forces compared with those luted with the other cements. LOCATOR abutments of 6 mm in length were more resistant to tensile forces than those of 3 mm in length in combination with all cements. (J Prosthet Dent 2019;122:152.e1-e6)

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Clinical Implications

The retention of LOCATOR abutments to root dentin in overdentures increased with the increase in their length from 3 to 6 mm with the cement types tested. Length did not affect the results with Parapost Paracore resin cement, which could be indicated for shorter LOCATOR abutments.

nitride coating. The LOCATOR abutment is cemented to the intraradicular dentin after root canal preparation with specially designed drills. The LOCATOR abutment is a cap with an interchangeable retentive component that engages with the retentive insert to stabilize and increase retention of the CRO under tensile forces. Clinically, the LOCATOR abutment is embedded in the CRO, while the retentive insert is attached to the tooth or implant,³ where the LOCATOR abutment length and design and the type of cement may affect its retention.⁴⁻⁸ Typically, longer LOCATOR abutments are more retentive and produce less stress on the intraradicular dentin.^{4,5,9,10}

Johnson and Sakumura⁵ measured the tensile forces required to remove endodontic posts from extracted maxillary lateral incisors and reported that retention increased by 30% when the post length increased from 7 to 11 mm. Similarly, Borer et al¹¹ studied the effect of post length on the retention of 2 different prefabricated posts and reported that posts with a length of 10 mm were significantly more retentive than those of 5 mm. In addition, the use of shorter posts may result in post loosening or root fracture.^{9,12,13} While Borer et al¹¹ reported that posts shorter than half of the root length would not lead to root fracture, Nissan et al¹⁴ suggested the use of reinforced composite resin cement to compensate for reduced post length. They also reported no significant differences between the mean retention force needed for the posts luted with Flexi-Flow composite resin cement for the 5-, 8-, and 10-mm post lengths used in their study.¹ Commercially available overdenture LOCATOR abutments are provided at a length of 6 mm, although it was reported by Pavlatos³ that these posts can be shortened to 3 mm. In some clinical situations, shorter LOCATOR abutments may be required because of unfavorable root anatomy or the need to preserve a 5-mm-apical gutta percha seal in the presence of bone loss. In that respect, the choice of cement can be critical.^{5-8,15,16}

Several types of luting agents, including zinc phosphate, glass ionomer, resin, and resin-modified glass ionomer cements, have been suggested for the cementation of posts.^{6,7,14,17-20} Although some studies reported similar or improved retention with traditional cements when compared with resin cements,^{19,20} others

reported contradictory results.^{6,14,17} Among conventional cements, the retention of cast posts-and-cores was significantly higher with zinc phosphate than with glass ionomer cement 24 hours after cementation.⁷

Although LOCATOR abutments for overdenture posts are provided at a length of 6 mm and although they can be shortened to as little as 3 mm,³ to the best of the authors' knowledge, no study has evaluated the effect of LOCATOR abutment length and cement type on their retention to intraradicular dentin. Therefore, the purpose of this study was to evaluate the effects of LOCATOR abutment lengths and cement types on their retention to the intraradicular dentin in overdentures. The null hypothesis tested was that length and cement parameters would not affect the retention of LOCATOR abutments.

MATERIAL AND METHODS

This study was approved by the Board Council and Research Center of the College of Dentistry, King Saud University (grant no. F1184). Eighty recently extracted human permanent single-rooted teeth were sectioned horizontally 1 mm incisal to the midfacial cemento-enamel junction with a straight fissure tungsten carbide bur (863GKEF; Komet) by using a high-speed handpiece under copious water coolant, leaving a flat coronal surface. The root canals were not endodontically treated.

The teeth were divided into 2 groups of 40 each. The retentive post space was prepared to a depth of either 3 or 6 mm. The post space was prepared initially with reamers (Peeso; Pulpdent Corp), then with the pilot drill provided by the manufacturer of the LOCATOR abutment (MODEL: #8924; Zest Anchor Inc), and finally with a countersink diamond rotary instrument (Zest Anchors Inc) mounted in a slow-speed handpiece under copious water coolant.

The roots of the teeth were roughened with an inverted cone tungsten carbide bur (#H2-012 Inverted Cone; Komet), and a hole was prepared 3 mm coronal to the apex by using a quarter round tungsten carbide bur (Komet). An orthodontic wire (Remanium spring hard wire; Dentaurem Inc) of 0.5-mm diameter was inserted into the hole and twisted to a length of 10 mm. The roots were then mounted in autopolymerizing acrylic resin (Ortho Resin; Dentsply Sirona) in a polyvinyl chloride cylinder. A dental surveyor (J.M. Ney Co) was used to position the roots parallel in the acrylic resin.

Eighty LOCATOR abutments (LOCATOR Root Attachment System; Zest Anchors Inc) of 6-mm length were obtained, and half of them were shortened to 3 mm with diamond disks (Chrome Cobalt cutoff disks; Jelenko Inc) in a slow-speed handpiece.

The LOCATOR abutments in each group were assigned to 4 subgroups (n=10) according to the cement type. Root canals were irrigated with 0.5% sodium

Table 1. Types, brands, manufacturers, and chemical compositions of luting cements used in this study

Material	Brand	Manufacturer	Chemical Composition
Dual-polymerized glass-reinforced composite resin	ParaPost Paracore	Parapost, Coltène	Bis-GMA, UDMA, trimethylolpropane trimethacrylate, TEGDMA, fluoride, barium glass, amorphous silica
Dual-polymerized composite resin	Variolink II	Ivoclar Vivadent AG	Paste A: Bis-GMA, UDMA, TEGDMA, barium glass, ytterbium trifluoride, initiator, stabilizer; paste B: Bis-GMA, UDMA, TEGDMA, barium glass, ytterbium trifluoride, Ba-Al-fluorosilicate glass, and spheroid mixed oxide, initiator, stabilizers
Dual-polymerized, self-adhesive composite resin	RelyX Unicem	3M ESPE	Powder: glass powder, silica, calcium hydroxide, substitute pyrimidine, peroxy compound, pigment, initiator; Liquid: methacrylated phosphoric ester, dimethacrylate, stabilizer, initiator
Zinc phosphate	Kleio	Lascod SpA	Powder: zinc oxide; liquid: buffered solution of phosphoric acid

Bis-GMA, bisphenol-A-diglycidylmethacrylate; TEGDMA, triethylene glycol dimethacrylate; UDMA, urethane dimethacrylate.

hypochlorite and saline and then dried with absorbent paper points (Sure-endo; Sure Dent Corp). After ensuring that the LOCATOR abutments fit passively when completely seated in their respective canals, they were luted with one of the 4 different luting agents (Table 1). For the dual-polymerized glass-reinforced resin composite cement, the root dentin was conditioned with the nonrinse conditioner (ParaBond Non-Rinse Conditioner; Coltène) for 30 seconds, and adhesive resin (ParaBond Adhesive A/B; Coltène) was applied for 30 seconds. The LOCATOR abutments were then cemented by using dual-polymerized glass-reinforced resin composite cement (ParaPost Paracore; Coltène), where the cement was applied directly from the tip of the syringe into the root. The LOCATOR abutments were also coated with the cement and then inserted into the canal with slight pressure by using the insertion key of the attachment kit (ZAAG Denture Cap Tool Kit, Zest Order #9201; Zest Anchors). Excess cement was removed, and the cement was photopolymerized (XL 2500; 3M ESPE) for 40 seconds.

For the dual-polymerized resin cement, the root dentin was acid etched with 37% phosphoric acid gel (Ivoclar Vivadent AG) for 15 seconds. The adhesive resin (Excite DSC; Ivoclar Vivadent AG) was applied to the canal with a microbrush, and excess adhesive was removed with paper points (Ultradent Products, Inc). The abutments were luted with dual-polymerized resin cement (Variolink II; Ivoclar Vivadent AG). The cement was mixed with a 1:1 ratio on a mixing pad for 10 seconds and applied to the root canal with a lentulo spiral (Lentulo Spiral 25/1; Dentsply Sirona). The abutments were then coated with the cement and inserted into the prepared intraradicular canal. Excess cement was removed and photopolymerized as described previously.

For the dual-polymerized self-adhesive resin cement, the LOCATOR abutments were luted by using a dual-polymerized self-adhesive resin cement (RelyX Unicem; 3M ESPE). The cement capsule was activated for 2 seconds and mixed in a high-speed triturator (RotoMix Capsule Dental Amalgamator; 3M ESPE) for 10 seconds. The LOCATOR abutments were coated with the cement,



Figure 1. Specimen in custom self-aligning testing assembly mounted in universal testing machine.

and the resin cement was applied to the intraradicular canal (Elongation Tip; 3M ESPE). Excess cement was removed and photopolymerized as described previously.

For the conventional cement, zinc phosphate cement (Kleio; Lascod SpA) was mixed on a thick, cold, glass slab. The powder was divided into multiple portions and introduced into the liquid in increments. The cement was introduced into the root canal with a lentulo spiral (Paste filler; Kerr Corp) rotating in a slow-speed handpiece. The abutments were coated with the cement and inserted into the prepared canal. The cement was allowed to set, and then, excess cement was removed.

The specimens were stored at 100% relative humidity at 37 °C for 24 hours before testing. Subsequently, each specimen was vertically secured in a universal testing machine (Model 8500 Plus Dynamic Testing System; Instron). A custom self-aligning testing assembly was used which included a U-shaped, stainless-steel rod with an opening at each end as well as a horizontal rod that

Table 2. Summary of 2-way ANOVA and Tukey tests of main factors (cement materials and different lengths) and their interaction for retention of LOCATOR abutments

Source	Sum of Squares	df	Mean Square	F	P
Cement	750548.371	3	250182.790	17.488	<.001
Length	581220.363	1	581220.363	40.627	<.001
Cementxlength	31497.429	3	10499.143	0.734	>.05
Error	1030057.150	72	14306.349		
Total	7802103.861	80			

df, degrees of freedom.

passed through a channel prepared through the lower part of the acrylic resin block and the openings of the U-shaped rod (Fig. 1). The hook of the lower part of the testing machine held the curved portion of the U-shaped rod, and the extended part of the cemented LOCATOR abutment was clamped by using a custom fixation attached to the upper part of the universal testing machine (Fig. 1). Tensile force was applied with a load cell of 5 kN at a crosshead speed of 0.5 mm/min. Each specimen was tested to failure, and the forces required for the dislodgment of the LOCATOR abutments were recorded in Newton (N).

Statistical analyses of the data were performed by using a 2-way ANOVA and the Tukey HSD post hoc test, where the tensile force was the dependent variable and the length (2 levels) and cement types (4 levels) were the independent variables (SPSS v16.0; SPSS Inc) ($\alpha=.05$ for all tests).

RESULTS

Both the cement type ($P<.001$) and the length of the LOCATOR abutment ($P<.001$) significantly affected the mean tensile forces (Table 2). Interaction terms were not significant ($P>.05$). Regardless of the LOCATOR abutment length, the use of Parapost Paracore cement for luting abutments to radicular dentin presented significantly higher results compared with those of other cements ($P<.001$), except for the 6-mm LOCATOR abutments luted with Variolink II ($P>.05$) (Table 3).

In the 3-mm groups, the Parapost Paracore resin cement showed significantly the highest retention compared with other dual-polymerized resin, self-adhesive resin, and zinc phosphate cement groups ($P<.05$) (Fig. 2).

DISCUSSION

This purpose of this in vitro study was to investigate the effect of 2 lengths and 4 cement types on the retention of abutments to intraradicular dentin in an overdenture. Since length and cement type significantly affected the mean retention values, the null hypothesis was rejected.

The root canals were not obturated with endodontic sealers to eliminate possible confounding factors.

Table 3. Mean force and standard deviations (SD) for retention of LOCATOR abutment in Newton (N)

Cement Type	LOCATOR Abutment Length	
	3 mm	6 mm
Parapost Paracore	314 ±116 ^{Aa}	510 ±107 ^{Ba}
Variolink II	156 ±95 ^{Ab}	353 ±187 ^{Bab}
RelyX Unicem	94 ±62 ^{Ab}	196 ±90 ^{Bb}
Zinc phosphate	134 ±93 ^{Ab}	321 ±155 ^{Bb}

Values are presented as mean ±SD. Similar uppercase letters in each row and similar lowercase letters in each column indicate statistically no significant difference ($\alpha=.05$).

However, such sealers could decrease post retention.^{18,21} Tensile force was used in this study to determine the values required to remove the abutments from the intraradicular canal in overdentures to replicate the type of force generated during denture removal. In addition, pull-out retention tests have been widely accepted and used in studies that have evaluated the retentive values of cemented endodontic posts.^{5-7,14,19-21}

The authors are unaware of recent studies addressing the effects of the length of abutments and cement types on their retention. Therefore, the most reasonable comparisons that can be made with previous studies relate to studies that investigated different endodontic metal posts. The results of the present study indicated that abutment length had a significant effect on retention. Abutments that were 6 mm in length exhibited higher retention values than those of 3 mm in length, regardless of the type of cement. This finding is consistent with those of previous studies of metal posts^{4,5,11} and also indicates that retention increases in proportion to length and surface area.

In the present study, the retentive forces of the 3 mm abutments can be compared with the results reported by Sahafi et al,²² in which they recorded 238 N for ParaPost resin cement and 180 N for zinc phosphate cement when 3-mm parallel titanium ParaPost XH posts were used. The reasons for the differences with the present study could be related to the surface treatment of the posts.²²

The mean force required to dislodge LOCATOR abutments luted with Parapost Paracore resin cement was significantly higher than forces associated with the other cements 24 hours after cementation. A possible reason for this finding is the optimal monoblock bonded interface between the abutment, cement, and dentin, resulting in a single cohesive mass.²³ Unlike traditional cements, adhesive resin cement systems may provide a micromechanical and chemical bond to the dentin and to the post itself.^{15,19,24} Parapost Paracore and Variolink II resin cements exhibited significantly higher retention than those cemented with the self-adhesive universal resin cement (RelyX Unicem). Also, abutments luted with zinc phosphate cement recorded significantly higher retention compared with those cemented with the self-adhesive universal resin cement. This result is not consistent with the findings reported by Balbosh et al,¹⁹

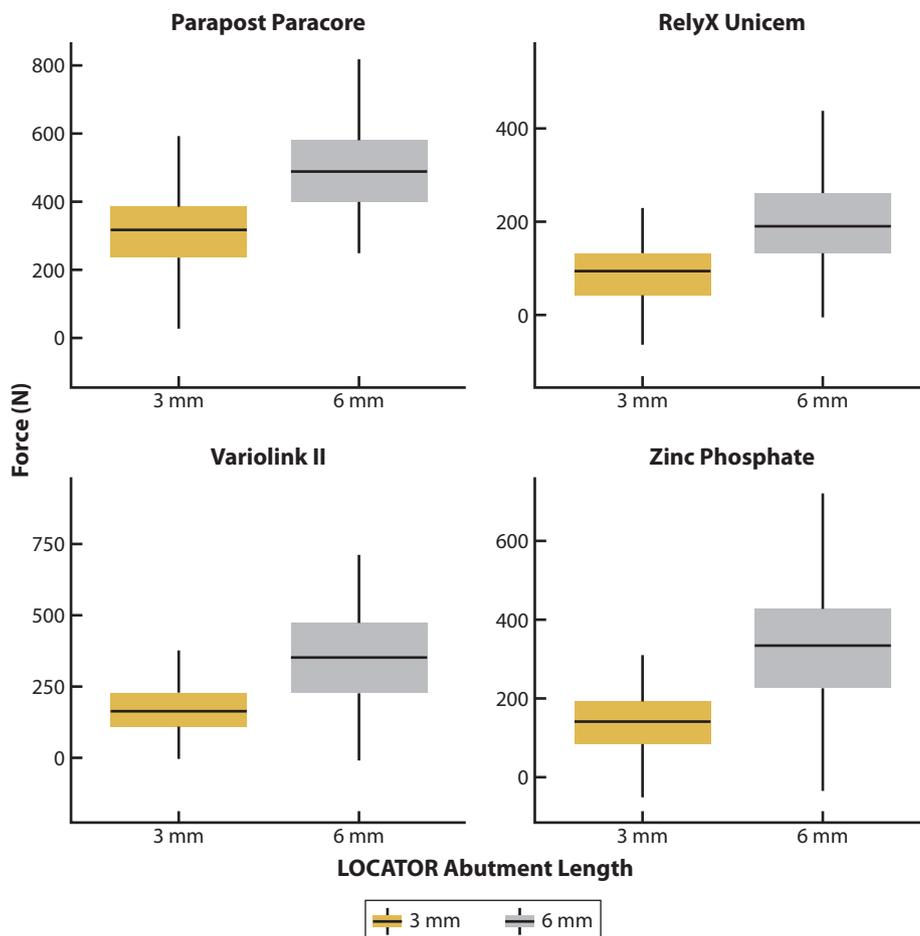


Figure 2. Boxplot with interquartile range and medians of retention results (N) of LOCATOR abutments in overdentures as function of length and cement type.

in which the retention recorded for titanium posts luted with the self-adhesive universal resin cement (RelyX Unicem) was not significantly different from the retention values obtained with zinc phosphate cement. However, when the intraradicular dentin was roughened with a diamond rotary instrument, retention values were statistically higher for the self-adhesive resin cement.¹⁹

In the present study, large standard deviations were recorded as reported in previous studies.^{6,7,21,22} The reason for this may be related to the complex physical and biological properties of intraradicular dentin. It has been suggested that abutments may be shortened up to 3 mm in length.³ The results of this study partly support this assumption, provided that the 3-mm abutments were luted with a strong adhesive resin cement. The results of the present study indicated that the retention of 3-mm abutments luted with Parapost Paracore resin cement was comparable with the retention of the 6-mm abutments luted with the other cements. Intraoral stresses from removable dentures are less than those from natural teeth.^{25,26} Furthermore, the type of force on the intraradicular attachments during denture removal is

primarily a tensile force along the long axis of the tooth, unlike forces associated with fixed prostheses luted to natural teeth. Intraoral forces on overdenture attachments are complex because the load acting on abutments can be much higher for shorter abutments, with occlusal forces producing a leverage that could lead to its loosening. Therefore, long-term clinical studies are recommended to determine the clinical performance of 3-mm LOCATOR abutments in overdentures.

Thermocycling and dynamic loading were not conducted in the present study, and therefore, the results represent early clinical failure. In vitro artificial aging could have altered the results. Also, endodontic treatment was not performed on the extracted teeth before luting the abutments, which is a limitation of this study. Future studies should include different ferrule designs and the use of endodontic sealer.

CONCLUSIONS

Based on the findings of this in vitro study, the following conclusions were drawn:

1. Abutments of 6 mm in length in overdentures were more resistant to tensile forces than those of 3 mm in length in combination with both resin-based and conventional cement types tested 24 hours after luting.
2. In the 3-mm groups, dual-polymerized Parapost Paracore resin cement showed significantly higher mean retention values compared with other dual-polymerized resin, self-adhesive resin, and zinc phosphate cement groups.
3. Mean retention values for abutments of 6 mm in length were similar when cemented with dual-polymerized resin cements (Parapost Paracore and Variolink II) and were significantly higher than for those luted with self-adhesive resin or zinc phosphate cement.

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