

A Comparative Evaluation of the Bond Strength of Universal Resin Luting Cement and Self-adhesive Resin Luting Cement to Zirconia-reinforced Glass Ceramics: An *in vitro* Study

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Abstract

Background: Dental resin cements are widely used for luting indirect restorations, such as ceramic or zirconia crowns, veneers, and inlays, due to their superior mechanical properties and adhesive capabilities. The efficacy of bonding to zirconia and glass ceramics varies by cement type.

Aim: To evaluate and compare the bond strength of universal resin luting cement and self-adhesive resin luting cement, with surface-treated zirconia reinforced glass ceramic.

Materials and methods: Twenty CAD-CAM-milled and fully sintered zirconia-reinforced glass-ceramic (ZGC) blocks of 12 X 14 X 2 mm were prepared. Each specimen was embedded in self-cure acrylic resin cylinders, with one surface exposed for bonding. The specimens were randomly divided into two groups with 10 in each. The specimens in groups 1 and 2 were luted with self-adhesive resin cement and universal resin cement, respectively. The specimens were mounted on the universal testing machine, and the debonding chisel was allowed to make contact with the interface of the luting agent and the ceramic. Then, the load was applied at a crosshead speed of 1mm/min at the interface. The debonding load was recorded in newtons, and the shear bond strength was calculated in MPa. Overall comparisons were analyzed using the Kruskal-Wallis test. Pairwise comparisons were done using the Mann-Whitney U test. The level of significance was set at $p < 0.05$ for all tests.

Results: Universal resin cement demonstrated a significantly higher mean bond strength (6.94 ± 0.55 MPa) compared to self-adhesive resin cement (5.54 ± 1.09 MPa) with the surface-treated ZGC blocks. Intergroup comparison revealed a statistically significant difference in bond strength between the tested resin cements ($p = 0.002$).

Conclusion: Universal resin cement demonstrated the highest bond strength, whereas self-adhesive resin cement showed the lowest bond strength to the tested ceramic substrate.

Keywords: Ceramics, Luting agents, Self-adhesive resin cement, Zirconia.

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1. Introduction

Zirconia-reinforced glass ceramics have emerged as a prominent material in restorative dentistry due to their superior mechanical properties and esthetic appeal [1]. These ceramics offer an

excellent balance of strength and translucency, making them suitable for a wide range of applications, including crowns, bridges, and veneers [2]. However, the successful long-term performance of these restorations heavily relies on a strong and durable bond between the ceramic and the tooth structure, which is typically achieved through resin luting cements [3].

The selection of an appropriate luting cement is critical for ensuring the longevity and integrity of indirect restorations. Traditionally, conventional resin luting cements have been employed, requiring multi-step etching, priming, and bonding procedures [4]. While effective, these methods can be technique-sensitive and time-consuming. In response to these challenges, self-adhesive resin luting cements have been developed, aiming to simplify the bonding process by incorporating adhesive monomers that can interact directly with the tooth structure and restorative material without separate etching or priming steps [5]. More recently, universal resin luting cements have been introduced, offering versatility by allowing for various bonding strategies depending on the clinical situation, including self-etch, etch-and-rinse, or selective etch modes [6].

Despite the advancements in luting cement technology, the bond strength to zirconia-reinforced glass ceramics remains a significant area of research. The unique composition and surface characteristics of these ceramics can influence their interaction with different types of luting agents [7]. Previous studies have investigated the bond strength of various cements to different ceramic substrates, highlighting the importance of surface treatment and cement chemistry [8, 9]. However, a direct comparative evaluation of universal resin luting cement and self-adhesive resin luting cement specifically bonded to zirconia-reinforced glass ceramics is still needed to provide clear clinical guidance.

Therefore, this *in vitro* study aimed to evaluate and compare the bond strength of a universal resin luting cement, a self-adhesive resin luting cement (Ivoclar Vivadent AG, Schaan, Liechtenstein), and a conventional resin luting cement (Ivoclar Vivadent AG, Schaan, Liechtenstein) when bonded to zirconia-reinforced glass ceramic specimens. The findings of this research will contribute to a better understanding of the performance of these contemporary luting materials and provide valuable insights for clinicians in selecting the optimal luting agent for zirconia-reinforced glass

ceramic restorations, ultimately enhancing the predictability and success of dental treatments.

2. Materials and methods

This *in vitro* study was conducted in the Department of Prosthodontics, Crown and Bridge, G Pulla Reddy Dental College and Hospital, Kurnool, Andhra Pradesh, India, and the Institutional Ethical Clearance (IEC No.: GPR/23/04/RC/PG/CONS/23M008) was obtained from the Institutional Research Board. The materials and equipment used in the study are presented in Table 1.

Table 1. Materials and equipment used in the study.

Materials/Equipment	Manufacturers' details
Zirconia reinforced glass ceramic CAD/CAM milled & sintered (Vita Suprinity)	VITA Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany.
Speedcem Plus	Ivoclar, Schaan, Liechtenstein
Multilink N	Ivoclar, Schaan, Liechtenstein
Silane	Ultradent Products Inc., South Jordan, UT, USA.
Porcelain etch	Ultradent Products Inc., South Jordan, UT, USA.
LED composite light curing device	Woodpecker Medical Instrument Co., China.
Polymethylmethacrylate resin (DPI RR Cold-cure)	Dental Products of India, Mumbai, India.
Universal Testing Machine	Instron U200

2.1 Sample preparation

A total of 20 specimens of fully sintered zirconia-reinforced glass-ceramic (ZGC) blocks (Vita Suprinity (VITA Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany), measuring 10 × 2 mm, were prepared. Each glass-ceramic block was embedded in acrylic resin cylinders measuring 25 mm height × 25 mm diameter (DPI RR cold-cure) prepared from polythene molds with one surface exposed for bonding. Specimens were surface-treated with 10% hydrofluoric (HF) acid Ultradent Products Inc., South Jordan, UT, USA), then rinsed with deionised water. Silane (Ultradent Products Inc., South Jordan, UT, USA) was coated on a ZGC block with a brush and was allowed to evaporate for 60 seconds, according to the manufacturer's instructions.

The ZGC blocks embedded in the acrylic block were randomly divided into two groups with 10 in each (n = 10). Then, a Tygon tube was attached to the treated surfaces of ZGC blocks in each group. In group 1, the Tygon tube was filled with a self-adhesive resin cement and was cured with an LED curing lamp (Woodpecker Medical Instrument Co., Guilin, China for 10 seconds on all sides. In group 2,

the Tygon tube attached to the surface-treated ZGC block was filled with a universal resin cement and was cured similarly to the specimens in group 1.

2.2 Evaluation of shear bond strength

The specimens were placed in a fixture mounted on a universal testing machine (Instron). A chisel with a flat blade was made to contact the interface of the cement and the ZGC block. Then, a shear bond strength (SBS) test was performed by applying a load at a crosshead speed of 1mm/min until debonding occurred (Figure 1). The load required to debond the specimen was recorded in newtons (N), and the SBS was calculated in MPa using the following formula.

$$\text{SBS (MPa)} = \text{Debonding load (N)} / \text{Bonded area}$$

2.3 Statistical Analysis

The obtained data were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS), version 26.0, IBM Corporation, New Jersey, USA. Overall comparisons were analyzed using the Kruskal-Wallis test. Pairwise comparisons were done using the Mann-Whitney U test. The level of significance was set at $p < 0.05$ for all tests.

3. Results

The mean bond strength of various groups is presented in Table 2. Universal resin cement demonstrated higher mean bond strength (6.94 ± 0.55 MPa) with the ZGC blocks compared to self-adhesive resin cement (5.54 ± 1.09 MPa). Intergroup comparison revealed a statistically significant difference in bond strength between the tested resin cements ($p = 0.002$). The independent t-test confirmed the superiority of universal resin cement over self-adhesive resin cement in terms of bonding performance. The mean bond strength values of the tested groups are presented in Table 2. Universal resin cement exhibited a higher mean bond strength (6.94 ± 0.55 MPa) to zirconia reinforced glass ceramic blocks when compared to self-adhesive resin cement (5.54 ± 1.09 MPa).

The Kruskal-Wallis test demonstrated a statistically significant difference in bond strength between the groups ($p < 0.05$). Further intergroup analysis using the Mann-Whitney U test revealed that the universal resin cement showed significantly higher bond strength values than the self-adhesive resin cement ($p = 0.002$). These findings indicate that universal resin cement provided superior bonding performance to

zirconia reinforced glass ceramics compared to self-adhesive resin cement.

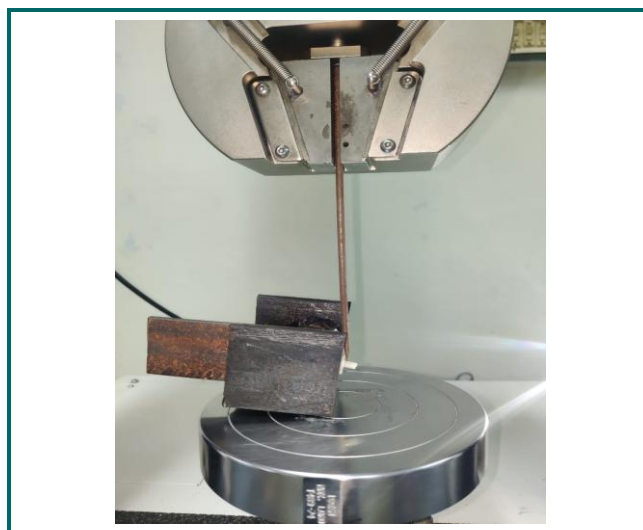


Figure 1. Specimen subjected to shear bond strength testing.

Table 2. Comparison of the mean shear bond strength (MPa)

Groups	Mean \pm SD [#]	Standard Error	p - Value
Self-adhesive resin cement	5.5430 \pm 1.09297	0.34563	0.002*
Universal resin cement	6.9370 \pm 0.55305	0.17489	

[#]Standard deviation, and *Significant difference.

4. Discussion

In the present *in vitro* study evaluating the bond strength of universal resin and self-adhesive resin luting cements bonded to zirconia-reinforced glass ceramics, a statistically significant difference was observed between the groups ($p = 0.002$), with universal resin cement demonstrating superior bond strength compared to self-adhesive resin cement. This finding is consistent with previous studies, which have reported that adhesive resin cement systems generally provide higher bond strength to zirconia-based ceramics than self-adhesive systems due to enhanced chemical and micromechanical interactions at the cement-ceramic interface [10-13].

The superior bonding performance of universal resin cements is largely attributed to functional phosphate monomers, particularly 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP), which have been shown to chemically bond to zirconia oxide layers and contribute to stable, durable adhesive interfaces [11,12]. Yoshida *et al.* demonstrated that phosphate ester monomers form strong chemical bonds with zirconia surfaces, significantly improving resin cement adhesion [11]. Similarly, Kern emphasized that chemical

adhesion mediated by functional monomers is a critical factor influencing the long-term success of zirconia bonding, often outweighing purely mechanical retention mechanisms [12].

Universal resin cements are typically used in combination with adhesive protocols involving surface pretreatment steps such as airborne particle abrasion or the application of primers and adhesives, which increase surface roughness, wettability, and surface energy of ceramic substrates [14,15]. These surface modifications facilitate improved resin infiltration and micro-interlocking, thereby enhancing bond strength [15]. In contrast, self-adhesive resin cements were designed to simplify clinical procedures by eliminating separate etching and bonding steps; however, this simplification often compromises the quality of the adhesive interface, particularly when bonding to high-strength ceramic materials such as zirconia-reinforced glass ceramics [16].

The lower bond strength values observed for self-adhesive resin cement in the present study are in agreement with previous investigations reporting inferior adhesion of self-adhesive systems to zirconia when compared to conventional or universal resin cements used with adhesive strategies [17,21]. The other study also demonstrated that self-adhesive resin cements exhibit significantly reduced bond strength to zirconia unless combined with additional surface treatments, highlighting their inherent limitations when used alone [16]. This reduced performance may be related to insufficient surface demineralization and limited chemical interaction between the cement and the ceramic substrate [17,18].

Furthermore, the chemistry of self-adhesive resin cements relies on acidic functional monomers intended to simultaneously demineralize and infiltrate the substrate; however, their acidity is often neutralized rapidly during polymerization, limiting their ability to establish strong and durable bonds with ceramic surfaces [16]. In contrast, universal resin cements benefit from the synergistic action of adhesive primers and resin matrices, which enhances polymer network formation and interfacial stability [14,15].

Surface treatment remains a decisive factor influencing bond strength outcomes. Studies have shown that airborne particle abrasion and tribochemical silica coating significantly improve the bonding performance of resin cements to

zirconia by increasing surface area and promoting micromechanical retention [19-21]. However, even with surface pretreatment, self-adhesive resin cements generally demonstrate lower bond strength values than adhesive-assisted resin cements, reinforcing the importance of adhesive strategy selection [19,21].

The role of ceramic composition must also be considered when interpreting bond strength results. Zirconia-reinforced glass ceramics possess a complex microstructure combining glassy and crystalline phases, which influences surface reactivity and bonding behaviour [19,20]. Zhang and Lawn emphasized that zirconia-containing ceramics exhibit reduced etchability compared to silica-based ceramics, necessitating the use of chemical bonding agents such as phosphate monomers to achieve reliable adhesion [19]. This further explains the improved performance of universal resin cements observed in the present study.

From a clinical perspective, higher bond strength values are associated with improved retention, reduced marginal leakage, and enhanced longevity of indirect restorations [15,22]. Blatz *et al.* highlighted that reliable resin-ceramic bonding is essential for the success of modern esthetic restorations, particularly in minimally invasive preparations where mechanical retention is limited [15]. Therefore, the superior bond strength demonstrated by universal resin cement in this study suggests its preferential use in clinical situations demanding high adhesive reliability.

Aging and degradation of the adhesive interface are also critical considerations. Previous studies have shown that resin cement bonds to zirconia may deteriorate over time due to hydrolytic degradation and thermal stresses, with adhesive-assisted resin cements demonstrating greater resistance to aging compared to self-adhesive systems [23]. Teixeira GS *et al.* reported that self-adhesive resin cements exhibited a more pronounced reduction in bond strength after aging procedures, underscoring concerns regarding their long-term durability [23].

Despite the valuable insights provided by this study, certain limitations must be acknowledged. In-vitro testing conditions cannot fully replicate the complex oral environment, where factors such as cyclic loading, temperature fluctuations, and saliva exposure may influence cement performance. Additionally, the present study

evaluated only one ceramic material and two cement types, and variations in ceramic microstructure, surface treatment protocols, and cement composition could yield different outcomes. Future studies should focus on evaluating the long-term durability of bonding systems through thermocycling and mechanical fatigue testing, as well as assessing the clinical performance of these materials through randomized controlled trials. Investigating the effect of combining self-adhesive resin cements with selective primers or surface treatments may also provide insight into optimizing their bonding performance.

5. Conclusion

Within the limitations, this *in vitro* study reported that the surface-treated ZGC exhibited a significantly higher shear bond strength with the universal resin cement compared to the self-adhesive resin cement.

Conflicts of interest: The authors declared no conflicts of interest.

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