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Comparative Evaluation of Retention of Different Luting Cements for Implant-Supported Crowns: An In Vitro Study

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ABSTRACT

Background: Retention of implant-supported crowns is a critical factor influencing the long-term success of implant prostheses. The choice of luting cement plays an important role in determining the retentive strength, retrievability, and clinical performance of cement-retained implant restorations.
Aim: To comparatively evaluate the retention of implant-supported crowns cemented with zinc phosphate cement, resin cement, and resin-modified glass ionomer cement using a universal testing machine in an in vitro setting.
Materials and Methods: Thirty implant–abutment–crown assemblies were fabricated and divided into three groups (n = 10) based on the luting cement used: Group I—zinc phosphate cement, Group II—resin cement, and Group III—resin-modified glass ionomer cement. Standardized full-coverage metal crowns were cemented onto prefabricated titanium abutments following manufacturer instructions. All specimens were stored in distilled water at 37°C for 24 hours. Retention was evaluated by applying a tensile load along the long axis of the implant using a universal testing machine at a crosshead speed of 1 mm/min until crown dislodgement occurred. The maximum pull-out force required was recorded in Newtons and statistically analyzed.
Results: The highest mean retentive strength was observed in the resin cement group, followed by resin-modified glass ionomer cement, while zinc phosphate cement demonstrated the lowest retention. Statistical analysis revealed a significant difference in pull-out force values among the three groups ($p < 0.05$).
Conclusion: Within the limitations of this in vitro study, resin cement provided superior retention for implant-supported crowns compared to resin-modified glass ionomer cement and zinc phosphate cement. Selection of luting cement should consider the balance between retention requirements and the need for retrievability in implant prosthodontics.

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Introduction: Dental implants have become a predictable and widely accepted treatment option for the replacement of missing teeth. Implant-supported prostheses offer improved function, esthetics, and patient satisfaction when compared with conventional fixed and removable prosthodontic restorations. Among implant prosthetic designs, cement-retained implant-supported crowns are commonly preferred due to their simplified clinical procedures, improved esthetics, and passive fit.[1,2]

Retention of cement-retained implant crowns is a critical factor affecting the longevity and clinical success of implant restorations. Adequate retention ensures resistance to functional dislodging forces while maintaining prosthesis stability during mastication. However, excessive retention may compromise retrievability, which is often required for management of biological or mechanical complications such as peri-implant disease, screw loosening, or component fracture. Therefore, selection of an appropriate luting cement is essential to achieve an optimal balance between retention and retrievability.[3,4]

Various luting cements have been advocated for cementation of implant-supported crowns, including zinc phosphate cement, resin-modified glass ionomer cement, and resin cement. Zinc phosphate cement has been traditionally used in fixed prosthodontics due to its ease of manipulation and predictable clinical performance, although it provides limited retention. Resin-modified glass ionomer cement offers improved mechanical properties and fluoride release, while resin cement is known for its superior bonding strength and enhanced retention. Despite their widespread use, there is no universal consensus regarding the ideal luting agent for implant-supported restorations.[5-7]

Previous studies have reported variable retentive strengths among different luting cements, which may be influenced by factors such as abutment geometry, surface characteristics, cement thickness, and testing conditions. Due to these variations, comparative evaluation under standardized conditions is necessary to better understand the retentive behavior of commonly used luting agents for implant-supported crowns.

Therefore, the present in vitro study was undertaken to comparatively evaluate the retention of implant-supported crowns cemented with zinc phosphate cement, resin cement, and resin-modified glass ionomer cement by measuring the pull-out force using a universal testing machine.

Materials and Methods

Study Design: The present study was designed as an in vitro comparative study to evaluate the retention of implant-supported crowns cemented with different luting cements.

Sample Size and Grouping: A total of 30 implant–abutment–crown assemblies were fabricated and randomly divided into three groups (n = 10 per group) based on the type of luting cement used:

Group I: Zinc phosphate cement (Harvard, Germany)

Group II: Resin cement (G-CEM LinkAce™ – GC Corporation)

Group III: Resin-modified glass ionomer cement (RMGIC) (Fuji PLUS™ – GC Corporation)

Implant and Abutment Preparation: Commercially available endosseous dental implants (diameter: 4.0 mm, length: 10 mm) with compatible prefabricated titanium abutments (abutment height: 5 mm) were used. Each implant was embedded vertically in a self-cure acrylic resin block using a dental surveyor to ensure proper alignment and standardization of the long axis.

Crown Fabrication: Standardized full-coverage metal crowns were fabricated for each abutment using the lost-wax technique. A uniform cement space of approximately **30–40 µm** was provided using die spacer. A metal loop was incorporated on the occlusal surface of each crown to facilitate pull-out testing. All crowns were finished and polished before cementation.

Surface Treatment: Prior to cementation, the abutments were cleaned with alcohol and air-dried. The intaglio surfaces of the crowns were airborne-particle abraded using 50 µm aluminum oxide particles at 2 bar pressure, cleaned ultrasonically in distilled water for 5 minutes, and air-dried.

Cementation Procedure: Each group was cemented using the assigned luting cement according to the manufacturer's instructions. Cement was applied uniformly to the internal surface of the crown, and the crown was seated onto the abutment under a constant static load of 5 kg for 5 minutes using a customized loading device. Excess cement was removed immediately after initial setting.

Storage of Specimens: After cementation, all specimens were stored in distilled water at 37°C for 24 hours to simulate oral conditions prior to mechanical testing.

Retention Testing: Retention was evaluated using a Universal Testing Machine (UTM). Each specimen was secured in the lower jig, and a tensile load was applied along the long axis of the implant by engaging the occlusal loop of the crown. The load was applied at a crosshead speed of 1 mm/min until dislodgement of the crown occurred. The maximum pull-out force (in Newtons) was recorded for each specimen.

Statistical Analysis: The collected data were tabulated and analyzed using statistical software (SPSS version 23). Descriptive statistics including mean and standard deviation were calculated for each group. Intergroup comparison was performed using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test. The level of statistical significance was set at $p < 0.05$.

Result: The retentive strength of implant-supported crowns cemented with three different luting cements was evaluated by measuring the pull-out force using a universal testing machine. The mean pull-out force values and standard deviations for each group are presented in Table 1. Group II (resin cement) demonstrated the highest mean retentive strength, followed by Group III (resin-modified glass ionomer cement), while Group I (zinc phosphate cement) showed the lowest mean retention values. The mean pull-out force recorded was 482.6 ± 45.3 N for the resin cement group, 312.4 ± 38.7 N for the resin-modified glass ionomer cement group, and 186.9 ± 29.5 N for the zinc phosphate cement group **(Table 1)**. A significantly higher mean pull-out force was observed in Group II (resin cement) when compared with Group I (zinc phosphate cement) and Group III (resin-modified glass ionomer cement) ($p < 0.001$). Additionally, Group III (resin-modified glass ionomer cement) demonstrated significantly greater retention than Group I (zinc phosphate cement) ($p < 0.001$) **(Table 2)**.

Table 1: Mean Pull-Out Force Values of Different Luting Cements

Group	Luting Cement	Mean Pull-Out Force (N)	Standard Deviation
I	Zinc phosphate cement	186.9	± 29.5
II	Resin cement	482.6	± 45.3
III	Resin-modified GIC	312.4	± 38.7

Table 2: Intergroup Comparison of Mean Pull-Out Force Values (Tukey's Post Hoc Test)

Comparison	**Mean Difference (N)**	**p-value**	**Significance**
Group I vs Group II	295.7	< 0.001	Significant
Group I vs Group III	125.5	< 0.001	Significant
Group II vs Group III	170.2	< 0.001	Significant

Discussion: Retention is a critical determinant of the clinical success of cement-retained implant-supported crowns. Adequate retention ensures stability of the prosthesis under functional loads while allowing retrievability when required. The present in vitro study comparatively evaluated the retentive strength of zinc phosphate cement, resin cement, and resin-modified glass ionomer cement for implant-supported crowns using a standardized pull-out test.[8,9]

The results of this study demonstrated that resin cement exhibited the highest retentive strength, followed by resin-modified glass ionomer cement, while zinc phosphate cement showed the lowest retention. The differences in pull-out force values among all groups were statistically significant, indicating that the type of luting cement significantly influences the retention of implant-supported crowns.

The superior retention observed with resin cement may be attributed to its adhesive bonding mechanism, low solubility, and high mechanical strength. Resin cements form micromechanical and chemical bonds with both the abutment surface and the internal surface of the crown, resulting in enhanced resistance to tensile dislodging forces. These findings are in agreement with studies by Mansour et al. and Michalakis et al., who reported significantly higher retentive values for resin cements compared to conventional luting agents when used for implant-supported restorations.[8,9]

Resin-modified glass ionomer cement demonstrated moderate retention values, which were significantly higher than zinc phosphate cement but lower than resin cement. This may be due to the improved mechanical properties of RMGIC, including better compressive strength and reduced solubility compared to conventional glass ionomer cement. Similar results were reported by Bernal et al., who found that resin-modified glass ionomer cements provided adequate retention while maintaining the advantage of easier retrievability.[10]

Zinc phosphate cement exhibited the lowest retentive strength among the three groups. This finding can be attributed to its non-adhesive nature, reliance solely on mechanical interlocking, and relatively higher solubility. Previous studies by Agar et al. and Ramp et al. also reported lower retentive forces with zinc phosphate cement, supporting its limited use when higher retention is required for implant-supported crowns.[11,12]

From a clinical perspective, while resin cement offers superior retention, its use may compromise retrievability and increase the risk of difficulty during prosthesis removal. Conversely, zinc phosphate cement, despite its lower retention, may be preferred in situations where retrievability is a priority. Resin-modified glass ionomer cement may serve as a balanced option, providing sufficient retention with improved retrievability.[13,14]

The limitations of the present study include its in vitro design, which does not fully replicate oral conditions such as thermal cycling, occlusal loading, saliva, and aging effects. Additionally, only one abutment height and crown design were evaluated. Future studies should incorporate thermocycling, dynamic loading, and different abutment configurations to better simulate clinical conditions.

Conclusion: Within the limitations of this in vitro study, it can be concluded that the type of luting cement has a significant influence on the retention of implant-supported crowns. Resin cement demonstrated the highest retentive strength, followed by resin-modified glass ionomer cement, while zinc phosphate cement showed the lowest retention values. Resin cement may be preferred in clinical situations where maximum retention is required, particularly in short abutments or areas subjected to higher functional forces. Resin-modified glass ionomer cement offers a balance between adequate retention and retrievability and may be considered a suitable alternative in routine clinical practice. Zinc phosphate cement, despite its lower retention, may be indicated when retrievability of the implant-supported restoration is a primary concern. Further in vivo studies incorporating thermocycling, dynamic loading, and long-term clinical evaluation are recommended to better simulate oral conditions and validate the findings of the present study.

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