Effect Of Silver Diamine Fluoride And Potassium Iodide On The Microtensile And Shear Bond Strength Of Resin Modified Glass Ionomer To Dentin Of Primary Molars: In-Vitro Study

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Abstract

Aim: The present study aimed to evaluate the effect of silver diamine fluoride (SDF) and potassium iodide (KI) on the micro-tensile and shear bond strength of resin-modified glass ionomer cement (RMGIC) to dentin of primary molars.

Methods: Sixty freshly extracted primary molars were collected and stored in saline. For the micro-tensile bond strength, 20 teeth were sectioned into 2 halves through the carious lesions while for the shear bond strength 40 teeth were assigned and divided randomly into 2 groups. Group I was treated with 38% SDF followed by KI while group II was treated with deionized water and then both groups were restored with RMGIC. The specimens were placed in the universal testing machine to apply tension and shear forces until bond failure.

Results: The mean and standard deviation of micro-tensile bond strength for group I and group II were 8.75±0.96 and 8.43±1.04 respectively with no statistically significant difference with an adhesive failure mode in both group. While the mean and standard deviation of shear bond strength for group I and group II were 1.38±0.22 and 1.26±0.41 with no statistically significant difference with an adhesive failure mode in both groups.

Conclusion: Pretreatment of primary dentin with 38% SDF and (KI) did not affect the micro-tensile nor the shear bond strength of RMGIC.

Keywords: Bond Strength, Potassium Iodide, Primary Molars, Resin Modified Glass Ionomer, Shear, Silver Diamine Fluoride, Tensile.

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the dental tissues. The tooth discoloration can be reduced by the incorporation of potassium iodide (KI)into SDF during application.

The current study aimed to investigate the effect of SDF and KI on the micro-tensile and shear bond strength of resin-modified glass ionomer cement to dentin of primary molars**(Abdullah et al., 2020).**

Material and Methods

Study Design

This study was an in-vitro study conducted to measure the effect of silver diamine fluoride and potassium iodide on the micro-tensile and shear bond strength of resin-modified glass ionomer cement to dentin of primary molars.

Sample Size Calculation

A power analysis was designed to have adequate power to apply a 2-sided statistical test of the null hypothesis that SDF does not affect the bond strength of resin-modified glass ionomer restoration to dentin of primary molars. Sample size calculation was performed using G*Power version 3.1.9.4 2 based on the results of **Nasr and Saber, 2020**. By adopting an alpha (α) level of 0.05 (5%), a Beta (β) level of 0.2 (20%), a power of 80%, and an effect size of 0.454, the predicted sample size (n) was a total of (60) samples.

Ethical Approval

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Dentistry, Cairo University, Egypt on 28/7/2020 with approval number 29-7-20.

Eligibility Criteria

Sixty freshly extracted carious first and second primary molars were collected from the Pediatric Dentistry and Dental Public Health Department, Cairo University.

Inclusion Criteria:

- Freshly extracted carious first and second primary molars with at least two remaining surfaces of the tooth structure.
- Caries extends radiographically more than half the distance between dentin-enamel junction (DEJ) and the pulp chamber.

Exclusion Criteria:

- Teeth with previous restorations.

Introduction

Dental caries is one of the most prevalent chronic diseases and the primary cause of oral pain and tooth loss. It is defined as the localized destruction of susceptible dental hard tissues by acidic by-products from bacterial fermentation of dietary carbohydrates. In recent years, the improvement of our understanding of the caries process and the evolution of novel restorative materials has given us the capacity to practice dentistry with a minimally invasive approach**(Zhao et al., 2019).**

The primary objectives of minimally invasive dentistry are to prevent or arrest active disease using non-operative management techniques whichhave a variety of well-documented advantages over traditional techniques by minimizing unnecessary tooth tissue loss, decreasing insult to the dentin-pulp complex, and reducing the risk of iatrogenic damage to adjacent hard and soft tissues. They also maximize the strength of the residual tooth structure by using optimal adhesive restorative materials designed to restore function and aesthetics with durable, long-lasting restorations that are easy for the patient to maintain**(Mackenzie and Banerjee, 2017).**

Silver diamine fluoride (SDF) is an effective, efficient, safe, and affordable agent that is used successfully to prevent or arrest carious lesions in patients unable to tolerate invasive treatment, including young children, elderly populations, special needs, and medically compromised patients**(Bridge et al., 2021).**

Treatment with SDF promotes tooth desensitization and arrest of carious lesions by blockage of the dentinal tubules, destruction of cariogenic bacteria, remineralization of the demineralized tooth structure, and inhibition of dentinal collagen degradation**(Seifo et al., 2020).**

Despite its benefits, the adverse effects associated with SDF application are pulpal irritation, dental staining, and oral soft tissue irritation. The main disadvantage of SDF is the black staining of the arrested carious lesions due to the precipitation of silver by-products in polished with silicon carbide paper to create a uniform surface.Then approximately 4 mm of RMGIC was applied on the dentin surface after being mixed via amalgamator for 10 s according to the manufacturer's instructions and was polymerized using visible light curing unit for 20 s.

After the RMGIC is hardened, the specimens were stored in saline for 24 hours. Then the specimens were fixed in acrylic blocks and were sectioned using a low-speed water-cooled diamond saw to obtain slices approximately 0.7 mm in thickness. Each specimen was placed in the testing for Universal Testing Machine and stressed in tension at a crosshead speed of 1 mm per minute until bond failure then recorded the maximum stress at failure and convert it to Mega Pascals (MPa) units as follows: $\tau = P/A$ Where*;*

➢ τ = Micro-tensile bond strength in MPa
➢ P = Load at failure in Newton (N)
➢ A = The bonded surface area in square millimeters (mm^2)

2. Evaluation of shear bond strength

Forty extracted primary molars were mounted in acrylic resin molds with their carious surfaces exposed, perpendicular to the long axis of the mold. To obtain a flat dentin surface, the carious surface of the crowns was gently polished using the low-speed diamond disk with water coolant. Then the roots of the teeth were cut off 2 mm below the cementum-enamel junction using a low-speed cutting machine and mounted in acrylic resin molds. Teeth were randomly allocated to either:

- Group I (Intervention group): 20 teeth were treated with 38% SDF on the carious dentin surface and agitated using a micro-brush for 1 minute followed by application of KI for 3 minutes till forming a creamy mix, followed by a 30-second rinse with distilled water.
- Group II (Control group): 20 teeth were treated with deionized water on the carious dentin surface for 1 minute.

All specimens were stored in saline for 14 days at room temperature to keep them constantly hydrated. After storage, the carious

- Teeth with pits and fissure sealants.
- Teeth with hypoplasia or hypomineralization.

Sample Storage

Teeth were cleaned with a hand-scaling instrument and stored in a saline solution at room temperature for a maximum of two months. Each tooth was stored in a sterile opaque glass separate container, and the containers were numbered sequentially.

Randomization and Allocation Concealment

The teeth were randomly assigned to intervention and control groups using simple randomization with an allocation ratio of 1:1.

Sequence Generation:

The co-supervisor generated a random sequence using computer software at random.org.

Allocation Concealment:

The generated random sequences were kept with the co-supervisor.

Implementation:

The co-supervisor was responsible for randomization and allocation concealment and informed the principal investigator about the allocation of the sample.

Sample Preparation

1. Evaluation of micro-tensile bond strength

Twenty extracted primary molars were sectioned through the center of the carious lesion using an automated diamond saw forming two similar halves. Following sectioning, these two specimens were randomly allocated to either:

- Group I (Intervention group): 20 specimens were treated with 38% SDF on the carious dentin surface and agitated using a micro-brush for 1 minute followed by application of KI for 3 minutes till forming a creamy mix, followed by a 30-second rinse with distilled water.
- Group II (Control group): 20 specimens were treated with deionized water on the carious dentin surface for 1 minute.

All specimens were stored in saline for 14 days at room temperature to keep them constantly hydrated.After storage, the carious surface of each specimen was flattened with a diamond bur in a high-speed handpiece and stereomicroscope at 40x magnification then failure mode was categorized into three types including type 1 which indicates an adhesive failure between dentin and RMGICs with exposing dentin surfaces, type 2 which denotes a cohesive failure in RMGICs or dentin, and type 3 which indicates partially adhesive failure and partially cohesive failure, a mixed failure.

Results

1. Evaluation of micro-tensile bond strength

For the micro-tensile bond strength, 20 teeth were sectioned into 2 equal halves through the carious lesions and randomly allocated to 2 equal groups:

Group I (Intervention group)**:** 20 specimens treated with 38% SDF and (KI) on the carious dentin surface followed by resin-modified glass ionomer cement.

Group II (Control group)**:** 20 specimens treated with deionized water followed by resin-modified glass ionomer cement.

Micro-tensile bond strength was represented as mean and standard deviation (mean±SD) in MPa with (8.75±0.96) for group I and (8.43±1.04) for group II.Paired t-test showed no statistically significant difference in micro-tensile bond strength between groups with a *P*-value =0.463, as shown in **Table (1)**.

surface of each specimen was flattened with a diamond bur in a high-speed handpiece and polished with silicon carbide paper to create a uniform surface. A plastic cylindrical-shaped moldwith an internal diameter of 3 mm and 4 mm in height was placed at right angles on the cut surface of the polished flat dentin and restored with RMGIC in increments to create a standardized bonding area, and polymerized using visible light curing unit for 20s. After the RMGIC is hardened, the polyvinyl mold was removed and the teeth were stored in saline for 24 hours.

Using the Universal Testing Machine a shear force was applied perpendicularly to the RMGIC cylindrical button at a distance of 1 mm from the dentin surface to the loading head until bond failure and the load necessary to debond RMGICs was recorded in N. The bond strength was expressed in MPa by dividing the load at failure by the bonded surface area in square mm, as follows: MPa: τ = P/A Where;

- ➢ τ = Shear bond strength in MPa.
- ➢ P = Load at failure in N.
- ➢ A = The bonded surface area in mm^2.

3. Evaluation of the failure mode

Following micro-tensile and shear testing, the failure mode was evaluated by examining the debonded samples with a

Table (1): Descriptive statistics for micro-tensile bond strength in MPa for both groups

Group	Mean	SD	Median	Minimum	Maximum	Range	*P-* value
Group I	8.75	0.96	8.24	7.2	10.2	2.9	0.463(NS)
Group П	8.43	1.04	8.35	7.1	10.1	3.0	

*significant (p≤0.05) ns; non-significant (p>0.05)

2. Mode of failure of micro-tensile bond strength

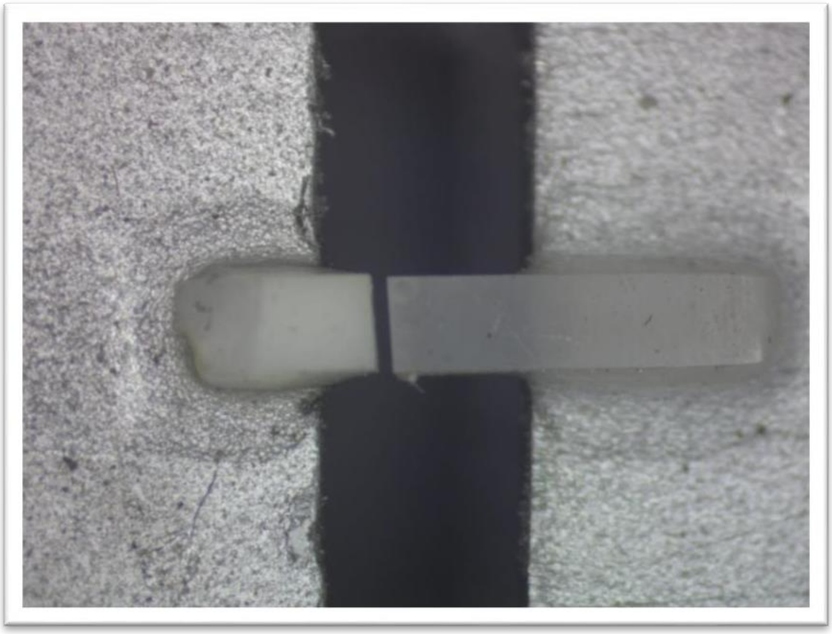
For micro-tensile bond strength, the mode of failure was presented in frequencies and percentages where 100% of the samples in both groups failed adhesively, as shown in **Table (2) and Figure (1).**

Table (2): Frequencies and Percentages of the mode of failure for micro-tensile bond strengthin both groups

Failure mode		Group I	Group П
Adhesive	**Frequency**	20	20

	Percentage	100%	100%
Cohesive	**Frequency**	0	0
	Percentage	0%	0%
Mixed	**Frequency**	0	0
	Percentage	0%	0%

Figure (1): Adhesive mode of failure for the micro-tensile bond strength inspected under the stereomicroscope



3. Evaluation of shear bond strength

For the shear bond strength, 40 teeth were randomly allocated to 2 equal groups:

Group I (Intervention group)**:** 20 teeth treated with 38% SDF and (KI) on the carious dentin surface followed by resin-modified glass ionomer cement.

Group II (Control group)**:** 20 teeth treated with deionized water followed by resin-modified glass ionomer cement.

Shear bond strength was represented as mean and standard deviation (mean±SD) in MPa with (1.38±0.22) for group I and (1.26±0.41) for group II. Paired t-test showed no statistically significant difference in shear bond strength between groups with a *P*-value =0.248, as shown in **Table (3).**

Table (3): Descriptive statistics for shear bond strength in MPa for both groups.

Material	Mean	SD	Median	Minimum	Maximum	Range	P- value
Group I	1.38	0.22	1.37	1.0	1.8	0.7	0.248(NS)
Group Π	1.26	0.41	1.41	0.4	1.9	1.4	

***significant (p≤0.05) ns; non-significant (p>0.05)

4. Mode of failure of shear bond strength

For shear bond strength, the mode of failure was presented in frequencies and percentages where 100% of the samples in both groups failed adhesively, as shown in **Table (4) and Figure (2).**

Table (4): Frequencies and percentages of the mode of failure for shear bond strength in both groups.

Failure mode		Group I	Group Π
Adhesive	**Frequency**	20	20
	Percentage	100%	100%
Cohesive	**Frequency**	0	0
	Percentage	0%	0%
Mixed	**Frequency**	0	0
	Percentage	0%	0%

Figure (2): Adhesive mode of failure for the shear bond strength inspected under the stereomicroscope

tooth is to repair destruction from a carious lesion. In recent years, advancement in our understanding of the caries process and the development of adhesive restorative materials has created the ability to practice in consideration of a minimally invasive dentistry philosophy **(Quock et al., 2012).**

Discussion

Dental caries continues to be a prevalent disease, even in advanced countries. Traditionally the discipline and practice of operative dentistry have been closely related to our understanding of the caries disease process. It has been observed that the primary reason for cavity preparation and filling of a significant difference between the two groups (*P*-value=0.463). This finding was in agreement with **Uchil et al., 2020** whichcan be attributed tothe fact that SDF releases fluoride ions and aids in the deposition of silver phosphate to restore mineral content, enhancing the micro-hardness of carious dentin surfaces and consequently bond strength. However, the silver granule precipitate formed on the denatured collagen fibrils after SDF application could result in reduced restorative material bond strength to SDF-modified dentin **(Puwanawiroj et al., 2018; Uchil et al., 2020).**

The shear bond strength of group I was 1.26±0.41 MPa, and the shear bond strength of group II was 1.38±0.22 MPa with no statistically significant difference between the two groups (*P*-value=0.248) which can be explained by the possibility that SDF-modified dentin zone was partly removed at the superficial level when polished with silicon carbide paper **(Sharma et al., 2022).**

On the contrary, **Soliman et al., 2020; Sa'ada et al., 2021** reported that pre-treatment of primary dentin with 38% SDF increases the shear bond strength between RMGIC and primary dentin with a statistically significant difference which can be justified by the fact that reduced collagen degradation and promotion of remineralization by the anti-matrix metalloprotease action of SDF can improve the chemical bond of RMGIC to the collagen fibrils. Moreover, fixation of the organic material by SDF leads to enhanced interlocking of RMGIC to dentin **(Jiang et al., 2020; Soliman et al., 2021; Sa'ada et al., 2021)**.

In the present study, the mode of failure was observed by the stereomicroscope for micro-tensile and shear bond strength where all samples failed within the adhesive. This finding was consistence with **Vuong, 2020** and can be attributed to the fact that SDF forms a film on the dentin surface and deposits in some dentinal tubules impairing the adhesive interface of the RMGIC **(Saad et al., 2017; Vuong, 2020**).

The strength of the in-vitro experimental study was achieved by being carried out in

Since the early 1970s,SDF is an effective non-invasive treatment option that has been used to arrest dental caries in countries throughout the world, primarily in pediatric populations.It has been proven that SDF possesses a bactericidal effect that can reduce the adherence and growth of cariogenic bacteria, promotes remineralization, and inhibits demineralization. It is indicated for high caries-risk patients who are medically compromised or require additional support and can not tolerate invasive treatment **(Zhao et al., 2017).**

However, the main adverse effect that is commonly reported is that the caries lesion is stained dark by the SDF. Using a saturated (KI) solution can mask the staining by reacting with silver ions. Additionally, SDF and KI in combination have been shown to be effective in boosting resistance to a cariogenic challenge**(Zhao et al., 2018; Zhao et al., 2019).**

Before the placement of adhesive restorative materials, SDF can be applied immediately as a part of the SMART. The SMART procedure helps to eliminate cariogenic bacteria, enhances pulp vitality, and promotes the remineralization of the carious lesion. Although this technique has the advantages of minimal tooth preparation and caries-preventing properties of both SDF and glass ionomer cement, there has been little research on the combined effects of these products**(Chibinski et al., 2017; Modasia and Modasia, 2021).**

Several studies have investigated the effect of SDF and SDF/KI on the bond strength of dental adhesives and resin-modified glass ionomersbut no solid conclusion can be drawn due to the high degree of variation in the studies **(Jiang et al., 2020).**So the present study aimed to measure the effect of SDF and KI on the micro-tensile and shear bond strength of resin-modified glass ionomer to dentin of primary molars.

In the present study, the micro-tensile bond strength of group I was 8.75±0.96 MPa, and the micro-tensile bond strength of group II was 8.43±1.04 MPa with no statistically

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laboratory conditions. This removed the possibility of clinical errors such as limited mouth opening, moisture control, and standardized size of the specimen. However, the limitation of the study includes the difficulty to simulate the oral conditions regarding the biological aspects of caries and many factors that may contribute to bond strength in vital teeth.

Conclusions

Application of silver diamine fluoride and potassium iodide does not adversely affect the micro-tensile nor the shear bond strength of resin-modified glass ionomer cement to carious primary dentin.

The adhesive failure was reported during the evaluation of the tensile and shear bond strength of resin-modified glass ionomer cement to carious primary dentin.

Conflict of interest:

The author has no conflict of interest to disclose.

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