COMPARATIVE EVALUATION OF THE EFFECT OF APPLICATION OF SILVER DIAMINE FLUORIDE AND POTASSIUM IODIDE ON THE BOND STRENGTH OF GIC TO ERODED DENTIN – AN IN-VITRO STUDY

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Abstract

Silver diamine fluoride (SDF) is an excellent tool currently used widely to treat and prevent dental caries. However, it involves the drawback of causing black stains which may be reversed by the application of Potassium iodide (KI) after SDF treatment. The current study aims to evaluate the effect of application of SDF and KI on the bond strength of GIC to eroded dentin. Thirty maxillary premolars were subjected to an acid-pH cycle, and their corresponding intervention. Group1:SDF followed by GIC; Group 2: SDF and KI followed by GIC; Group 3(Control): GIC alone. The microtensile bond strength was calculated with the universal testing machine (UTM). To test the comparison of bond strength between the groups, Kruskal Wallis One-way ANOVA test and Bonferroni multiple comparison test were used. The mean microtensile strength of Group 1 (SDF and GIC) was 5.15 MPa (±1.45), group 2 (SDF and KI followed by GIC) was 10.42MPa (± 2.07), as compared to Group 3 (GIC alone) 4.5 (±0.9). The application of KI significantly increased the bond strength between GIC and eroded dentinal surfaces treated with SDF.

Keywords: *Microtensile bond strength, Glass ionomer cement, Potassium iodide, Silver diamine fluoride*

1. Introduction

Silver diamine fluoride (SDF), a topical fluoride solution is currently being used at 38% concentration (44,800 ppm fluoride) as an alternative to invasive dental treatment.[1] SDF inhibits dentine demineralization, prevents dentine collagen degradation, and can also transform hydroxyapatite into fluorapatite, which enables dental hard tissues to resist acidic challenges.[2]

In large lesions, adjunctive restorative procedures to SDF are considered to maximize its effectiveness.[3] Thus, SDF can be used in conjunction with Glass Ionomer cement (GIC) for cavitated lesions to combine the benefits of caries arrest and a restoration. The application of GIC over SDF-treated lesions is referred to as 'Silver-Modified Atraumatic Restorative Technique (SMART)'. Earlier studies on restorative procedures have shown an improved bond strength of GIC to tooth surface after the application of SDF and an increased resistance to marginal caries.[3] In addition, it has also shown to produce good pulpal response and promote reparative dentine formation.[4] Zhao *et al.*[5] demonstrated *ex-vivo* this benefit which further supports silver-modified atraumatic restorative treatment to prevent restorative failure. Nevertheless, the clinical use of SDF has been limited by its property of causing black stains to both tooth and restoration. This is caused by the environmental oxygen which initiates a reduction reaction of free silver ions which converts the lesion black. This has raised a huge concern for aesthetics by both the patient and parent. An alternative proposed to overcome this limitation is to apply potassium iodide (KI) solution. The KI reacts with the available silver to produce a white reaction product thus obscure the black stains.[6] However, potassium iodide forms a chalky white product which does not render the tooth its natural hue. Though the SDF stains remain masked under the application of potassium iodide, aesthetic demands remain incompletely addressed. A proposition to the application of GIC over the KI-treated teeth may help overcome this concern.

However, a lacunae in research exists as to how the application of KI over SDF affects GIC's bond strength to dentin. The aim of the present study was thus, to compare the bond strengths of GIC to eroded dentin after application of SDF with and without the application of KI.

2. Materials And Methods

The present study was performed at the J. J. Murphy Research Centre, Perumbavoor, India, and the Department of Pediatric and Preventive Dentistry, of our Institute. The ethical clearance for the present study was provided by the Ethical Committee of our institute (ECASM-AIMS-2021-305; Dated: 08-06-2021).

Study samples

Thirty freshly extracted 1st maxillary premolars were collected and stored from patients who reported to the department for orthodontic reasons. Premolars with any signs of caries, fracture, or visible morphological alterations in enamel were excluded from the study. Teeth were stored in 0.9% normal saline at room temperature till the start of the experiment.

Sample size

The sample size of 30 premolars was calculated at a 95% confidence interval based on previous research by Zhao *et al.*[7]

Sample preparation

Each sample was prepared by sectioning at the CEJ utilizing a high-speed diamond disk bur (Nexus Medodent) under water-cooling. The coronal tooth structure was then embedded into separate self-cure acrylic resin blocks of 2 cm × 2 cm × 2 cm dimensions. The blocks were then polished with a 400-grit silicon carbide sandpaper (Aryalac Chemicals; Navi Mumbai, Maharashtra) to even all surfaces. A round diamond bur (API Ashoosons, New Delhi, India) was used in a high-speed hand piece to prepare an occlusal cavity of 2mm diameter and 1mm depth into dentine on the occlusal aspect of each premolar. **(Figure 1)**

Fig 1: Sample preparation

Acidic pH cycle

All the samples underwent an acid-pH cycle which involved immersion in freshly opened bottles of Coca-Cola (Hindustan Coca-Cola beverages Pvt., Maharashtra; pH 2.58, 30 mL/specimen) for 2 minutes and placement in artificial saliva (10 mL/sample) for 1 minute. The artificial saliva was prepared according to the formula by Ammaechi *et al.*[8,9] with the pH kept at 6.75. The cycle was done thrice for each sample to simulate the ingestion of a carbonated drink. Following the cycle, the samples were placed in artificial saliva at 37 °C which was changed daily in order to avoid oversaturation. The entire process was repeated for all samples on a weekly basis for 2 months.

Study Interventions

All the samples were equally divided into 3 groups (n = 10 per group) for their respective interventions as described in **Figure 2**.

38% SDF (Kids-e-Dental LLP, India) was applied based on the protocol by Horst *et al.*[10]. The application of potassium iodide (KI; 250ml, Qualitech chemicals laboratory reagent, India) was similar to a study by Nasr *et al.*[11]. A 2mm loop was made out of 19-gauge stainless steel wire and was placed into the prepared occlusal cavity at the junction between treated tooth surface and GIC of all samples before the direct application of GIC (GC Fuji IX Gold Label, GC Corporation) to obtain datum for calculation of bond strength for each specimen. GIC was mixed and placed according to manufacture instructions by the principal investigator. **(Figure 3).**

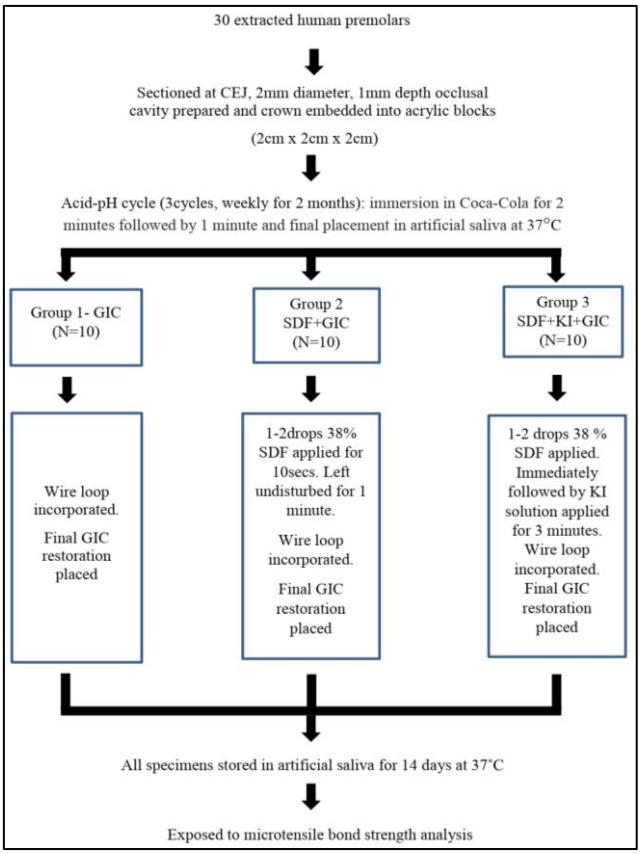

Fig 2: Flowchart of study methodology

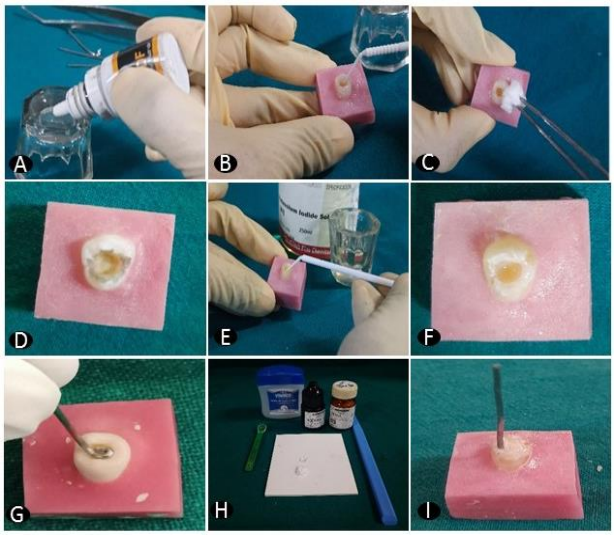

Fig 3: Step-wise interventionof Group 3 samples with SDF, KI and GIC

Bond strength test

The tensile strength was evaluated with the universal testing machine (ElectroPuls 3000; Instron, Norwood, USA), with a flat edge loading head. The shear force (1kN) was perpendicular to the 2mm steel wire loop and the loading head (1 mm/minute). The bond strength was calculated in mega-Pascals (MPa). The load at failure recorded in kilograms was divided to the bonded surface area in square mm.

3. Statistical Analysis

Statistical analysis was conducted using IBM® SPSS® Statistics Software version 20.0 software. Tensile stresses were presented using Mean and Standard deviation & Median (IQR). To compare the statistical significance of mean between three groups, Kruskall-Wallis test followed by Bonferroni multiple comparison test was used. The significance level was considered at $p \leq 0.05$ for all tests. Box Plot was graphically drawn for representation of comparison of tensile stress between 3 groups.

4. Results

Descriptive statistics of microtensile bond strength for both groups were presented in **Table 1** and **Figure 4**. Comparison of the median tensile stress using the Kruskal Wallis One-way ANOVA test, among the 3 groups, is presented in Table 1.

TABLE 1: Descriptive statistics for micro-tensile bond strength (Mpa)

	Group 1		Group 2		Group 3		p value
	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	
Tensile stress	4.5990 ± .93664	4.4050 (4.0400, 5.4575)	5.1580 ± 1.45601	4.6600 (4.0550, 6.5125)	10.423± 2.07989	10.5800 (8.6700, 12.4300)	<0.001

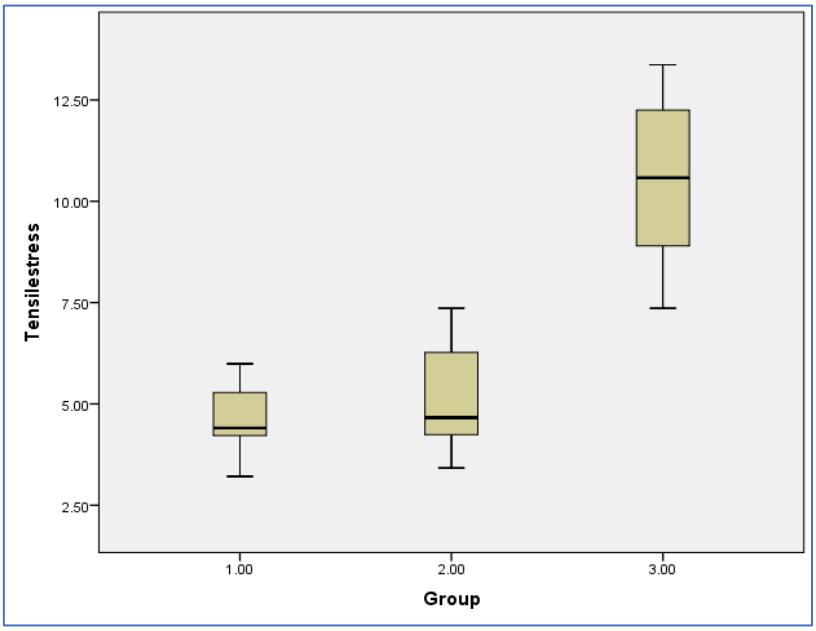

Fig.4: Box plot showing micro-tensile bond strength (Mpa) for 3 groups

The comparison shows statistically significant difference with a p value <0.001. The multiple comparison test showed a statistically significant difference between GIC-treated group and group treated with SDF, KI and GIC with p value <0.001. There was also a statistically significant difference between the group treated with SDF and GIC and group treated with SDF, KI and GIC. However, there was no statistically significant differences found between Groups1 (GIC) and 2 (SDF and GIC) (p=1.000).

The bond strength of group 3 samples which were treated with SDF and KI followed by GIC was significantly higher as compared to the other two groups, followed by group 2 treated with SDF and GIC, and the least value was observed in the group treated with GIC alone.

5. Discussion

Conventional dental treatment for Early Childhood Caries is generally considered invasive and cooperation from children during a dental procedure poses a major challenge for pediatric dentists. Currently, the use of silver diamine fluoride has proved to be successful for the prevention and management of early carious lesions. Zhi *et al.*[12] found that SDF applied annually can arrest active caries, and a biannual application can further enhance the caries arrest rate of SDF. Similar findings were concluded from the review conducted by Fung *et al.*[13]

A disadvantage of SDF is its potential to cause black stains of the arrested carious lesions. The resultant esthetics of SDF application showed a low acceptance among children and caregivers and has become a primary barrier for its clinical use.[14] Patel *et al.*[15] found that after SDF application, the black stains appeared within 2 minutes and continued to increase up to 6 hours post-application. No significant differences were found with respect to the staining potential between 38% and 12% SDF concentrations.

Research has brought forth the solution to reverse the black stains of SDF with the use of KI. KI forms silver iodide, a chalky white product after reaction with silver ions. Garg[16] confirmed that the overall staining compared to SDF alone drastically reduced. It was thus, suggested that KI could be applied for cases where esthetics are important. Nguyen[17] concluded similar results from their color analyses, which supported the application of KI treatment after SDF application to overcome stains.

Innumerable studies, both in-vitro and in-vivo, have been conducted to determine the bond strength of different materials to demineralized tooth surfaces. Choi *et al.*[18] conducted a laboratory study and demonstrated lesser bond strength of Resin modified-GIC (RMGIC) to carious dentin than to non-carious dentin; while, RMGIC to non-carious dentin had a greater bond strength than conventional GIC. Erosion is a chemical process which can cause an irreversible loss of minerals of tooth structure.[19] Soft drink consumption in general, has been considered as the most common factor for the development of dental erosion.[20-22] GIC has shown immense potential in treating eroded lesions. However, with respect to the bond strength, it has been concluded that adhesive materials such as GIC and RMGIC may be used in eroded dentin without jeopardizing the quality of the bond.[23] Studies evaluating bond strength of various restorations to carious induced teeth following SDF treatment found neither any adverse effects in the bond strength, nor an increase in bond strength.[24-27] The absence of negative effects on the adhesion of GIC to artificial carious dentine surface following the application of KI solution and SDF have been reported.[7,11] However, a drastic increase in the bond strength of RMGIC with SDF-KI application has also been reported.[28]

The present study was performed to overcome the lacunae in research on the effect of KI-SDF application on bond strength of GIC to eroded dentine surfaces. The results showed a lesser improvement in bond strength of GIC to eroded dentine following SDF treatment alone, while a significant two-fold increase in bond strength following the application of SDF

with KI. However, further clinical research may be directed towards the in-vivo longevity and stability of such restorations on larger samples.

6. Conclusions

Within the constraints of this study, the results concluded a significant increase in bond strength between GIC and eroded dentine after treatment with SDF and KI. The bond strength was approximately doubled following the application of KI.

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