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## The Effect of Silver Diamine Fluoride on Microleakage and Shear Bond Strength of Glass Ionomer

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### ABSTRACT

**Purpose:** This study was conducted to evaluate the impact of silver diamine fluoride (SDF) on Glass ionomer restoration (Fuji IX) microleakage and shear bond strength. **Material and Methods:** The present study was carried out on 40 primary extracted human molars. The primary molars were equally divided into 2 groups (Group I, Group II). (Group I) including: 20 primary molars were used for microleakage testing under stereomicroscope at x40. (Group II) including: 20 primary molars were used for shear bond strength testing using Instron Universal Testing Machine. Each group was subdivided into 2 subgroups; subgroup 1 which been treated with SDF then restored by Glass ionomer restoration and subgroup 2 which was restored with Glass ionomer without SDF. **Result:** In microleakage analysis comparing both groups in both surfaces, the highest mean value was recorded in glass ionomer without SDF group in the occlusal surface ( $758.77 \pm 69.65$ ), followed by glass ionomer without SDF group in the gingival surface ( $643.74 \pm 83.77$ ), then glass ionomer with SDF group in the occlusal surface ( $126.06 \pm 10.70$ ), with the least value was recorded in Glass ionomer with SDF group in the gingival surface ( $109.12 \pm 5.58$ ). In shear bond strength analysis, the higher mean value was recorded in Glass ionomer with SDF group ( $9.38 \pm 1.12$ ), while that recorded in Glass ionomer without SDF group was ( $1.97 \pm 0.16$ ). **Conclusion:** The results of the current analysis suggest that the use of SDF minimized microleakage and increased intensity of shear bond strength for Glass ionomer restoration.

### KEYWORDS

Silver Diamine Fluoride,  
Microleakage,  
Shear bond Strength,  
Glass Ionomer Restoration

### INTRODUCTION

Tooth decay is a natural procedure in which biofilm bacteria cause pH fluctuations that can lead to the loss of dental hard tissue and visible lesions, and is the most extreme childhood disease in the world<sup>(1)</sup>.

- Paper extracted from Master thesis titled “The Effect of Silver Diamine Fluoride on Microleakage and Shear Bond Strength of Glass Ionomer”

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Water fluoridation, toothpaste fluoride, fluoride varnish, sealants, interim therapeutic restorations or atraumatic restorations and Silver Diamine Fluoride are popular caries prevention agents. Fluoride work to reduce the incidence and severity of dental caries that need restorative dental treatment in pre-eruptive, post-eruptive, systemic and topical circumstances <sup>(2)</sup>.

Silver compounds have been used in dentistry since 1840. Silver Diamine Fluoride ( $\text{Ag}(\text{NH}_3)_2\text{F}$ ) (SDF) is a liquid which has been used to prevent tooth decay since 1970. While its mode of action is not well known, the silver nitrate destroys, bacteria and fluoride remineralizes and prevents bacteria. Silver salts cause dentin sclerosis/calcium calcification<sup>(3)</sup>. A variety of in vitro trials have been performed supporting the SDF's clinical effectiveness indicating that SDF decreases the vulnerability of dental tissue to chemical acid challenges and helps to remineralize enamel <sup>(4,5)</sup>.

As a cariostatic agent, SDF has been used to enable silver phosphate deposition to restore mineral content. Therefore, we suggested that the use of SDF may boost the performance of the restorations in operative dentistry, and the Glass ionomer restoration microleakage would decrease<sup>(6)</sup>.

Microleakage involves the entry the bacteria, ions and fluids between the cavity wall and the restoration resulting in its failure. Therefore, the adhesion of restorative materials to dental tissue is very critical <sup>(7)</sup>. The ideal restorative material should be similar in physical characteristics to dental tissue. It should adhere well to dentin and enamel, and should not undergo structural oral variations. Although no restorative material is available with any of these characteristics. There is a major stage in the manufacturing of restorative products that can bind chemically to dentin and enamel and release fluoride. Glass ionomer cements (GICs) were designed by McLean, Wilson, and Kent towards the end of the twentieth century and are now widely used <sup>(7)</sup>.

In order to withstand various dislodging forces operating within the oral cavity, the therapeutic efficacy of restorative materials depends on strong dentinal surface adhesion. These forces are determined in terms of compression strength, tensile strength, and shear strength. The resistance to forces that transfer restorative material past the structure of the tooth is the shear bond strength. Clinically, Because the main dislodging forces at the tooth restoration interface are sheared, the restorative material is critical. Consequently, the greater shear bond strength indicates stronger bonding of the material to the tooth<sup>(8)</sup>.

GC Fuji IX, a newer glass ionomer generation, was designed specifically for geriatric and paediatric patients, and was introduced in the late 1990s to clinical practice. It has high strength, wear resistance, chemical adhesion to the tooth structure, fluoride release and radio opacity, and it is very viscous, has better aesthetics and is condensable. This improvement was due to a decrease in the size of the glass particles in the matrix, allowing the silica and polyacrylic acid particles to react more quickly <sup>(8)</sup>.

## MATERIALS AND METHODS

In this study we used 38% Silver diamine fluoride (SDF) (solution) (Tedequim, Argentina), glass ionomer restoration (Fuji IX) (GC America, America), nail varnish (Yolo United states ), 0.5% basic fuchsin solution ( Atom scientific, United Kingdom) and self-cure acrylic resin blocks (Chand Handicraft, India). This study was performed on 40 extracted human primary molar teeth for testing microleakage and shear bond strength. Surface debridement was done with the hand-scaling instrument, cleaning with a rubber cup and slurry of pumice, and teeth were subsequently stored in distilled water at temperature of 4°C until further use<sup>(9)</sup>.

### Sample grouping

The 40 extracted human primary molar teeth were divided equally in to 2 Groups; (Group I, Group II) for testing microleakage and shear bond strength.

- (Group I): 20 primary molars were used for microleakage testing using stereomicroscope.
- (Group II): 20 primary molars were used for shear bond strength testing using Instron Universal Testing Machine.

Each group was further subdivided into 2 subgroups:

- (Subgroup 1): 10 primary molars in which cavity was treated with SDF then restored with Glass ionomer (Fuji IX).
- (Subgroup 2): 10 primary molars in which cavity was restored with Glass ionomer (Fuji IX) only.

### Sample preparation

#### *Preparation for microleakage testing (Group I): -*

A standardized Class V cavity was prepared on the buccal surface of each tooth using tungsten carbide straight fissure bur size #330 (SS White Bure, New Jersey) under air-water cooling. The bur was replaced after every five preparations. The dimensions of the preparations measured 3mm in length, 2mm in width, and 1mm in depth with the occlusal margin placed in enamel and the gingival margin placed in dentin. A William's graduated periodontal probe was used to confirm the dimensions of the cavity<sup>(10)</sup>. The teeth were randomly assigned into two subgroups (1 and 2).

#### *Placement of Silver Diamine Fluoride*

In subgroup 1, the SDF solution was applied to dentine surface for 2 minutes using a standardized microbrush until the creamy white solution turned clear. The reaction products were washed off with copious distilled water and then blot dried according to manufacturer instruction presented in (Fig.1).

#### *Placement of Glass ionomer (FujiIX)*

Glass ionomer (FujiIX) was mixed according to the manufacturer's directions:

First and foremost, Shake or tab to loosen powder, then depress plunger, then click once in capsule

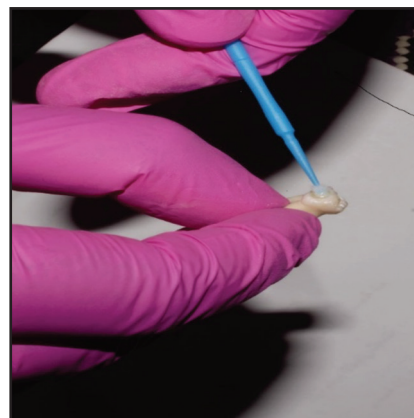


Figure (1) Application of Silver Diamine fluoride (SDF)

applier to trigger, then mix for ten seconds, then two clicks to prime capsule, then slowly syringe in cavity, and finally finish the restoration after setting.

#### *Preparation for shear bond strength testing*

The teeth were partially submerged into separate self-cure acrylic resin blocks of 1 cm × 1 cm × 2 cm in size<sup>(10)</sup>. The teeth were sectioned with a slow-speed diamond abrasive disc (Toboom, China) through a plane parallel to the longitudinal axis at the level of the middle third to expose a flat dentine surface. The tooth surface was then ground flat using silicon carbide rough paper of 180-grit (eQualle, Chicago, USA). The dentin surface was polished with 600-grit silicon carbide paper (eQualle, Chicago, USA) to standardize the smear layer<sup>(10)</sup>.

### Testing Procedures

#### *Microleakage analysis*

Specimens were stored in distilled water at 37°C for 24 hours after finishing and polishing procedures. The specimens then were submitted to 1000 thermocycles with 30s baths at temperature of 5°C and 55°C and a dwell time of 10 s in a resting bath at 24°C. Root ends were sealed with a layer of composite resin and double-coated with

nail varnish up to 1mm from the restoration margins. All samples were subsequently immersed in 0.5% basic fuchsin solution (atom scientific, India) for 24 hours. After removal from the dye solution, the teeth were washed and sectioned longitudinally through the centre of the restorations in a bucco/lingual plane with a diamond saw, then microleakage was measured in both surfaces; occlusal and gingival Marginal leakage, as indicated by the depth of dye penetration at the margins, was evaluated under stereomicroscope (United Scope LLC, Irvine, California). at x40 magnification for each restoration, the section with greater leakage was selected for scoring. The evaluations were carried out blindly by an evaluator who wasn't aware of the groups <sup>(11)</sup>.

### Shear bond strength analysis

The specimens were evaluated for the bond strength of Glass ionomer (Fuji) to dentin. Samples were positioned into a positioning jig and tested for shear strength with Instron Universal Testing Machine using at a crosshead speed of 0.5 mm/min. The strengths of the samples were calculated and expressed in MPa. Statistical analysis of the mean shear bond strength values was obtained in the various groups <sup>(11)</sup>.

## RESULTS

### I- Microleakage analysis

#### Comparison of both surfaces within the same group

Comparison of both surfaces is presented in Table (1) and (Fig. 2,3)

In glass ionomer without SDF group, a higher mean value was recorded in the occlusal surface ( $758.77 \pm 69.65$ ), in comparison to the gingival surface ( $643.74 \pm 83.77$ ). This difference was statistically significant ( $p=0.00$ ). In glass ionomer with SDF group, a higher mean value was recorded in the occlusal surface ( $126.06 \pm 10.70$ ), in comparison to the gingival surface ( $109.12 \pm 5.58$ ). This difference was statistically significant ( $p=0.00$ ).

**Table (1)** Descriptive statistics and comparison of microleakage in both surfaces within each subgroup (independent *t* test)

		Subgroup 2	Subgroup 1
<b>Occlusal</b>	Mean	758.77	126.06
	Std Dev	69.65	10.70
<b>Gingival</b>	Mean	643.74	109.12
	Std Dev	83.77	5.58
T		5.09	27.99
p-value		0.00*	0.00*

*P-value Significant at  $\leq 0.05$*

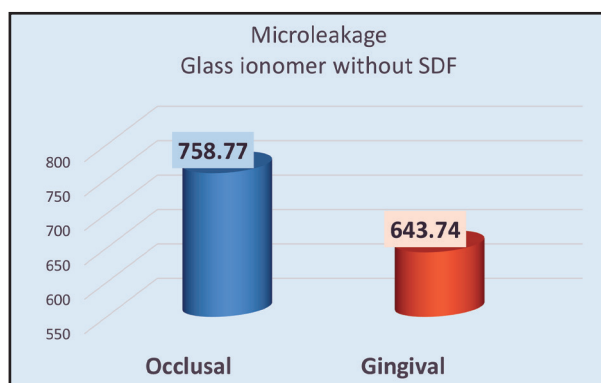


Figure (2) Bar chart illustrating mean values of microleakage analysis in subgroup 2

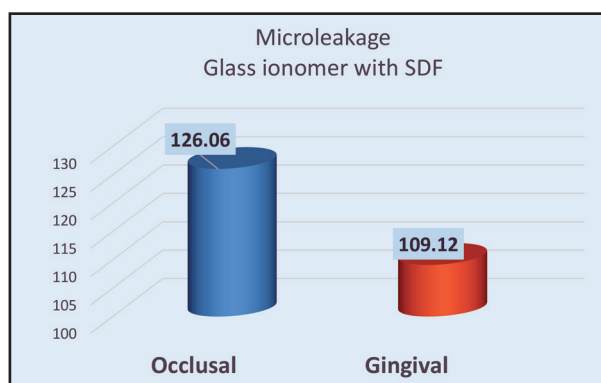


Figure (3) Bar chart illustrating mean values of microleakage analysis in subgroup 1

## II-Shear bond strength (MPa) analysis: -

### Comparison between groups

The highest mean value was recorded in glass ionomer with SDF group ( $9.38 \pm 1.12$ ), while the lower value was recorded in glass ionomer without SDF group ( $1.97 \pm 0.16$ ). Independent t test revealed that the difference between groups was statistically significant ( $p=0.00$ ), as presented in Table (2) and (Fig.4)

Table (2) Descriptive statistics and comparison of mean value of shear stress (MPa) between subgroups (independent t test)

	(Shear bond strength (Mpa)	
	Subgroup 2	Subgroup 1
Mean	1.97	9.38
Std Dev	0.16	1.12
T	29.29	
p-value	*0.00	

*P-value significant at  $\leq 0.05$*

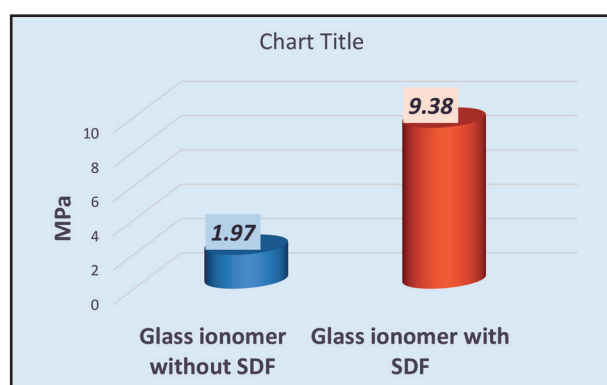


Figure (4) Bar chart illustrating mean values of shear bond strength (MPa) in both subgroups

## DISCUSSION

The purpose of this study was to see how the 38 percent Silver Diamine Fluoride of Glass ionomer restoration affected microleakage and shear bond strength (Fuji IX), SDF is used as an agent for promoting the arrest and remineralization of active carious lesions. It is helpful for active dentinal lesions. It can be used as a caries detector as it stains only carious dental tissue. It also helps uncooperative children or children who require more advanced behaviour management <sup>(12)</sup>.

In all the experiments, there was a clear difference between the caries arrest shown in the treatment and the control arms. A study showed that 38% SDF application contributed to a rise in caries arrest rate of 1 percent-20 percent compared to control of 12 percent SDF <sup>(13)</sup>.

In any randomized control trial, no severe adverse effects, such as allergic reactions, toxicity, or pulpal irritation, have been documented <sup>(14)</sup>. There has been evidence of unusual gingival reactions and chemical skin burns. From a pharmacokinetic viewpoint, SDF use is safe even when applied to multiple carious lesions during the same visit. No quantitative evidence is available for serum toxicity in children following SDF application <sup>(15)</sup>. A new survey <sup>(16)</sup> measuring adult serum silver and fluoride ion concentrations after SDF application to three teeth per participant, however, showed that serum concentrations reaching acute toxic levels were not obtained by either silver or fluoride.

In this study, microleakage was investigated in vitro by the process of dye penetration because. is a commonly accepted and favoured, readily available, affordable, and non-toxic technique. 0.5 percent simple fuchsin is the most effective dye for microleakage disclosure <sup>(17)</sup>; Consequently 0.5% simple fuchsin was used. Samples were identified by a microscope after sectioning to certify that the penetration of dye came from the interface of dentin/restoration and not from another process of dentin. The most infiltrated specimen of each tooth was



then chosen and its length was measured in millimetres by a computer program. This calculation of microleakage is considered to be more tolerable than the evaluation of the score because it allows quantitative and parametric statistical analysis <sup>(18)</sup>.

For a variety of reasons, the fluoride-releasing alternative to costly compounds and composites, as well as amalgamation, is simple to use, treat, and place in many cases. In this study, glass ionomer restoration (Fuji IX) was used. It has wear-resistant, attaches to the tooth structure chemically, as a true glass ionomer, has a tooth-like coefficient of thermal expansion, and releases impressive amounts of rechargeable fluoride. It's available in hand-mix powder-liquid and pre-measured capsules. It is the right product for geriatric and paediatric restorations (non-stress areas) Intermediate Restorative reconstruction (IRM).

Results showed that the least leakage was found in the SDF group relative to glass ionomers without the SDF group in this current analysis. Work on the impact on the bond strength and microleakage of resin-modified glass ionomer cement of silver diamine fluoride-potassium iodide and 2 percent chlorhexidine gluconate cavity cleansers is a previous report <sup>(11)</sup> that complies with the results of our research. Which showed that the SDF-KI application had the least microleakage of all the groups. Furthermore, another study working on the effect of silver diamine fluoride on the adhesion and microleakage of a tooth enamel pit and fissure sealant revealed that, compared with those treated with SDF, most of the samples that were not treated with SDF (81.6%) showed microleakage, Microleakage was found in 47 % of the cases. <sup>(19)</sup>.

On the other hand, another analysis had shown a contrary outcome; in which there was no major difference between the control group (no SDF pretreatment) and the experimental group (38% SDF pretreatment) in terms of microleakage <sup>(3)</sup>. The effects of the previous contradiction might be due to permanent teeth being used (extracted human man-

dibular third molars) not primary molar teeth, and the use of Resin Composite restoration, not Glass ionomer restoration.

The mean shear bond strength value was found to be higher for the SDF treated group in the present study and was lower for Glass ionomer without SDF group. This was consistent with another research comparing silver diamine fluoride with photodynamic treatment on the integrity of the resin-modified glass ionomer cement bond to demineralized dentin, and found that dentin treated with 38% SDF and potassium iodide when bonded to Glass ionomer repair showed improved bond strength compared to other treatment regimens <sup>(20)</sup>. Furthermore, further research working on the bond strength and microleakage of silver diamine fluoride-potassium iodide resin-modified glass ionomer cement and 2 percent chlorhexidine gluconate cavity cleansers showed that the application of SDF-KI had a dramatic improvement in the bond strength of Glass ionomer restoration <sup>(11)</sup>.

On the other hand, there was another study that showed a contradictory result which suggested that the treatment of silver diamine fluoride does not have an important influence on the strength of the bond of glass ionomer cement to dentin lesions, and improved retention was achieved by enabling SDF solution to be set for one week before GIC placement <sup>(21)</sup>. This outcome was due to using (Ultra-Tester Machine) which is different than used in our study (Instron Universal Testing Machine)

## CONCLUSION

Within limitation of this study, it was found that the Silver Diamine Fluoride (SDF) has reduced the microleakage and improved the shear bond strength of Glass ionomer restoration.

## RECOMMENDATIONS

Further studies can be done comparing Silver Diamine Fluoride (SDF) with more recent preventive agents of dental caries.

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