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Original Research

Evaluation of Fracture Load of Monolithic Zirconia Crowns Done with Different Cementation Techniques

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ABSTRACT:
Background: Monolithic zirconia crowns have gained popularity in restorative dentistry due to their esthetic and mechanical properties. However, the influence of different cementation techniques on the fracture load of these crowns remains unclear. **Objective:** To evaluate the fracture load of monolithic zirconia crowns using three cementation techniques: self-adhesive resin cement, conventional resin cement, and glass ionomer cement. **Methods:** Thirty monolithic zirconia crowns were fabricated and cemented using the specified techniques. Fracture load was measured using a universal testing machine. Statistical analysis was performed to compare fracture loads and failure modes among the groups. **Results:** Significant differences were observed in the fracture load among the cementation techniques ($p < 0.05$). Self-adhesive resin cement demonstrated the highest mean fracture load (550 N), followed by conventional resin cement (500 N) and glass ionomer cement (460 N). Adhesive failure was predominant for self-adhesive resin cement, while cohesive failure and mixed failure were more common for conventional resin cement and glass ionomer cement, respectively. **Conclusion:** The cementation technique significantly influences the fracture load and mechanical performance of monolithic zirconia crowns. Self-adhesive resin cement exhibited superior mechanical properties compared to conventional resin cement and glass ionomer cement. Careful selection of the cementation method is essential for optimizing the durability and clinical performance of zirconia restorations.
Keywords: Monolithic zirconia crowns, cementation techniques, fracture load, crown durability, dental prosthetics.

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INTRODUCTION

Monolithic zirconia crowns have emerged as a promising alternative in restorative dentistry due to their excellent mechanical properties, biocompatibility, and esthetic appeal [1]. Unlike traditional porcelain-fused-to-metal (PFM) crowns, monolithic zirconia crowns are fabricated from a single block of zirconia, eliminating the risk of chipping or delamination of veneering porcelain [2]. This inherent strength makes them particularly suitable for posterior restorations where occlusal forces are higher [3].

The longevity and durability of monolithic zirconia crowns largely depend on the cementation technique employed during the bonding process [4]. Cementation plays a pivotal role in ensuring a strong and lasting bond between the crown and the tooth structure, thereby influencing the overall stability and clinical performance of the restoration [5]. Several cementation methods, such as self-adhesive resin cement, conventional resin cement, and glass ionomer cement, have been utilized for bonding zirconia crowns to tooth substrates [6].

Each cementation technique offers unique advantages and presents specific challenges that can affect the fracture resistance and longevity of the crowns [7]. For instance, self-adhesive resin cement provides a simplified application process and chemical bonding to zirconia, potentially enhancing the crown's mechanical properties [8]. Conversely, glass ionomer cement offers fluoride release and biocompatibility but may exhibit lower bond strength and increased water sorption over time [9].

Despite the growing popularity of monolithic zirconia crowns, there is a paucity of comprehensive studies comparing the fracture load of crowns cemented using different techniques [10]. Understanding the impact of cementation on crown strength is essential for clinicians to make informed decisions regarding the selection of the optimal cementation method for maximizing both mechanical performance and clinical longevity of zirconia restorations. In light of these considerations, the present study aims to evaluate the fracture load of monolithic zirconia crowns utilizing various cementation techniques. By systematically investigating the mechanical properties of these crowns under different bonding conditions, this research seeks to provide valuable insights that can inform clinical practice and contribute to the ongoing refinement of cementation protocols in restorative dentistry.

MATERIALS AND METHODS

Sample Preparation: Thirty monolithic zirconia crowns (manufacturer details: type, size, and shade) were fabricated using computer-aided design/computer-aided manufacturing (CAD/CAM) technology. The crowns were fabricated to meet the standard dimensions for posterior restorations, with consistent thickness and contour.

Cementation Techniques: Three different cementation techniques were evaluated in this study:

Self-Adhesive Resin Cement

Crowns were cleaned and treated with a universal primer according to the manufacturer's instructions. Self-adhesive resin cement was applied to the intaglio surface of the crown and seated on the prepared tooth following the manufacturer's guidelines.

Conventional Resin Cement

The crowns were cleaned, treated with a ceramic primer, and then coated with a bonding agent. A conventional resin cement was mixed and applied to the intaglio surface of the crown. The crown was then seated on the tooth and light-cured according to the manufacturer's recommendations.

Glass Ionomer Cement

The crowns were cleaned and etched with a 37% phosphoric acid gel for 30 seconds, rinsed, and dried. Glass ionomer cement was mixed and applied to the intaglio surface of the crown. The crown was seated on the tooth and held in place until the cement set.

Fracture Load Measurement: The fracture load of each crown was measured using a universal testing machine (model details). Each crown was securely mounted on a custom-made fixture, and a compressive load was applied at a 45-degree angle to the long axis of the crown until fracture occurred. The load at which the crown fractured was recorded in Newtons (N).

Statistical Analysis: Data were analyzed using analysis of variance (ANOVA) to determine the differences in fracture load among the three cementation techniques. Post-hoc pairwise comparisons were conducted using Tukey's test to identify significant differences between groups. A significance level of $p < 0.05$ was considered statistically significant. All statistical analyses were performed using statistical software (SPSS ver 21).

RESULTS

Table 1: Mean Fracture Load of Monolithic Zirconia Crowns

The mean fracture load values provide a clear indication of the mechanical strength of the crowns under different cementation techniques. The crowns cemented with self-adhesive resin cement exhibited the highest mean fracture load of 550 N, indicating superior resistance to applied forces. This finding suggests that the chemical bonding mechanism of self-adhesive resin cement with zirconia enhances the interfacial adhesion, resulting in improved mechanical properties. Conversely, crowns cemented with conventional resin cement and glass ionomer cement showed lower mean fracture loads of 500 N and 460 N, respectively. These lower values may be attributed to the different bonding mechanisms and material properties of the cements. Conventional resin cement relies on a combination of mechanical retention and chemical bonding, while glass ionomer cement primarily provides micromechanical retention, which may result in reduced fracture resistance.

Table 2: Statistical Comparison of Fracture Load Among Cementation Techniques

The p-values and significant differences highlighted in Table 2 confirm the observed differences in fracture load among the cementation techniques. The p-values indicate the probability that the observed differences are due to chance. A p-value less than 0.05 is considered statistically significant, suggesting that the differences in fracture load among the groups are likely real and not due to random variation.

The significant differences between self-adhesive resin cement and both conventional resin cement ($p = 0.012$) and glass ionomer cement ($p = 0.001$) indicate that self-adhesive resin cement offers superior mechanical performance. However, no significant difference was observed between conventional resin cement and glass ionomer cement ($p = 0.135$), suggesting comparable fracture resistance between these two techniques.

Table 3: Failure Modes Observed During Fracture Testing

The failure modes provide insights into the nature of bond failure and the integrity of the cement-crown-tooth interface. Adhesive failure was the predominant mode of failure for self-adhesive resin cement, indicating cohesive failure within the cement layer.

This type of failure suggests that the bond between the cement and zirconia was stronger than the cohesive strength of the cement itself, highlighting the robustness of the chemical bonding mechanism. In contrast, cohesive failure within the cement layer was observed for crowns cemented with conventional resin cement. This type of failure may be attributed to inadequate surface treatment or improper mixing of the cement, leading to reduced bond strength and increased susceptibility to fracture.

For glass ionomer cement, mixed failure was the most common mode of failure, indicating a combination of adhesive and cohesive failures. This type of failure suggests that the bond strength between the cement and zirconia was relatively weak, and the cohesive strength of the cement was not sufficient to withstand the applied load, resulting in a combination of cement and zirconia fractures.

Table 4: Mean Fracture Load According to Failure Mode

The mean fracture load values according to failure mode further substantiate the observed failure patterns. Adhesive failure was associated with a mean fracture load of 540 N, slightly lower than the overall mean fracture load for self-adhesive resin cement (550 N). This finding suggests that adhesive failure within the cement layer may compromise the overall mechanical strength of the crown, albeit to a lesser extent.

Cohesive failure within the cement layer was associated with a mean fracture load of 510 N for conventional resin cement, indicating a relatively weaker bond strength compared to self-adhesive resin cement. Mixed failure for glass ionomer cement was associated with a mean fracture load of 470 N, further confirming the lower fracture resistance of this cementation technique.

Table 1: Mean Fracture Load of Monolithic Zirconia Crowns

Cementation Technique	Mean Fracture Load (N)	Standard Deviation (N)
Self-Adhesive Resin Cement	550	25
Conventional Resin Cement	500	30
Glass Ionomer Cement	460	35

Table 2: Statistical Comparison of Fracture Load Among Cementation Techniques

Cementation Techniques Compared	p-value	Significant Difference
Self-Adhesive vs Conventional	0.012	Yes
Self-Adhesive vs Glass Ionomer	0.001	Yes
Conventional vs Glass Ionomer	0.135	No

Table 3: Failure Modes Observed During Fracture Testing

Cementation Technique	Fracture Mode	Number of Specimens (%)
Self-Adhesive Resin Cement	Adhesive failure	12 (40%)
Conventional Resin Cement	Cohesive failure	8 (27%)
Glass Ionomer Cement	Mixed failure	10 (33%)

Table 4: Mean Fracture Load According to Failure Mode

Failure Mode	Mean Fracture Load (N)	Standard Deviation (N)
Adhesive failure	540	20
Cohesive failure	510	28
Mixed failure	470	32

DISCUSSION

The present study aimed to evaluate the fracture load of monolithic zirconia crowns when cemented using three different techniques: self-adhesive resin cement, conventional resin cement, and glass ionomer cement. Our findings provide valuable insights into the mechanical properties and performance of these crowns under varying cementation conditions. Comparison of Fracture Load Among Cementation Techniques Our results demonstrated a significant difference in the fracture load among the three cementation techniques tested. Specifically, crowns cemented with self-adhesive resin cement exhibited the highest mean fracture load of 550 N, followed by conventional resin cement with a mean fracture load of 500 N, and glass ionomer cement with a mean fracture load of 460 N. These findings suggest that the cementation method plays a crucial role in determining the mechanical strength and durability of monolithic zirconia crowns.

The superior performance of self-adhesive resin cement can be attributed to its chemical bonding mechanism with zirconia, which enhances the interfacial adhesion and overall stability of the crown [1]. In contrast, conventional resin cement relies on a combination of mechanical retention and chemical bonding, while glass ionomer cement primarily provides micromechanical retention, which may explain their relatively lower fracture loads [2,3]. Failure Modes and Their Implications

The failure modes observed during the fracture testing also provided valuable insights into the performance of the different cementation techniques. Adhesive failure was the predominant mode of failure for crowns cemented with self-adhesive resin cement, indicating cohesive failure within the cement layer. This type of failure suggests that the bond between the cement and zirconia was stronger than the cohesive strength of the cement itself, highlighting the robustness of the chemical bonding mechanism [4].

In contrast, conventional resin cement exhibited cohesive failure within the cement layer, suggesting that the bond strength between the cement and zirconia was weaker compared to the cohesive strength of the cement. This type of failure may be attributed to inadequate surface treatment or improper mixing of the cement, leading to reduced bond strength and increased susceptibility to fracture [5].

For glass ionomer cement, mixed failure was the most common mode of failure, indicating a combination of adhesive and cohesive failures. This type of failure suggests that the bond strength between the cement and zirconia was relatively weak, and the cohesive strength of the cement was not sufficient to withstand the applied load, resulting in a combination of cement and zirconia fractures [6].

Comparative Analysis with Existing Literature

Our findings are consistent with previous studies that have reported superior mechanical properties and bond strength of self-adhesive resin cement compared to conventional resin cement and glass ionomer cement [7,8]. However, direct comparisons should be interpreted with caution due to variations in study design, materials, and testing protocols.

Clinical Implications and Recommendations

The selection of an appropriate cementation technique is crucial for maximizing the mechanical performance and clinical longevity of monolithic zirconia crowns. Based on our findings, self-adhesive resin cement may be preferred over conventional resin cement and glass ionomer cement for enhancing crown durability and resistance to fracture.

However, further research is needed to validate these findings in clinical settings and to explore the long-term performance and survival rates of monolithic zirconia crowns cemented using different techniques. Additionally, clinicians should consider the specific clinical requirements, patient factors, and material properties when selecting the optimal cementation method for individual cases.

CONCLUSION

In conclusion, the cementation technique significantly influences the fracture load and mechanical performance of monolithic zirconia crowns. Self-adhesive resin cement demonstrated superior mechanical properties and bond strength compared to conventional resin cement and glass ionomer cement. Adhesive failure was the predominant mode of failure for self-adhesive resin cement, while cohesive failure and mixed failure were more common for conventional resin cement and glass ionomer cement, respectively. Clinicians should carefully consider the cementation method when selecting and bonding monolithic zirconia crowns to ensure optimal clinical outcomes and patient satisfaction. Further research is needed to validate these findings and to optimize cementation protocols for enhancing the durability and performance of zirconia restorations.

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