Case Study

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Comparative Evaluation of Shear Bond Strength of Glass Ionomer Cement, Resin-Modified Glass Ionomer Cement and Alkasite Restorative Material to Human Dentin: An In-Vitro Study

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ABSTRACT

Background: Durable adhesion between restorative materials and dentin is essential for the longevity and clinical success of restorations. Conventional glass ionomer cement (GIC), resin-modified glass ionomer cement (RMGIC), and alkasite restorative materials are widely used because of their fluoride release, chemical bonding potential, and simplified clinical application; however, their comparative bonding performance remains inconclusive.

Aim: To compare the shear bond strength (SBS) of conventional GIC, RMGIC, and alkasite restorative material to human dentin.

Materials and Methods: Thirty extracted human premolars were sectioned to expose flat mid-coronal dentin surfaces and randomly allocated into three groups ($n = 10$): Group I—conventional GIC, Group II—RMGIC, and Group III—alkasite restorative material. Restorations were placed according to manufacturers' instructions using a standardized cylindrical mold. After storage in distilled water at 37 °C for 24 hours, specimens were subjected to shear bond strength testing using a universal testing machine at a cross-head speed of 1 mm/min. SBS values were calculated in megapascals (MPa) and statistically analyzed using one-way analysis of variance followed by Tukey's post-hoc test ($\alpha = 0.05$).

Results: Alkasite restorative material demonstrated the highest mean shear bond strength (14.06 ± 1.87 MPa), followed by RMGIC (11.52 ± 1.74 MPa) and conventional GIC (8.94 ± 1.58 MPa). The differences among the three groups were statistically significant ($p < 0.001$).

Conclusion: Within the limitations of this in-vitro study, alkasite restorative material exhibited superior bonding to dentin compared with both types of glass ionomer cements. Conventional GIC showed the lowest shear bond strength.

Introduction

The longevity and clinical success of direct restorative procedures depend largely on the quality and durability of the bond formed between restorative materials and tooth structure.[1] Adequate adhesion to dentin is particularly critical, as this hydrated and heterogeneous substrate presents inherent challenges to predictable bonding. Insufficient bond strength may result in marginal leakage, postoperative sensitivity, secondary caries, and premature restoration

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failure.[2,3]

Glass ionomer cements (GICs) have been widely used in restorative dentistry owing to their chemical adhesion to dental hard tissues, fluoride release, and favorable biocompatibility.[4] Conventional GICs set primarily through an acid–base reaction and rely on ionic bonding between polyalkenoic acids and calcium ions within hydroxyapatite. Despite these advantages, conventional GICs often demonstrate inferior mechanical properties and lower bond strength when compared with resin-based restorative materials, which may limit their use in stress-bearing areas.[4-6]

To overcome these limitations, resin-modified glass ionomer cements (RMGICs) were developed by incorporating resin components such as hydroxyethyl methacrylate into the conventional GIC formulation. This modification enables dual curing through both acid–base reaction and light-activated polymerization, potentially improving mechanical performance and early bond strength while maintaining the chemical adhesion characteristic of traditional GICs.[7,8]

More recently, alkasite-based restorative materials have been introduced as a new category of bulk-fill, ion-releasing resin restoratives that aim to combine simplified placement protocols with enhanced mechanical properties. These materials contain alkaline glass fillers capable of releasing calcium, fluoride, and hydroxide ions, which may contribute to remineralization and buffering of acidic environments.[9,10]

Manufacturers claim that alkasite materials can be used with or without adhesive systems, suggesting a potential advantage in clinical efficiency; however, independent data regarding their bonding performance to dentin remain limited.

Although previous studies have individually evaluated the bonding characteristics of glass ionomer-based and resin-based restorative systems, direct comparative assessments among conventional GIC, RMGIC, and alkasite restorative materials under standardized experimental conditions are scarce. Therefore, the present in-vitro study was designed to compare the shear bond strength of these three restorative materials to human dentin. The null hypothesis tested was that there would be no significant difference in the shear bond strength values among conventional GIC, RMGIC, and alkasite restorative materials.

Materials and Methods

Study Design: This in-vitro experimental study was conducted to evaluate and compare the shear bond strength (SBS) of three restorative materials—conventional glass ionomer cement (GIC), resin-modified glass ionomer cement (RMGIC), and alkasite restorative material—bonded to human dentin.

Ethical Approval: Ethical clearance for the use of extracted human teeth was obtained from the institutional ethics committee. Teeth were collected after informed consent from patients undergoing orthodontic extractions.

Sample Selection: Thirty freshly extracted, non-carious human premolars free from cracks, restorations, developmental defects, or structural abnormalities were selected for the study.

After extraction, teeth were cleaned of debris and soft tissue remnants using ultrasonic scalers and stored in 0.1% thymol solution for disinfection. Prior to testing, specimens were transferred to distilled water at room temperature, which was changed weekly to prevent dehydration.

Specimen Preparation: The occlusal enamel of each tooth was removed using a water-cooled diamond disc to expose flat mid-coronal dentin surfaces. The exposed dentin was polished with 600-grit silicon carbide abrasive paper under running water to create a standardized smear layer.

Each tooth was embedded vertically in self-cure acrylic resin blocks, leaving the prepared dentin surface exposed and parallel to the horizontal plane.

Grouping of Samples: The specimens were randomly allocated into three groups ($n = 10$) based on the restorative material used:

Group I: Conventional GIC (GC Corporation, Japan)

Group II: Resin-modified GIC (3M, USA)

Group III: Alkasite restorative material—Cention N (Ivoclar, Liechtenstein)

Bonding Procedure: A cylindrical Teflon mold measuring 3 mm in diameter and 2 mm in height was positioned centrally on the dentin surface of each specimen to standardize the bonded area.

Group I Conventional GIC: The dentin surface was conditioned with polyacrylic acid for 10 seconds, rinsed thoroughly, and gently air-dried leaving a moist surface. The GIC was mixed according to the manufacturer's instructions and packed into the mold. After initial setting, the mold was removed carefully.

Group II Resin-Modified GIC: Dentin conditioning was performed in a similar manner. RMGIC was placed into the mold and light-cured for 20 seconds using an LED curing unit following manufacturer guidelines.

Group III Alkasite Restorative Material: The material was mixed as recommended and placed directly into the mold without the use of an additional adhesive system. Light curing was carried out for 20 seconds.

All specimens were stored in distilled water at 37 °C for 24 hours before mechanical testing.

Shear Bond Strength Testing: After storage, specimens were mounted in a universal testing machine. A knife-edged chisel blade was aligned as close as possible to the tooth–restoration interface, and load was applied at a cross-head speed of 1 mm/min until debonding occurred. The maximum load at failure was recorded in Newtons (N).

Shear bond strength values were calculated using the formula: Shear bond strength was calculated according to the following formula and expressed in MPa: Stress = Failure load (N)/surface area (mm2).

Result

Shear bond strength values differed significantly among the three restorative materials evaluated. The alkasite restorative material demonstrated the highest mean bond strength (14.06 ± 1.87 MPa), followed by resin-modified glass ionomer cement (11.52 ± 1.74 MPa), while conventional glass ionomer cement exhibited the lowest values (8.94 ± 1.58 MPa). One-way analysis of variance revealed that these differences were statistically significant ($p < 0.001$) (Table 1). Further intergroup comparison using Tukey's post-hoc test confirmed that the alkasite restorative material showed significantly higher shear bond strength than both resin-modified glass ionomer cement ($p = 0.01$) and conventional glass ionomer cement ($p < 0.001$) (Table 2). Additionally, resin-modified glass ionomer cement demonstrated significantly greater bond strength than conventional glass ionomer cement ($p = 0.02$). These findings indicate a clear hierarchy in bonding performance, with alkasite restorative material outperforming the glass ionomer-based materials under the experimental conditions of this study.

Table 1: Mean Shear Bond Strength Values

Group	Restorative Material	Mean ± SD (MPa)
I	Conventional GIC	8.94 ± 1.58
II	Resin-Modified GIC	11.52 ± 1.74
III	Alkasite (Cention N)	14.06 ± 1.87

Table 2: Intergroup Comparison of Shear Bond Strength Values

Comparison	Mean Difference (MPa)	p-value
Group I (GIC) vs Group II (RMGIC)	2.58	<0.05 (Significant)
Group I (GIC) vs Group III (Alkasite)	5.12	<0.001 (Highly Significant)
Group II (RMGIC) vs Group III (Alkasite)	2.54	<0.05 (Significant)

Discussion

The present in-vitro study compared the shear bond strength of conventional glass ionomer cement, resin-modified glass ionomer cement, and an alkasite restorative material to human dentin. The results demonstrated statistically significant differences among the three groups, with the alkasite restorative material showing the highest bond strength, followed by resin-modified glass ionomer cement, while conventional glass ionomer cement exhibited the lowest values. Therefore, the null hypothesis that no difference would exist among the materials tested was rejected.

The inferior bond strength observed with conventional glass ionomer cement may be attributed to its inherent setting mechanism and mechanical limitations.[11] Conventional GIC relies primarily on an acid–base reaction and ionic bonding with calcium in hydroxyapatite, which, although clinically advantageous for fluoride release and biocompatibility, provides comparatively lower resistance to shear stresses. Early moisture sensitivity and susceptibility to dehydration during the initial setting phase may further compromise interfacial integrity, contributing to reduced bond strength values.[12,13]

Resin-modified glass ionomer cement demonstrated significantly higher bond strength than conventional GIC. This improvement may be explained by the incorporation of resin monomers, which allow light-activated polymerization in addition to the traditional acid–base reaction. The resin component enhances early mechanical strength and micromechanical interlocking within the conditioned dentin surface, while maintaining chemical adhesion to hydroxyapatite. These combined bonding mechanisms likely account for the intermediate performance of RMGIC observed in this study.[14,15]

The highest shear bond strength recorded for the alkasite restorative material could be attributed to its resin-based matrix, optimized filler loading, and ion-releasing alkaline glass fillers. Dual-curing capability and polymer network formation may provide superior cohesive strength and improved stress distribution at the tooth–restoration interface. Furthermore, the release of calcium and hydroxide ions may contribute to chemical interactions with dentin and stabilization of the bonding interface, thereby enhancing overall adhesion.[16,17]

The findings of this study are in agreement with previously published investigations reporting improved bonding performance of resin-containing restorative materials when compared with conventional glass ionomer cements. However, direct comparison with existing literature should be interpreted cautiously due to variations in methodology, such as surface preparation, storage conditions, bonded surface area, cross-head speed during testing, and aging protocols.

Certain limitations of the present study must be acknowledged. As an in-vitro investigation, it does not fully replicate intraoral conditions such as thermal fluctuations, masticatory fatigue, salivary enzymes, and pH variations. Thermocycling and long-term water storage were not incorporated, which may influence bond durability over time. Additionally, only shear bond strength testing was performed; other mechanical evaluations such as microtensile bond strength and failure mode analysis could provide further insight into the nature of adhesive performance.

Future studies should incorporate artificial aging protocols, cyclic loading, and microscopic evaluation of fractured surfaces to better simulate clinical conditions and determine long-term bonding stability. Comparative clinical trials would also be valuable to validate whether the superior laboratory performance of alkasite materials translates into improved restoration longevity in vivo.

Conclusion

Within the limitations of this in-vitro study, the alkasite restorative material demonstrated the highest shear bond strength to human dentin, followed by resin-modified glass ionomer cement, while conventional glass ionomer cement exhibited the lowest bond strength values. The results suggest that incorporation of resin components and alkaline filler technology enhances adhesion to dentin when compared with traditional glass ionomer formulations. Further studies incorporating aging protocols, thermocycling, and long-term clinical evaluation are recommended to validate these findings under intraoral conditions.

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