Comparison of Two Luting Agents Used for the Retention of Cast Dowel and Cores

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Purpose: **The first purpose of this study was to compare the retentive values of zinc phosphate and Panavia F resin cements when used for luting cast dowel and cores. The second purpose was to determine whether the use of a lubricant when making the resin pattern for a custom dowel and core would have an effect on the final retention of dowels cemented with either zinc phosphate or Panavia F cements.**

Methods and Materials: **Sixty-three caries-free extracted single-rooted human teeth were randomly divided into three groups of 21. Root canal preparations were standardized for all 63 teeth. Clinical protocols for fabricating and cementing dowel and core restorations were examined, comparing zinc phosphate and Panavia F resin cements. Direct dowel patterns were fabricated using the Para Post system and cast in a noble metal alloy. Group I dowel spaces were lubricated with GC lubricant prior to dowel pattern fabrication and cleaned with Cavidry solvent before cementing the cast dowel and core with zinc phosphate cement. Group II dowel spaces were rinsed with water only prior to dowel pattern fabrication. The dowels and cores in this group were cemented with Panavia F resin cement. Group III dowel spaces were lubricated with GC lubricant prior to dowel pattern fabrication; the dowel spaces were cleaned with Cavidry solvent before the cast dowel and cores were cemented with Panavia F cement. The tensile force necessary to remove the cast dowel and cores was determined using a universal testing machine. Results were statistically analyzed using one-way ANOVA and Tukey's HSD test.**

Results: **The dowels and cores in Group I had significantly higher retentive values than either of the two Panavia F groups ($p \leq 0.001$). No difference in retentive values ($p > 0.05$) was found between dowels luted with either of the lubricating agents in the Panavia F groups.**

Conclusions: **Zinc phosphate cement had higher retentive values when cementing cast dowel and cores than Panavia F. The type of lubricant used for the resin dowel fabrication (water or GC lubricant that was removed with a solvent) had no effect on the retention of cast dowels cemented with Panavia F.**

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WHEN THERE is inadequate coronal tooth structure to provide retention and resistance form for a full coverage restoration, a foundation restoration is often indicated. A cast dowel and core is usually the corono-radicular stabilizer of choice for single-rooted teeth and premolars.[1] One advantage to using custom cast dowel and cores is that the dowel and core are cast as one unit with the same material, thereby providing the best possible junction between the dowel and the core. Another advantage is that the dowel will fit a flared or irregularly shaped canal more intimately than a prefabricated dowel.[2]

The primary retentive elements of a cast dowel and core are its design and fabrication, providing an intimate fit between the dowel and canal walls. Consequently, the selection of a luting agent should be secondary to the design and fabrication of an accurately fitting cast dowel and core. According to the recommendations of the manufacturer of Panavia F (Kuraray Medical, Inc.,

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Okayama, Japan), cementation of prefabricated dowels and cast dowel and cores are both indications for the use of this resin cement. One might inquire why a resin cement is needed for luting a cast dowel and core when it has been shown that zinc phosphate cement is both clinically acceptable and remains a common standard for comparison.[3] One reason is that when short, excessively tapered, or irregular canals are present, retention of the dowel is more problematic and a stronger cement may be indicated.

Inconclusive and conflicting results have been reported relative to the retentive capability of cements and composites when cementing cast dowel and cores. Radke et al[4] found glass ionomer cement and zinc phosphate cement to have comparable retentive values whereas polycarboxylate and composite were less retentive. Interestingly, these authors did not use a multiple comparison test after finding a significant difference with the analysis of variance (ANOVA).

Leary et al[5] studied the bond strength of composite resins compared with zinc phosphate and glass ionomer cements when luting cast dowel and cores. Their ANOVA revealed no significant difference between the cements, but the authors concluded that the use of Gluma prior to the resin cement appeared to enhance the bond strength at the interface between the dowel and canal.

Gomes et al[6] studied the influence of ultrasound on the retrieval of cast dowel and cores cemented with zinc phosphate and resin cements. The study indicated that the use of ultrasonic vibration for 10 minutes on the cast dowel and cores cemented with zinc phosphate reduced the force necessary for their removal by 39%; however, no significant difference was found for posts luted with resin cement. Zinc phosphate and resin cement were compared without the application of the ultrasonic vibration, and no statistically significant difference was found between the forces required to dislodge the dowels.

Resinous cements have been studied extensively, and several investigations have evaluated the ability of adhesive resins to retain prefabricated dowels. Some studies have reported significantly greater retention for dowels cemented with adhesive resins,[7-13] whereas others have reported conflicting results.[14-16]

Fixed prosthodontics textbooks indicate the need for canal lubrication prior to cast dowel and core fabrication; however, they do not provide any specific instructions on how to remove excess lubricant from the dentinal surface.[17,18] Maryniuk et al[19] were the first to indicate the need for cleaning dentinal surfaces prior to the cementation of the cast dowel and core with zinc phosphate. This study indicated that residual lubricant greatly reduced the retention of cemented cast dowel and cores. The authors showed that cavity cleaner solvent removes the lubricant from a canal more effectively than water. The cavity cleaner solvent also increased the retention of custom dowel and cores to a value higher than that achieved if the canal space had never been lubricated, making this method the optimal condition under which zinc phosphate should be used. After lubrication, the prepared tooth surface becomes much smoother in appearance, and washing with water does not change the surface significantly as seen under scanning electron microscopy, indicating that the lubricant was not water soluble. The original rough surfaces were restored and some dentinal tubules were exposed, by swabbing the lubricated surface with a cavity cleaner. The active ingredients of the solvent Cavidry as indicated by the manufacturer are methyl ethyl ketone and ethyl acetate. Cavidry is used for rapid drying, degreasing, and cleaning. There is no research on the effect of residual lubricant in a canal on the retention of cast posts and cores luted with resin cements.

The purpose of this study was to compare the retentive values of custom cast dowel and cores cemented with Panavia F and zinc phosphate cements, and to evaluate the effect of canal space lubrication on the retentive strength of cast dowels cemented with these two cements.

Methods and Materials

Sixty-three single-rooted teeth were extracted and stored in saline solution and were transferred into 5.25% sodium hypochlorite solution 24 hours prior to preparation. The clinical crowns of the teeth were sectioned at the cemento-enamel junction (CEJ) perpendicular to the long axis of the root. All dowel spaces were prepared using the short Gates™ Glidden drill burs (Becker-Parkin Dental Supply Company, Inc., Plantation, FL) (28 mm) sizes 3 and 4 taken to the working length of 10 mm. The Para Post system (Whaledent, New York, NY) standardized the diameter of the post spaces. First the yellow Para Post drill (1.0 mm) was used, followed by the red (1.25 mm), and then the black drill (1.5 mm). Specimens were randomly distributed into three groups

of 21 samples each. The posts were cemented randomly into teeth from one of the three groups.

Para Post plastic burnout posts (Whaledent) corresponding to the size of the black drill were seated into the canal. Complete seating was verified by measurement in mm. Each black Para Post plastic burnout post was connected to a green plastic burnout post with Sticky Wax (Kerr Co., Romulus, MI) to provide a handle. After casting the post, the handle was gripped by the clamp of the Satec universal testing machine for testing retention.

The patterns were invested using Cera-Fina investment material (Whip Mix, Louisville, KY), with adjustments of 8.5 cc of distilled water and 6.0 cc of special liquid concentrate. The dowel patterns were cast using a Pd-Cu-Au alloy (PG200; Baker Dental Corp., Lake Zurich, IL). Cast dowels were checked under a 10× microscope to ensure passive fit. Cast dowels were microblasted with 50 μm aluminum oxide particles and steam cleaned.

Figure 1. Tooth root and dowel mounted in tensile testing apparatus.

Group I

After canal preparation, GC lubricant (GC America, Alsip, IL) was scrubbed inside the canal by wrapping cotton around a 30K endodontic file (Becker-Parkin Dental Supply Company, Inc.). Two days later, before the cast dowels were cemented, the canal walls were cleaned with Cavidry solvent (Parkell, Farmingdale, NY), applied with cotton wrapped around an endodontic file until no visible red lubricant was apparent. The canals were dried with paper points (Whaledent). Zinc phosphate (Shofu Dental Corp., Menlo Park, CA) cement was mixed according to manufacturer's recommendations and injected into the canal with a Jiffy tube (Teledyne Water Pik, Fort Collins, CO), then applied to the dowel, and the dowel seated. Each dowel was inserted and held in position with finger pressure until the cement set. After setting, excess cement was removed with an explorer.

Group II

The specimen canals in this group were lubricated with water and dried with absorbent points as in Group I. Recommendations of the manufacturer were carefully followed for mixing and applying Panavia F (Kuraray Medical, Inc., Okayama, Japan). The cast dowels were coated with Alloy Primer (Kuraray Medical, Inc.) and allowed to dry. Oxyguard II (Kuraray Medical, Inc.) was placed on the cement-tooth junction to aid the polymerization of the surface of the Panavia F following cementation. No canal cleaning solvent was used.

Group III

The specimens in this group were prepared the same as those in Group II, but the GC lubricant was used prior to fabrication of dowel patterns, and the canal was cleaned with Cavidry prior to cementing with Panavia F.

A Ney surveyor (J. M. Ney Co., Bloomfield, CT) was used to align the cast dowels parallel to the axis of travel of the Satec universal testing machine (Satec Material Testing Equipment, T series, Scottsdale, AZ). The apical end of each tooth was embedded in a block of polymethylmethacrylate (Jet acrylic, Lang Dental MFG. Co., Wheeling, IL); the acrylic block protected the tooth from fracturing during removal of the dowels.

A mounting jig was bolted to the Satec universal testing machine. A clamp arising from the mounting jig secured the tooth against the force applied by the Satec universal testing machine (Fig 1). The dowel alone was displaceable.

The Satec universal testing machine was calibrated prior to data collection. Vertical force was applied at a crosshead speed of 1 mm/min until the dowel-dentin seal was broken. The post/tooth junction was visually assessed until the cement seal was broken. Graphs of each sample confirmed coincidental cement bond failure with a certain peak. These tensile force readings were recorded, and the mean values and their standard deviations were calculated.

To test for the differences between the groups, a pilot study was conducted under the same conditions as the main study. Each of the three groups had five specimens that were not included in the main study's data. An ANOVA was performed. With an N of 21 specimens, power for the study was 0.80 at a probability level of 0.05 for a large effect size. For the final study, the data were analyzed with ANOVA and, where differences were found, these were identified with Tukey's Honest Significant Difference Test at $p \leq 0.05$.

Table 1. ANOVA Results for the Retention (kg) of the Two Cements in Three Test Groups

Cements	*Sum of Squares*	*df*	*Mean Square*	*F*	*p-Value*
Between groups	2525.2	2	1262.6	7.376	0.001
Within group	10,270.2	60	171.2		
Total	12,795.5	62			

Results

Table 1 shows the results of the ANOVA comparison for the three groups in the present study. Zinc phosphate with the lubricant and solvent had significantly higher retentive values (43.2 ± 13.1 kg) than Panavia alone (31.7 ± 12.6 kg) and Panavia with the lubricant and solvent (28.4 ± 13.5 kg). Significant differences were found when comparing Group 1 to the other two groups, with an $F = 7.376, p \leq 0.001$ (Table 2).

Upon visual inspection of the retrieved dowels, it was apparent for Groups II and III that the dowels were completely covered with resin. The serrations could not be identified. With these two groups, the resin cement was firmly attached to the cast dowels instead of the root canal and dentinal surfaces. In contrast, the serrations on the dowels in Group I were easily identified because the cement film was retained within the dowel space and between the dowel serrations.

Discussion

For the luting agent to function as an adjunct rather than the primary element of retention there should be an optimum fit between the dowel and core and the residual tooth. To reduce extraneous sources of error to a minimum, time and effort were taken to ensure a consistent method of investing and casting such that maximal casting accuracy was assured. Nevertheless, casting always introduces some variability, and variations in fit occurred within this project, as reflected by the retention values recorded here.

No complications were observed when cementing the cast dowels; it is conceivable that voids developed if air was trapped in the canal. The operator in the present study oscillated the posts during placement. This allowed for any air to escape. Panavia F recommends that cement be placed only on the post and not into the canal. The tooth surface is primed with ED Primer and this will accelerate the set of Panavia F, hampering full seating. By viewing the samples it is evident that there were no voids due to the post being encased in cement. This would hint to the bond breaking at the cement-dentin level. With zinc phosphate the failure was within the cement layer.

Radke's[4] values of failure of cemented posts are zinc phosphate ($x = 16.03, SD = 2.12$) and composite resin (Den Mat) ($x = 8.5, SD = 7.35$). Leary's[5] values of failure of cemented posts are zinc phosphate ($x = 10.92, SD = 2.84$) and Comspan and Gluma ($x = 13.35, SD = 2.84$). Both studies obtained much lower values for mean bond strength than the current study.

Parallel-sided posts that have serrations were proven to have the greater retention. One reason for a decreased retentive value in Leary's study may be due to the use of smooth-surfaced posts, in which tapered posts were fabricated using a wax pattern impression technique.

Table 2. Tukey's HSD Test for the Retentive Values (kg) of Two Cements in Three Test Groups

Cements	*N*	*Mean**	*Standard Deviation*	*F*	*p-Value*
Zinc phosphate +Lubricant +Solvent	21	43.2[a]	13.1	7.376	0.001
Panavia F	21	31.7[b]	12.6		
Panavia F +Lubricant +Solvent	21	28.4[b]	13.5		

*Mean values with the same superscript letter indicate no significant difference.

Longer posts have been proven to have a higher retentive value. In Radke's study, posts that were 8 mm in length were used. These posts were 2 mm shorter than the posts used in the current study.

The current study did not store the cemented posts in a 100% humid environment for at least 24 hours. It was assumed that since a crown will be seated over the cemented post, the postdentin margin would not be subjected to the humid environment of the oral cavity.

The standard deviations were comparable for all three groups of specimens and were of the same order of magnitude common to other retention/adhesion studies. This was to be expected since one operator handled all specimens, and all materials were used in accordance with the manufacturers' recommendations. Since all aspects of the cast dowel and core system are equal within each sample, the predominant mode of retention should come from the luting agent.

The data reported here indicate that the retention achieved with zinc phosphate is greater ($p < 0.001$) than that achieved with Panavia F regardless of the technique used. Additional procedures have been suggested to augment the retention of resin cement. Etching dentin prior to the cementing process may provide added retention by removing the smear layer. If a hybrid layer is needed for optimal cement-dentin bonding to occur, it is possible that adequate preparation of the dentin within the canal space was not achieved prior to bonding. The manufacturers of Panavia F recommend etching enamel but not dentin.

In an effort to study ways to increase post retention, researchers examined the internal dentin surface of prepared canals. By examining selected endodontically treated teeth with scanning electron microscopy, they were able to detect a smear layer, presumably the result of the canal preparation process.[20] Smear layer removal in dentinal bonding is an ongoing debate. The smear layer covers the open dentinal tubules and does not allow penetration of the resin into these tubules. Each luting agent has a unique chemical makeup. Efforts have focused on the removal of the smear layer with 17% ethylene diamine tetracetic acid (EDTA) and 5.25% sodium chloride (NaCl), and comparison of zinc phosphate cement, polycarboxylate cement, and unfilled resin cement for cementation efficiency. Results indicated that removal of the smear layer and use of unfilled resin cement were significantly more retentive than zinc phosphate cement without smear layer removal.[21]

Scotchbond® (3M Company, St. Paul, MN) has been shown to increase the retention of Dentatus® (Dentatus, Stockholm, Sweden) screwposts cemented with composite resin. The manufacturer of Scotchbond Dental Adhesive recommends that the smear layer remain undisturbed. It seems that there is a polar interaction between the negative charge of the phosphate group in the Scotchbond and the positive charge of the calcium in the smear layer and in the dentin.[10]

Application of a proprietary lubricant during some stage of the fabrication process may ultimately lead to a less retentive restoration. If a nonwater-based lubricant is not used, the lubricant should be thoroughly cleaned with a solvent.[22] Clinically, a lubricant may not be required in fabricating a direct cast dowel and core pattern. It is the opinion of the authors that water-based lubricants or water itself can provide the same lubricating action to protect against resin-dentin bonding. Because no acrylic resin went into the dowel space, a future study might evaluate if water alone will prevent resin-dentin adhesion.

Although clinical failure of dowels and cores occurs, the mechanism of failure is unclear. It has been suggested that since dowel and core restorations are subjected to repeated tension, compression, and torquing forces, dislodgement occurs when the cement fatigues and the bond to dentin or to the dowel is lost. The present study used a tensile test, in effect, applying a shear force to the interface between dowel and cement or cement and dentinal surface. While the applied forces do not directly reflect intraoral dislodging forces, it was felt that the study would provide a relative comparison of the retentive properties of the cements.[15]

The long clinical track record of zinc phosphate cement is of utmost importance. It is debatable whether retention should be provided solely by a composite resin. Fabrication of custom dowel and core foundations is an art form that must be maintained and not compromised because of some "miracle" cement. Furthermore, the clinical use of zinc phosphate appears to provide a simpler and faster cementation approach than required for Panavia F. Not only is the actual cement cheaper, but the materials for each step needed to apply Panavia F increase the cost.

Conclusions

Within the limitations of this study,

1. cast dowel and cores cemented with zinc phosphate cement had higher retentive values than cast dowel and cores cemented with Panavia F;
2. no significant difference was found between the retentive values achieved when the canals were lubricated with water then dried, and those which had a proprietary lubricant applied then removed with a solvent.

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