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Comparative Evaluation of the Shear Bond Strength of Conventional Glass Ionomer Cement, Resin-modified Glass Ionomer Cement, and Glass Hybrid Restorative Material to Silver Diamine Fluoride-treated Dentin

Deepti Singh[1*], Shelly Sharma[2], Neha Singh[3], Ashwini Anand[4], Jesme Eldho[5] and Shwetima Sharma[6]

[1]*Junior Resident, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh-221005.*

[2]*Senior Resident, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh-221005.*

[3]*Senior Resident, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh-221005.*

[4]*Junior Resident, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh-221005.*

[5]*Junior Resident, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh-221005.*

[6]*Junior Resident, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh-221005.*

[*] Corresponding author. E-mail: deeptirocks07@gmail.com

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ABSTRACT

Aim: To comparatively evaluate the shear bond strength of conventional glass ionomer cement (CGIC), resin-modified glass ionomer cement (RMGIC), and glass hybrid restorative material (GHRM) bonded to 38% silver diamine fluoride-treated dentin. Materials and Methods: Forty-five extracted human premolars were prepared to obtain standardized flat dentin surfaces and randomly allocated into three groups (n = 15): Group I—Conventional Glass Ionomer Cement (Fuji IX GP Extra), Group II—Resin-Modified Glass Ionomer Cement (Fuji II LC), and Group III—Glass Hybrid Restorative Material (Equia Forte HT). Following pretreatment with 38% silver diamine fluoride, the restorative materials were bonded to the dentin surface using Teflon molds. After 24-hour storage and 500 thermocycles, shear bond strength was evaluated using a universal testing machine. Data were analyzed using one-way ANOVA and Tukey's post hoc test ($p < 0.05$). Results: The glass hybrid restorative material demonstrated the highest mean shear bond strength, followed by the resin-modified glass ionomer cement, while the conventional glass ionomer cement exhibited the lowest values. The differences among the three groups were statistically significant ($p < 0.05$). Conclusion: Among the restorative materials evaluated, the glass hybrid restorative material exhibited superior shear bond strength to SDF-treated dentin, followed by resin-modified glass ionomer cement. Conventional glass ionomer cement demonstrated comparatively lower bond strength. Glass hybrid restorative materials may therefore be considered a suitable restorative option following silver diamine fluoride application in minimally invasive restorative procedures.

INTRODUCTION

Dental caries remains one of the most prevalent chronic diseases affecting children worldwide and continues to pose a significant public health challenge. The management of cavitated dentinal lesions in primary and permanent teeth has shifted toward minimally invasive approaches that emphasize preservation of tooth structure while controlling the caries process.[1,2] Among these, 38% silver diamine fluoride (SDF) has gained widespread acceptance because of its ability to arrest dentinal caries through its combined antimicrobial and remineralizing properties.[3,4]

Silver diamine fluoride is a colorless alkaline solution containing silver ions, fluoride ions, and ammonia. The silver component exerts a potent antibacterial effect by disrupting bacterial cell walls, inhibiting metabolic enzymes, and reducing biofilm formation, whereas fluoride promotes remineralization and enhances the resistance of demineralized tooth structure to future acid attack. Owing to its simplicity of application, cost-effectiveness, and high caries-arrest efficacy, SDF has become an important treatment modality, particularly for young children, patients with special healthcare needs, and individuals with limited access to conventional dental care.[5]

Despite its proven effectiveness in arresting caries, definitive restoration is often required following SDF application to restore tooth form, function, and esthetics.[6] Glass ionomer-based restorative materials are commonly recommended after SDF treatment because they chemically bond to tooth structure, release fluoride, exhibit favorable biocompatibility, and are suitable for minimally invasive restorative procedures. Conventional glass ionomer cement (CGIC), resin-modified glass ionomer cement (RMGIC), and newer glass hybrid restorative materials differ in their composition and mechanical properties, which may influence their bonding performance to SDF-treated dentin.[7,8]

The deposition of silver-containing reaction products on the dentin surface following SDF application may modify the dentin substrate and affect the adhesion of restorative materials. Previous studies have reported conflicting findings regarding the influence of SDF on the bond strength of restorative materials, and most investigations have focused on a single material rather than comparing different glass ionomer-based restoratives. Evidence directly comparing the bonding performance of conventional, resin-modified, and glass hybrid glass ionomer materials to SDF-treated dentin remains limited.

Therefore, the present in vitro study aimed to comparatively evaluate the shear bond strength of conventional glass ionomer cement, resin-modified glass ionomer cement, and glass hybrid restorative material bonded to 38% silver diamine fluoride-treated dentin. The null hypothesis was that there would be no significant difference in the shear bond strength among the three restorative materials following SDF pretreatment.

MATERIALS AND METHODS

Study Design

This in vitro experimental study was conducted to compare the shear bond strength of conventional glass ionomer cement (CGIC), resin-modified glass ionomer cement (RMGIC), and glass hybrid restorative material (GHRM) bonded to 38% silver diamine fluoride (SDF)-treated dentin.

Sample Selection

A total of 45 extracted human premolars free from cracks, restorations, developmental defects, and gross structural damage were selected. The teeth were cleaned of debris and soft tissue remnants using an ultrasonic scaler and stored in 0.1% thymol solution until use.

Specimen Preparation

The roots were embedded in self-cure acrylic resin blocks, leaving the crown exposed. A standardized flat mid-coronal dentin surface was prepared by removing the occlusal enamel using a water-cooled diamond disc. The exposed dentin surfaces were polished with 600-grit silicon carbide paper under running water to create a standardized smear layer.

Grouping of Specimens

The specimens were randomly divided into three groups (n = 15 each) according to the restorative material used:

Group I: Conventional Glass Ionomer Cement (Fuji IX GP Extra, GC Corporation, Japan)

Group II: Resin-Modified Glass Ionomer Cement (Fuji II LC, GC Corporation, Japan)

Group III: Glass Hybrid Restorative Material (Equia Forte HT, GC Corporation, Japan)

Silver Diamine Fluoride Application

All dentin surfaces were treated with 38% Silver Diamine Fluoride (e-SDF; Mumbai) according to the manufacturer's instructions. The SDF was applied with a disposable microbrush for 1-minute, excess solution was gently blotted, and the surfaces were allowed to air dry.

Table 1: Mean Shear Bond Strength (MPa) of the Study Groups

Group	Restorative Material	Mean ± SD (MPa)
I	Conventional GIC (Fuji IX GP Extra)	**5.82 ± 0.64**
II	Resin-Modified GIC (Fuji II LC)	**8.14 ± 0.71**
III	Glass Hybrid Restorative Material (Equia Forte HT)	**10.27 ± 0.83**

Table 2: Tukey's Post Hoc Comparison

Comparison	Mean Difference (MPa)	*p*-value
Group I vs Group II	2.32	<0.001
Group I vs Group III	4.45	<0.001
Group II vs Group III	2.13	<0.001

Bonding Procedure

A cylindrical Teflon mold with an internal diameter of 3 mm and height of 3 mm was positioned over the treated dentin surface. The respective restorative material was mixed and manipulated according to the manufacturer's instructions and packed into the mold. After initial setting, the mold was carefully removed, and the specimens were stored in distilled water at 37°C for 24 hours.

Thermocycling

The specimens were subjected to 500 thermocycles between 5°C and 55°C with a dwell time of 30 seconds and a transfer time of 10 seconds to simulate oral thermal stresses.

Shear Bond Strength Testing

The specimens were mounted in a Universal Testing Machine (Model: UNITEST-10, Manufacturer: ACME Eng, India) and loaded using a chisel-shaped blade at the restorative material–dentin interface at a crosshead speed of 1 mm/min until bond failure occurred. The maximum load at failure (N) was recorded and converted to shear bond strength (MPa) by dividing the load by the bonded surface area.

STATISTICAL ANALYSIS

The collected data were analyzed using SPSS software (Version 25.0; IBM Corp., Armonk, NY, USA). Data normality was assessed using the Shapiro–Wilk test. Intergroup comparisons of shear bond strength were performed using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test for pairwise comparisons. A p-value < 0.05 was considered statistically significant.

RESULT

The mean shear bond strength values of the three restorative materials bonded to 38% silver diamine fluoride-treated dentin are presented in Table 1. The glass hybrid restorative material (Group III) demonstrated the highest mean shear bond strength, followed by the resin-modified glass ionomer cement (Group II), while the conventional glass ionomer cement (Group I) exhibited the lowest mean bond strength.

One-way analysis of variance (ANOVA) revealed a statistically significant difference in shear bond strength among the three groups ($p < 0.001$). Tukey's post hoc analysis demonstrated that the mean shear bond strength of the glass hybrid restorative material was significantly higher than that of the conventional glass ionomer cement ($p < 0.001$) and resin-modified glass ionomer cement ($p < 0.05$). Additionally, the resin-modified glass ionomer cement exhibited significantly greater shear bond strength than the conventional glass ionomer cement ($p < 0.05$).

Overall, the findings indicate that glass hybrid restorative material exhibited the highest bond strength to 38% silver diamine fluoride-treated dentin, followed by resin-modified glass ionomer cement and conventional glass ionomer cement.

Table no 1 and 2

One-way ANOVA: $F = 134.62$, $p < 0.001$

DISCUSSION

The present in vitro study compared the shear bond strength of conventional glass ionomer cement (CGIC), resin-modified glass ionomer cement (RMGIC), and glass hybrid restorative material (GHRM) bonded to 38% silver diamine fluoride (SDF)-treated dentin. The results demonstrated a statistically significant difference among the three restorative materials, with the glass hybrid restorative material exhibiting the highest shear bond strength, followed by the resin-modified glass ionomer cement and the conventional glass ionomer cement.

Silver diamine fluoride has become an important agent in minimally invasive dentistry due to its ability to arrest dentinal caries through its antimicrobial and remineralizing actions. Following SDF application, silver-protein complexes, calcium fluoride, and other reaction products are deposited within the dentinal tubules and on the dentin surface.[9,10] These deposits alter the surface characteristics of dentin and may influence the bonding performance of restorative materials. Therefore, evaluating the bond strength of restorative materials to SDF-treated dentin is clinically relevant, particularly in the context of the Silver Modified Atraumatic Restorative Technique (SMART).[11]

The superior shear bond strength observed with the glass hybrid restorative material may be attributed to its refined glass particle technology, high-molecular-weight polyacrylic acid, and enhanced filler content, which improve mechanical properties and chemical interaction with dentin. In addition, the improved matrix formulation and increased fracture resistance of glass hybrid materials contribute to better stress distribution at the tooth-restoration interface, resulting in stronger adhesion to SDF-treated dentin.[12,13]

The resin-modified glass ionomer cement demonstrated significantly higher bond strength than the conventional glass ionomer cement. This finding may be explained by the dual setting mechanism of RMGIC, which combines the conventional acid-base reaction with resin polymerization. The presence of hydrophilic resin monomers, such as 2-hydroxyethyl methacrylate (HEMA), enhances adaptation to the dentin surface and contributes to improved bond strength and early mechanical stability.[14]

Conventional glass ionomer cement exhibited the lowest shear bond strength among the three materials. Although CGIC chemically bonds to tooth structure through ionic interaction between polyacrylic acid and calcium ions in hydroxyapatite, its lower mechanical strength and greater sensitivity during the initial setting phase may reduce its bonding effectiveness to dentin modified by SDF application.[15,16]

From a clinical perspective, these findings indicate that when definitive restoration is planned following SDF therapy, glass hybrid restorative materials may provide superior adhesion and improved restorative performance compared with conventional and resin-modified glass ionomer cements. Their higher bond strength, combined with fluoride release, biocompatibility, and ease of use, makes them an attractive restorative option for minimally invasive management of carious primary teeth.

The present study has certain limitations. Being an in vitro investigation, it could not completely replicate the complex oral environment, including masticatory forces, saliva, pH fluctuations, and long-term aging. In addition, only one concentration of SDF and one brand of each restorative material were evaluated. Future studies incorporating long-term aging protocols, cyclic loading, and clinical trials are recommended to validate these findings and assess their long-term clinical performance.

CONCLUSION

Within the scope of this in vitro study, the glass hybrid restorative material demonstrated the highest shear bond strength to 38% silver diamine fluoride-treated dentin, followed by the resin-modified glass ionomer cement, while the conventional glass ionomer cement exhibited the lowest bond strength. The findings suggest that glass hybrid restorative materials may be the preferred restorative option following silver diamine fluoride application, owing to their superior bonding performance and potential to enhance the longevity of minimally invasive restorations.

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