Original Article

Final Retention of Recemented Dental Casting Luted with Different Resin Cements

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Abstract

Background and Aim: Dislodgment of prosthetic crowns is a common occurrence. In such cases, recementation is a suitable treatment option. The aim of this study was to compare the retention in cementation and recementation using different resin cements.

Materials and Methods: In this in vitro, experimental study, 40 premolars were selected (n=10). They were standardized relative to some properties and then the wax patterns were prepared and cast. After 24 h, all specimens were decemented using Instron universal testing machine. The castings were then re-cemented and stored under the same conditions. After 24 h, the cemented copings were dislodged, and the separation load was recorded.

Results: The highest and the lowest mean retention values belonged to Panavia F2 and Maxcem cements in both initial cementation and recementation groups, respectively. Paired sample t-test showed a significant difference in the retention of G-CEM group between initial cementation and recementation (P=0.009). The two-factorial repeated measures ANOVA showed the significant effect of cement type on retention (P=0.009), and there was a significant difference in retention between initial cementation and recementation (P=0.006). The Tukey's HSD test revealed a significant difference in retentive strength between the Maxcem and Panavia F2 (P=0.011). The lowest mean difference was observed between Bifix SE and Maxcem groups (-16.75 kgf, P=0.89).

Conclusion: The maximum and minimum mean retention values belonged to Panavia F2 cement and Maxcem in both initial cementation and recementation groups, respectively. There was a significant difference between the initial cementation and recementation in G-CEM group.

Key Words: Cementation, Dental Cements, Resin cements, Dental Prosthesis Retention, Tensile Strength

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Introduction

Recently, improvements in cement properties such as strength, wear resistance, marginal integrity, and esthetics have increased the use of indirect restorations (1). The main factors determining the retention and resistance of indirect crowns include (a) total occlusal convergence, (b) surface area and height, (c) surface finish or roughness, (d) intracoronal auxiliary features of preparation, (e) relative adaptation of the restoration to the abutment, (f) texture of the internal surface of the casting, (g) splinting of multiple units, (h) strength properties of the cast metal super-structure, (i) type of cement, (j) use of venting or internal casting relief, (k) variations in cement viscosity, and variations in the seating forces (1,2).

Part of the clinical success of indirect restorations is related to the type of cement that is used for retention. For many years, cements have to endure functional and parafunctional forces in the humid environment of the oral cavity. They must retain their integrity and withstand stresses applied from the crown to the tooth (3). In fact, the stresses associated with chewing that are applied on the cements are greater than those applied to the tooth structure (4). For instance, some in vitro experiments have shown high stress levels applied to the cement, especially at the finish line (5,6). Also, studies have reported that microfractures are the primary cause of restoration failure or tooth fracture (7,8). Local stress concentration probably occurs at the site of failure (7,8). Other factors that may result in cement failure include premature occlusal contacts, saliva or blood contamination during cementation, microleakage, or failure of cement to adhere to the crown as it adheres to the tooth structure (9,10).

The available cements are classified into five main classes as follows: zinc phosphate cements, polycarboxylate cements, glass-ionomer cements, resin-modified glass-ionomer cements, and composite resin cements (11). Resin cements were introduced to overcome the weaknesses of the conventional cements with benefits such as optimal esthetics, favorable mechanical properties, dimensional stability, micromechanical adhesion, minimal solubility, and optimal biocompatibility (9,12). Resin cements can provide a strong bond between the tooth structure and restorative materials (1). Resin cements have greater marginal integrity than glass-ionomer cements. Resin cements are applied for restorations under high level of stress such as the Maryland bridge because they can withstand plastic deformation and dislodgment (10).

Most resin cements are subdivided into three subgroups depending on the tooth preparation process including etch-and rinse adhesives, self-etching primers, and self-adhesive systems. The dominant mechanism in the setting process is mediated by free radicals that are activated either by light or a self-curing mechanism (11). Due to the presence of resin in the structure of these cements, shrinkage during polymerization is inevitable. This process can induce some stress in the cement layer but the magnitude is still unclear (13,14).

Considering all the above, dislodgment of crown may commonly occur. In such cases, recementation is a suitable treatment option. Thus, the aim of this study was to compare the retention in cementation and recementation in use of different resin cements.

Materials and Methods

Study samples:

The Isfahan Regional Bioethics Committee granted ethical approval for this in vitro study (288079). The initial sample consisted of 40 extracted caries-free and crack-free, non-restored human maxillary first premolars with similar length and size. samples were excluded from the study if they had cracks, caries, previous restorations, or filled canals. The specimens were stored in 0.2% thymol at room temperature for 2 days and subsequently in distilled water at 4°C for up to 1 week before tooth preparation.

Tooth preparation:

The teeth were vertically mounted in self-cure acrylic resin (Meliodent, Heraeus Kulzer, Hanau, Germany) up to 2 mm below their cementoenamel junction while shallow notches were prepared on their external root surfaces to enhance their retention in the acrylic resin. Each tooth was aligned vertically by using a dental surveyor (Degussa-Ney, Yucaipa, CA, USA). They were then stored in 100% relative humidity.

The teeth were prepared according to Felton et al (15). It was started by vertically reducing the occlusal surface to the depth of the central groove to expose superficial dentin surface parallel to the occlusal surface. All remaining enamel was removed. The occlusal surfaces of the teeth were examined under a stereomicroscope (SMZ-1; Nikon Inc., Garden City, NY, USA) at ×19 magnification.

The preparation of axial wall was performed by using a chamfer diamond bur (Henry Schein Rexodent, Southall, UK) and high-speed hand piece (KaVo America, Lake Zurich, IL, USA) with water spray mounted on a milling machine (a surveyor with an aluminum jig). The table of the surveyor was moved relative to the fixed handpiece to obtain 1 mm chamfer margin around the entire circumference and control the taper. Furthermore, the tooth surfaces had the same roughness, because of using the same bur for preparation.

For each tooth, the occlusal surface was reduced parallel to the horizontal plane with axial length of 4 mm, 1 mm chamfer margin, and total axial taper of 20°. The sufficiency of preparation was evaluated by adapting foil strips (4 mm) to all tooth surfaces. Next, the weight of foil strips for each sample was compared with the mean weight of the reference foil strips (15).

Impressions were then made with polyvinyl siloxane (Panasil; Kettenbach GmbH & Co KG, Eschenburg, Germany) using the putty wash technique in prefabricated trays. In the initial step, separating foils (Plicafol, GS Folienfertigung, Lebach, Germany) were applied on the external tooth surfaces, and the preliminary impression was made by putty material.

After the setting time, the foil was detached and then the next phase of impression was made with low-viscosity material and poured with type IV dental stone (GC Fujirock EP, GC Corp, Leuven, Belgium) (16).

The wax patterns were prepared with a flat occlusal surface and 0.5 mm thickness using type I blue inlay wax (Kerr/Sybron, Orange, CA, USA). A ring-like wax attachment was added to the occlusal portion of the patterns for tensile strength testing after cementation as described by Tjan and Li (17).

Casting the crowns and cementation:

The patterns were invested with gypsum-bonded investment (Rema-Exakt; Dentaurum, Ispringen, Germany) and were cast with Ni-Cr-Be alloy (Rexillium III, Pentron, Wallingford, CT, USA). Investing and casting were performed by pilot testing to ensure accurate seating of crowns with minimal force on the stone dies and tooth preparations.

The accuracy of copings was assessed by using wash impression material (Fit Checker, GC Co., Tokyo, Japan). The internal surface of each casting was inspected using a stereomicroscope, and minute nodules were removed with a half-round bur in a slow-speed straight handpiece. The samples were excluded from the study if they did not have good adaptation or had large nodules.

Then, the inner surfaces of the copings were air-abraded with 50 μm alumina particles (Rocatec Pre; 3M ESPE, MN, USA) at 60 psi pressure for 15 s, with 3 cm distance, and were ultrasonically cleaned (Tecna3; Technogaz, Parma, Italy) in deionized water for 10 min. The samples were then randomly divided into four groups, each containing 10 copings according to the cement type:

Group 1: copings luted with Panavia-F2 cement (Kuraray, Osaka, Japan)

Group 2: copings luted with Maxcem cement (Kerr, Orange, CA, USA)

Group 3: copings luted with G-CEM cement (GC America, Alsip, IL, USA)

Group 4: copings luted with Bifix SE (Voco GmbH, Cuxhaven, Germany)

Before the cementation process, the castings and the teeth were gently air-dried using oil-free air spray. Cements were prepared and applied according to the manufactures' instructions.

Each casting was cemented with a seating force of 25 N measured by a force gauge (Chatillon model DPP; Ametek US Gauge Division, Largo, Fla) through a wood stick (100 mm length × 8 mm diameter) placed horizontally on the occlusal surface of the crown, and the force was maintained for 10 min.

Excess cements were removed, and the cemented copings were stored for 24 h in 100% humidity before dislodgment (14).

Measuring the crown retention:
After 24 h, all samples were decemented using a universal testing machine (Instron Ltd., High Wycombe, UK). Load was applied along the axis of draw of each prepared tooth with a crosshead speed of 1 mm/min.
The cement remnants were removed with a spoon excavator. After initial removal of the deposits, the teeth were cleaned in an ultrasonic cleaner containing sodium bicarbonate and water for 30 min. Then, the prepared surfaces were polished with pumice for 30 s, washed, and dried as recommended by Felton et al (15).
The castings were ultrasonically cleaned with cement remover solution (BioSonic® Cement Remover, Colten) and air abraded with 50 µm aluminum oxide powder.
The castings were then re-cemented and stored under the same conditions. After 24 h, the cemented copings were dislodged as mentioned above, and the separation load was recorded.
The data were analyzed with paired sample t-test, two-way repeated measures ANOVA, and the post-hoc Tukey's test using SPSS version 22.0 software (α=0.05) (14).

Results
Table 1 presents the mean and standard deviation of crown retention in initial cementation and recementation in different groups. The highest mean retention value pertained to the Panavia F2 cement in both initial cementation and recementation groups (242.30 N and 183.00 N, respectively). The Maxcem cement showed the lowest mean retention value among both initial cementation and recementation groups (148.90 N and 118.8 N, respectively).
In order to assess the retention in each group, the paired sample t-test was used. As shown in Table 1, there was a significant difference between the initial cementation and recementation values in G-CEM group (P=0.009).
Pairwise comparisons of the experimental groups by two-way repeated measures ANOVA showed the significant effect of cement type (P=0.009) on retention, and there was a significant difference in retention between initial cementation and recementation (P=0.006).
Table 2 presents the results of comparison of the mean retention of all 40 specimens for each cement. The Tukey's HSD test revealed significant differences in retentive strength between the Maxcem and Panavia F2 (P=0.011). Maxcem and Panavia F2 had the highest mean difference of retentive strength (-78.8 kgf, P=0.011). The lowest mean difference of retentive strength was observed between Bifix SE and Maxcem groups (-16.75 kgf, P=0.89).

Discussion
The aim of this study was to compare the retention in cementation and recementation between different resin cements. Studies have shown that one of the causes of failure of fixed prosthetic treatments is the lack of proper retention that may be influenced by the degree of taper (18), surface area of the preparations (19), internal surface roughness of the castings (20), auxiliary grooves (21), tooth surface preparation (22), and type of cement used (1). The clinical success of an indirect restorative procedure depends on the cementation technique employed to create a bond between the restoration and the tooth. In our study, all samples were standardized in terms of taper, axial wall length, surface area, and finish line to compare the retention in cementation and recementation using different resin cements as a single variable factor.
Our results showed a significant difference in the retention of initial cementation and recementation in G-CEM group that can be related to its composition. G-CEM powder is composed of fluoroaluminosilicate glass, and the liquid contains phosphate monomer that have the ability of bonding to tooth structure due to the presence of linked acidic functional groups capable of chelation with the calcium in hydroxyapatite. Therefore, its adhesion to tooth structure can be described as a combination of chemical and micromechanical adhesion. It is possible that all cements could not be eliminated from the tooth surface because of the chemical adhesion, and the cement remnants could have interfered with the

Table 1. Mean and standard deviation of retentive strength (Kgf) of metal crowns in initial cementation and recementation in use of different cements

Group	Retention in cementation (Mean± SD)	Retention in recementation (Mean± SD)	P value
Bifix SE	168.30 ± 56.00	132.90 ± 76.45	0.349
Maxcem	148.9 ± 50.82	118.80 ± 60.98	0.302
Panavia F2	242.30 ± 113.86	183.00 ± 97.94	0.272
G-CEM	232.90 ± 98.67	141.00 ± 43.92	0.009

SD: Standard deviation

Table 2. Pairwise comparisons (Tukey's HSD test)

Groups		Mean± SD	P value
Bifix SE	Maxcem	16.75 ± 23.75	0.89
	Panavia F2	-62.05 ± 23.75	0.06
	G-CEM	-36.35 ± 23.75	0.43
Maxcem	Panavia F2	-78.80 ± 23.75	0.01
	G-CEM	-53.1 ± 23.75	0.13
Panavia F2	G-CEM	25.70 ± 23.75	0.70

SD: Standard deviation

retention in recementation. However, its chemical adhesion depends on the presence of sufficient calcium in the superficial layer of the tooth which has been consumed in the previous step to establish the initial connection. Thus, G-CEM may not be suitable for recementation.

Self-adhesive cements are dual-cure hybrid materials that have acidic monomers to demineralize the tooth substrate; moreover, they have resin in their structure that causes volumetric shrinkage. Therefore, stress is created at the interface (13). Frassetto et al. (23) showed that the curing time was a significant factor for polymerization and shrinkage stress development in self-adhesive resin cements. Moreover, the self-adhesive cements showed lower stress values than the conventional dual-cure cement. Thus, the amount of stress in these materials depends on their composition and filler content because these factors affect the degree of conversion and cross-linking density of the cements (24).

In other cements, bond strength in recementation was lower than initial cementation but there was not a statistically significant reduction in retention in all of them. This finding is consistent with the results of Felton et al (15). It is assumed that this reduction is related to mild burnishing of the surface morphology of the teeth that occurs when the crowns are removed.

The results of this study exhibited that the highest mean retention value pertained to Panavia F2 cement in both initial cementation and recementation (242.30 and 183.00 N). Maxcem cement showed the lowest mean retention value in both initial cementation and recementation.

These results could be related to the difference in their acid-functionalized monomers;

Panavia-F2.0 has 10MDP and Maxcem has 4MET as acid-functionalized monomers. The cement structure might determine the quality and insolubility of the salt formed with tooth calcium. The salt made by MDP with tooth calcium is more insoluble than the salt made by 4-MET and phenyl-P (25,26). Nakamura et al. (27) stated that 10-MDP is insoluble in water because of its long carbonyl chain.

It is noteworthy to claim that the bond strength of the cements is affected by their acidity. The pH value of Panavia-F2.0 is more than 2 (pH of 2.4) but the pH value of Maxcem is about 2 (according to the manufacturers' information) that can lead to excessive roughening of the dentin, and may result in incomplete resin infiltration and poor adhesion. Moreover, presence of acidic monomers in self-adhesive cements could affect the amount of resin polymerization because they have negative effect on activation of amines as initiators. Evidence shows that presence of acidic monomers adjacent to dimethacrylates could decrease the rate and extent of polymerization; this can be explained by the fact that acidic monomers can have inhibitory effects on free radicals (28,29). Han et al. (12) claimed that the pH values of their samples were lower than 4 at initial minutes after mixing, and such early acidic conditions are essential for demineralization. However, the acidic condition continued for up to 48 h in G-CEM, Maxcem, and SCEM and might have an adverse effect on their polymerization. Similar results were reported by Shafiei et al, (30) who reported that among the acidic monomers, MDP produces greater bond strength. It seems the MDP present in Panavia-F2.0 is responsible for high bond strength to base metal alloys because it can chemically adhere to metal oxides made by superficial layer of nickel chromium, and cobalt chromium, by means of covalent bonds. It can therefore be assumed that the use of Panavia-F2.0 can result in successful outcomes.

Conclusion

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

1. The maximum retention value pertained to Panavia-F2 cement in both initial cementation and recementation.
2. Maxcem cement showed the lowest mean retention value in both initial cementation and recementation.

There was a significant difference in retention between the initial cementation and recementation in G-CEM group.

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