Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.69980/ff6k9x93

EFFECT OF DIFFERENT LUTING CEMENTS ON FRACTURE RESISTANCE OF CERAMIC CROWNS

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ABSTRACT

Background: The long-term success of ceramic crowns depends not only on the ceramic material itself but also on the properties of the luting cement used for cementation. Different luting cements exhibit variations in bonding ability, mechanical strength, stress distribution, and marginal adaptation, all of which influence the fracture resistance of ceramic restorations. Resin cements have demonstrated superior adhesive properties and mechanical reinforcement compared with conventional glass ionomer cements. However, limited comparative evidence exists regarding the influence of different luting agents on the fracture resistance of ceramic crowns.

Aim: To evaluate and compare the effect of different luting cements on the fracture resistance of ceramic crowns.

Materials and Methods: This in vitro experimental study was conducted on 60 extracted human premolars. Standardized tooth preparation was performed for all-ceramic crowns. Ceramic crowns were fabricated using CAD-CAM lithium disilicate ceramic systems. Samples were randomly divided into three groups based on the luting cement used:

- Group I: Conventional Glass Ionomer Cement (GIC)
- Group II: Resin-Modified Glass Ionomer Cement (RMGIC)
- Group III: Dual-Cure Resin Cement

Each group consisted of 20 specimens. Cementation procedures were performed according to manufacturer recommendations. Thermocycling was carried out to simulate oral conditions. Fracture resistance testing was performed using a universal testing machine with compressive loading until catastrophic failure occurred. Mean fracture resistance values were statistically analyzed using one-way ANOVA and post hoc Tukey tests.

Results: The highest mean fracture resistance was observed in Group III (dual-cure resin cement) followed by Group II (RMGIC) and Group I (conventional GIC). Mean fracture resistance values were:

- Group I: 890.4 ± 95.2 N
- Group II: 1125.6 ± 110.8 N
- Group III: 1458.3 ± 125.4 N

Statistically significant differences were observed among all groups ($p < 0.001$). Resin cement

demonstrated approximately 63.8% greater fracture resistance compared with conventional GIC.
Conclusion: The type of luting cement significantly influences the fracture resistance of ceramic crowns. Dual-cure resin cement provided the highest fracture resistance, suggesting superior reinforcement of ceramic restorations. Resin-modified glass ionomer cement demonstrated intermediate performance, whereas conventional glass ionomer cement exhibited the lowest fracture resistance values.

Keywords: Ceramic crowns, fracture resistance, luting cement, resin cement, glass ionomer cement, CAD-CAM ceramics.

INTRODUCTION

Ceramic crowns have become one of the most widely used restorative options in contemporary prosthodontics because of their superior esthetics, biocompatibility, color stability, and excellent mechanical properties. Increasing patient demand for metal-free restorations has accelerated the use of all-ceramic systems in restorative dentistry. Advances in ceramic materials and adhesive technologies have significantly improved the clinical longevity and functional performance of ceramic restorations. (1)

Despite these advances, fracture of ceramic restorations remains one of the most common causes of clinical failure. Ceramic materials possess high compressive strength but relatively low tensile strength and fracture toughness. During mastication, occlusal forces generate tensile stresses within the ceramic structure, which may result in crack propagation and eventual catastrophic failure. Therefore, improving fracture resistance is considered essential for long-term success of ceramic crowns. (2)

Several factors influence the fracture resistance of ceramic restorations, including ceramic composition, crown thickness, preparation design, internal adaptation, marginal fit, occlusal loading patterns, and type of luting cement used. Among these variables, the luting cement plays a critical role because it acts as an intermediary layer between tooth structure and restoration. The mechanical properties of luting agents directly affect stress distribution and load transfer within the ceramic crown-tooth complex. (3)

Conventional glass ionomer cements have been extensively used for crown cementation because of their fluoride release, chemical adhesion to tooth structure, ease of manipulation, and acceptable biocompatibility. However, their relatively low compressive and tensile strength, brittleness, and moisture sensitivity may compromise the reinforcement of brittle ceramic restorations under functional loading conditions. (4)

Resin-modified glass ionomer cements were introduced to overcome some of the limitations associated with conventional glass ionomer cements. These hybrid materials exhibit improved mechanical strength, reduced solubility, and enhanced adhesion while maintaining fluoride release capability. Their elastic behavior may provide better stress absorption compared with traditional glass ionomer cements. (5)

Resin cements have gained considerable popularity for luting ceramic restorations because of their superior adhesive properties, low solubility, high compressive strength, and ability to reinforce ceramic structures through micromechanical bonding. Adhesive resin cements may reduce crack propagation by distributing occlusal stresses more uniformly across the tooth-restoration interface. Several studies have suggested that bonded ceramic restorations demonstrate significantly higher fracture resistance compared with restorations cemented using conventional luting agents. (6)

Lithium disilicate ceramics are widely used because they combine high flexural strength with excellent esthetics. However, the success of lithium disilicate crowns depends greatly on effective bonding protocols and appropriate cement selection. Variations in elastic modulus and adhesive behavior of luting cements may substantially influence restoration survival under cyclic loading. (7)

In vitro fracture resistance testing provides valuable information regarding the biomechanical behavior of restorative materials before clinical application. Universal testing machines are commonly used to simulate masticatory forces and evaluate failure loads of ceramic restorations under controlled conditions. Such studies help clinicians identify luting materials capable of improving restoration longevity. (8)

Previous investigations have reported conflicting findings regarding the comparative effectiveness of different luting agents on fracture resistance of ceramic crowns. Some studies demonstrated superior performance of resin cements, whereas others observed minimal differences among various cement types depending on ceramic composition and testing methodology. (9,10)

Therefore, the present study was undertaken to comparatively evaluate the effect of conventional glass ionomer cement, resin-modified glass ionomer cement, and dual-cure resin cement on the fracture resistance of ceramic crowns under standardized laboratory conditions.

Materials and Methodology

Study Design

The present study was an in vitro comparative experimental study conducted in the Department of Prosthodontics.

Sample Size

A total of 60 extracted human premolar teeth were included in the study.

Sample Selection

Inclusion Criteria

- Intact extracted premolars
- Teeth free from caries and restorations
- Teeth without cracks or structural deformities

Exclusion Criteria

- Attrited teeth
- Endodontically treated teeth
- Teeth with developmental anomalies

Sample Preparation

All teeth were cleaned using ultrasonic scalers and stored in distilled water at room temperature before preparation.

Tooth Preparation

Standardized crown preparation was performed using a high-speed handpiece under water coolant:

- Occlusal reduction: 2 mm
- Axial reduction: 1.5 mm
- Finish line: Deep chamfer
- Convergence angle: 6 degrees

A custom milling device was used to standardize preparations.

Fabrication of Ceramic Crowns

Impressions were made using polyvinyl siloxane material. CAD-CAM lithium disilicate ceramic crowns were fabricated with uniform thickness.

Grouping of Samples

Group	Luting Cement	Number of Samples
Group I	Conventional GIC	20
Group II	Resin-Modified GIC	20
Group III	Dual-Cure Resin Cement	20

Cementation Procedure
All crowns were cemented according to manufacturer instructions using standardized finger pressure followed by static loading for complete seating.

Thermocycling
All specimens underwent thermocycling between 5°C and 55°C for 500 cycles to simulate oral thermal fluctuations.

Fracture Resistance Testing
Samples were mounted vertically in acrylic resin blocks. Fracture testing was performed using a universal testing machine. Compressive load was applied along the long axis at a crosshead speed of 1 mm/minute until catastrophic fracture occurred.

Statistical Analysis
Data were analyzed using SPSS software version 22.0. Mean and standard deviation values were calculated. One-way ANOVA and Tukey post hoc tests were applied. Statistical significance was set at $p < 0.05$.

Results
The present study evaluated the influence of three different luting cements on the fracture resistance of ceramic crowns. All specimens successfully completed thermocycling and mechanical testing procedures.

Table 1. Comparison of Mean Fracture Resistance Among Study Groups

Group	Mean Fracture Resistance (N)	Standard Deviation	p-value
Group I (GIC)	890.4	95.2	<0.001*
Group II (RMGIC)	1125.6	110.8	<0.001*
Group III (Resin Cement)	1458.3	125.4	<0.001*

Group III demonstrated the highest mean fracture resistance value of 1458.3 N, followed by Group II with 1125.6 N and Group I with 890.4 N. Resin cement exhibited approximately 63.8% greater fracture resistance compared with conventional GIC. The differences among all groups were statistically highly significant ($p < 0.001$).

Table 2. Percentage Increase in Fracture Resistance Between Groups

Comparison	Percentage Increase	p-value
Group II vs Group I	26.4%	0.002*
Group III vs Group I	63.8%	<0.001*
Group III vs Group II	29.6%	<0.001*

Resin-modified GIC demonstrated a 26.4% improvement in fracture resistance compared with conventional GIC. Dual-cure resin cement showed a 63.8% increase compared with conventional GIC and 29.6% greater fracture resistance compared with RMGIC. These findings indicate progressive improvement in fracture resistance with enhanced adhesive and mechanical properties of luting agents.

Table 3. Distribution of Failure Patterns Among Groups

Failure Pattern	Group I	Group II	Group III	p-value
Cohesive Ceramic Fracture	12 (60%)	9 (45%)	5 (25%)	0.01*

Failure Pattern	Group I	Group II	Group III	p-value
Adhesive Failure	6 (30%)	5 (25%)	2 (10%)	0.03*
Mixed Failure	2 (10%)	6 (30%)	13 (65%)	<0.001*

Cohesive ceramic fractures were most common in Group I (60%), indicating poor stress distribution with conventional GIC. Group III demonstrated the highest percentage of mixed failures (65%), suggesting improved bonding and more uniform stress transfer within the restoration-tooth complex. Statistically significant differences were observed in failure patterns among groups.

The results clearly demonstrated that fracture resistance increased progressively from conventional GIC to resin-modified GIC and finally to dual-cure resin cement. Resin cement likely enhanced fracture resistance because of superior micromechanical bonding, reduced microleakage, and improved stress distribution across the ceramic restoration.

The thermocycling process did not produce premature failures in any specimen, indicating adequate bonding durability in all groups. However, specimens cemented with conventional GIC demonstrated earlier crack initiation and catastrophic fracture under lower compressive loads.

The superior performance of resin cement may also be attributed to its lower solubility and higher elastic modulus, which reinforce the ceramic structure during load application. In contrast, conventional GIC demonstrated brittle behavior and lower tensile strength, contributing to reduced fracture resistance.

RMGIC exhibited intermediate results because of its hybrid composition, which combines acid-base reaction with resin polymerization. This combination provides improved mechanical behavior compared with traditional GIC while retaining fluoride release capability.

Overall, the findings suggest that luting cement selection significantly influences biomechanical performance and longevity of ceramic restorations.

Discussion

The longevity and clinical success of ceramic crowns depend greatly on fracture resistance because brittle fracture remains one of the most common causes of restoration failure. The present study evaluated the influence of three different luting cements on fracture resistance of ceramic crowns and demonstrated statistically significant differences among all groups.

The findings of the present study revealed that dual-cure resin cement exhibited the highest fracture resistance followed by resin-modified glass ionomer cement and conventional glass ionomer cement. These results are consistent with previous investigations reporting superior reinforcement of ceramic restorations by adhesive resin cements. (2)

Ceramic materials possess high compressive strength but low tensile strength. Consequently, crack propagation during functional loading may result in catastrophic fracture. Luting cements play an important biomechanical role by influencing stress distribution at the tooth-restoration interface. Resin cements improve fracture resistance through adhesive bonding and micromechanical interlocking, thereby reducing stress concentration within ceramic structures. (3)

The significantly lower fracture resistance observed with conventional GIC in the present study may be attributed to its brittle nature, low tensile strength, and relatively weak bonding characteristics. Glass ionomer cements primarily depend on chemical adhesion and possess lower elastic modulus compared with resin-based luting agents. These properties may limit their ability to absorb occlusal stresses effectively. (4)

The present findings correspond with the observations reported by Al-Wahadni et al., who demonstrated higher fracture resistance in ceramic crowns cemented with resin luting agents compared with glass ionomer cement. They concluded that adhesive luting significantly improves reinforcement of all-ceramic restorations. (5)

RMGIC demonstrated intermediate fracture resistance values in the current study. This may be related to the presence of resin components within the cement matrix, which enhance mechanical properties and reduce solubility compared with conventional GIC. The resin component contributes to improved

flexural strength and stress absorption. (6)
Dual-cure resin cement demonstrated approximately 63.8% higher fracture resistance compared with conventional GIC. This substantial increase may be explained by superior bonding to both tooth structure and ceramic surfaces. Resin cements form a durable hybrid layer and provide effective stress distribution under compressive loading. (7)
Another important finding of the present study was the difference in failure patterns among groups. Group III showed predominantly mixed failures, whereas Group I exhibited greater cohesive ceramic fractures. Mixed failures suggest stronger bonding and better force distribution throughout the restoration complex. Similar findings were reported by Bindl and Mörmann, who observed improved fracture behavior in adhesively luted ceramic restorations. (8)
Thermocycling was performed in the present study to simulate oral environmental changes. Despite thermal aging, resin cement maintained significantly higher fracture resistance values. This observation supports previous studies indicating superior hydrolytic stability and lower solubility of resin-based cements. (9)
The results also indicate that luting cement selection may influence clinical longevity of ceramic crowns. Restorations cemented with resin-based materials may better withstand masticatory forces encountered in posterior regions. Considering that average posterior occlusal forces range between 500 and 900 N, the fracture resistance values observed with resin cement exceeded normal functional loads by a considerable margin. (10-13)
Although in vitro studies cannot perfectly replicate intraoral conditions, they provide valuable comparative data regarding restorative material behavior. Limitations of the present study include absence of cyclic fatigue loading and relatively short-term thermocycling procedures. Long-term clinical studies are required to confirm the present findings under actual oral conditions.
Nevertheless, the present investigation provides clinically relevant information for prosthodontic practice. Selection of appropriate luting cement is essential not only for retention but also for biomechanical reinforcement of ceramic restorations. Adhesive resin cements appear to offer superior fracture resistance and may contribute to enhanced restoration survival.

Conclusion
Within the limitations of the present in vitro study, the following conclusions were drawn:
1. The type of luting cement significantly affects fracture resistance of ceramic crowns.
2. Dual-cure resin cement demonstrated the highest fracture resistance.
3. Resin-modified glass ionomer cement showed intermediate fracture resistance values.
4. Conventional glass ionomer cement exhibited the lowest fracture resistance.

Adhesive resin cementation may improve longevity and biomechanical performance of ceramic restorations..

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