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Effect of Silver Diamine Fluoride and Potassium Iodide on Tensile Bond Strength of Glass Ionomer Sealant on Demineralized Enamel

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ABSTRACT:Objectives: The aim of the current study to determine the effectof silver diamine fluoride and potassium iodide on tensile bond strength of glass ionomer sealant on artificially demineralized enamel.

Materials and Methods: The total number of teeth in the main study was (21) sound wisdom teeth that were extracted due to impaction. All samples were immersed in a demineralizing solution.Teeth samples were sorted into three groups at random, with each group containing (7) teeth samples, group A(Demineralization only)(baseline), group B (Demineralization + SDF) and group C (Demineralization + SDF + KI). After application of the glass ionomer fissure sealant and complete setting, and in order to avoid dehydration, the samples were kept for 24 hours in distilled water at room temperature. A universal testing machine was used to assess the tensile bond strength of glass ionomer sealant with a crosshead speed of (1mm/min). Data was analyzed by using one way ANOVA at the significant P-value of ($p \leq 0.05$).

Results: There were statistically significant differences among the three study groups of TBS test. There were increase tensile bond strength after SDF application (group B), followed by group C, while group A (baseline) showed the lower tensile bond strength.

Conclusion:There was an increase in tensile bond strength of Glass ionomer sealant after SDF and SDF/KI application in artificially demineralized teeth surface. The use of KI solution immediately after SDF treatment has no effect on the adherence of glass ionomer sealant to artificially carious enamel.

Keywords: Silver Diamine Fluoride, Potassium Iodide, Tensile Bond Strength.

I. INTRODUCTION

Dental caries is a common illness that affects people all over the globe and is a public health concern. It is caused by the weakening of the teeth's hard structures and the formation of cavities[1]. Dental caries is becoming more common as a result of the unrestricted use of sugary foods, poor oral hygiene practices, and insufficient use of health services. Caries was more prevalent in economically disadvantaged communities[1][2][3].

Fluorides were regarded pioneers in the remineralization technology, but throughout time, a number of new and unique remineralization methods have been marketed that have proven to be successful in the remineralization of hard tissues [4]. Silver diamine fluoride (SDF) is derived from these new materials. Silver diamine fluoride (SDF) is an alkaline topical fluoride solution that is colorless and contains fluoride ions as well as silver ions. SDF is widely used in a 38 percent solution for hypersensitivity therapy and caries prevention [5][6]. Meanwhile, topical fluoride treatment has been shown to be beneficial in the prevention of dental caries [7]. SDF is a caries-control agent that is safe, effective, efficient according to the study. It may satisfy the requirements of the millennium development objectives of the World Health Organization (WHO) and the US Institute of Medicine[6][8]. The most serious side effect of SDF is a darkening of the carious lesion [8][9]. To remove the black stains, Li etal[10] employed SDF with a 10% saturated KI solution, followed by glass ionomer cement[11]. Because KI has an antibacterial effect, it will slow the spread of caries by preventing biofilm formation and reducing further demineralization [12][13]. Many studies have been conducted since then to determine the efficacy of glass-ionomer sealants, and they have usually examined relative retention rates[14][15].

However, when the rate of caries is taken into account, glass-ionomers seem to be as effective as or better than other materials[16][17]. This might be owing to sealant retention deep inside the fissure, as well as the anti-caries properties of the sealant's fluoride release[17][18]. The current study's goal is to determine the impact of silver diamine fluoride and potassium iodide application in vitro on tensile bond strengthof glass ionomer sealant after an artificial enamel demineralization challenges.

II. MATERIALS AND MEHODS

A total of 21 healthy, non-carious upper and lower wisdom teeth, that were extracted due to impaction, and collected from specialized dental centers and private clinics.The inclusion-criteria of teeth was that they must not contain restorations, caries and hypo-mineralization, no developmental abnormalities, enamel hypoplasia, cracks, worn, or fractures in the teeth. A chemical agent like acid etching had no effect on the enamel surface. In this study, only intact samples were used. Teeth were collected and cleaned to remove dirt and plaque, then stored and put in a 0.1 percent thymol solution to suppress bacterial growth until the test (approximately a month)[19][20][21]. Using a disc diamond bur and water, the root section was cut and removed about 2mm below the level of cemento-enamel joints. The coronal section, on the other hand, was retained. The flattest part of each tooth sample's buccal portion was chosen[21][22]. All of the tooth specimens were put in an acrylic block that had been created by pouring acrylic material into the polyvinyl box's mold (tray trunk cable) for tensile bond strength measurement (TBS). after all specimens had their cold cure acrylic set, The acrylic resin level was made equal in the flattest part of the buccal crown portion[21]. The exposed sides of the teeth on the tray trunk cable were smoothed one after another using silicon carbide sheets of fine grit (600, 800, and 2400 grit). Finally, all samples were cleaned with deionized water and stored until the process began[20]. Teeth samples were sorted into three groups at random, with each group containing (7) teeth samples. All samples were immersed in a demineralizing solution which consisted of $CaCl_2$ (2.2 mM), NaH_2 PO_4 (2.2 mM), and acetic acid (0.05 M), pH of 4.5, regulated with KOH (1M), 15 ml/tooth for 96 hours at 37 C. Once the 96 hours had elapsed, all demineralized surfaces were randomized and experimental groups were formed to receive the indicated treatment[23]:

- **Group A (Demineralization only) (Baseline)**: Demineralization of enamel surfaces by inserting the samples in to the artificial caries solution (demineralization solution) for 96 hours at 37c and then teeth were rinsed with deionized water and dried, and then we put the GIC sealant (GC Fuje Triage type, Tokyo, Japan) in to the enamel of buccal surfaces of teeth and measure the tensile bond strength of samples[23].
- **Group B (Demineralization + SDF)**: Demineralization of buccal enamel surfaces as we mentioned above and then the teeth buccal surfaces were exposed to silver diamine fluoride (SDF) (e-SDF 38% / Manufactured by Globus Medisys / India) solution with small brush for 1 min (according to clinical application instruction), GIC sealant (GC Fuje Triage type, Tokyo, Japan) was placed, then the procedure of measuring the tensile bond strength of samples was performed[20][23].
- **Group C (Demineralization + SDF +KI)**: After demineralization of buccal enamel surfaces, the buccal enamel surfaces were treated with SDF + KI solution. A layer of 38% SDF solution(e-SDF 38% / Manufactured by Globus Medisys / India) was topically applied to the cavity for 1 min, immediately followed by a saturated KI solution (Potassium iodide solution was prepared by dissolving 10 gm of KI in 100 ml of deionized water in order to get 10 % KI solution)[24]. Until the creamy white solution turned clear. The reaction products were washed off with copious distilled water. Then it was dried and the GIC sealant (GC Fuje Triage type, Tokyo, Japan) was placed, the tensile bond strength of samples was measured[23][25].

After that, On the buccal surface of teeth, a hollow of polyvinyl tube with a diameter of 3 mm (internal diameter) and a height of 5 mm is inserted. It was approximately in the center of the specimen and was sealed with sealant material from that group[21][26]. In order to measure the TBS, the sealant was thinned down to a thickness of 2 mm and set. Over that, another 2 mm of sealant was applied. And before setting, a 14cm piece of 0.012 inch gauge stainless steel orthodontic wire that was twisted at one end and looped at the other and it was adjusted with small ready-made post screw. After fixation of twisted wire with screw head, it was placed inside the sealant material until all serrations of screw were covered and we waited until setting. Following complete setting, polyvinyl tubes were cut and removed[21][27]. To prevent dehydration, all samples were immersed in distilled water for 24 hours before being tested for SBS with a universal testing machine (UTM) (Electronic Elastic Strength Tester GTC04-2, Gester, CHINA)[21].

Tensile Bond Strength Measurement (TBS):

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Each specimen was attached between two clasps of the universal testing machine (UTM) (Electronic Elastic Strength Tester GTC04-2, Gester, CHINA). The specimens were placed in such a position that the load was applied at right angle or perpendicular to the sealant plug at a speed (1 mm/min). The point at which the sealant plug snapped off from the enamel surface indicated the breaking load and it signify the tensile stress [21][27]. The formula was used to determine the bonding strength:

Bond strength (MPA) = Load/Area (N/mm)

The load in Newtons (N) and the bonding surface area in millimeters (mm)

Where area = πr^2[27].

R : is the polyvinyl tube's radius in millimeters (mm)

π : 3.14 (fixed ratio) [28].

Statistical Analysis: A software program was used to perform statistical analysis (IBM SPSSversion 22). The results of the readings were statistically examined by using (One Way-ANOVA Test) was used to identify the existence or absence of a significant difference between groups, at the 0.05 level of significance, and to establish the significant difference between the groups, Duncan's Multiple Range-Test was performed.

III. RESULTS

According to the descriptive statistics, the study's findings revealed that the mean values of group B (Demineralization + SDF) of TBS test are the highest values followed by group C (Demineralization + SDF + KI), while the group A (Demineralization only) identified the weakest. The analysis of variance One way ANOVA-test for all groups of TBS test showed significant difference ($p \leq 0.05$) as listed in table(1). Group B has the greatest tensile bond strength values with a significant difference ($p \leq 0.05$), followed by group C, according to Duncan's Multiple Range test findings as seen in table (2), while group A has a lowest tensile bond strength values, and although group B had the highest mean TBS compared to group C, no significant difference between the two groups were seen.

IV. DISCUSSION

When compared to sound enamel, demineralized enamel had a reduced bond strength, which has also been explained in other studies. Despite the fact that no concrete evidence has been shown to support this claim, the soft demineralized enamel surface has been linked to this phenomenon[29].

The results of the present study showed decrease in the tensile bond strength on the demineralized enamel surface (Group A) and showed significant difference and this happened when GIFS bonded to enamel by a chemical reaction and mechanical bonding, and demineralization of enamel exposed the surfaces, boosting micromechanical interlocking and inspiring infiltrations by hybridization [30]. Furthermore, chemical interactions between polyacrylic acid (from GI) and calcium ions (from GI or hydroxyapatite) resulted in the formation of the ionomer, calcium polycarboxylate, which is capable of chemical chelation. As a result, when SDF is applied to the enamel surface, silver and silver oxide are produced, perhaps contributing to the increased tensile bonding strength between glass ionomer and metal seen in a prior work[29]. Another essential thing to note is that in the current study, the application of SDF on demineralized enamel resulted in a considerably greater bond strength, which was confirmed by Kim etal[30], who said, ‘SDF has the potential to enhance the microhardness of demineralized enamel by silver deposits' this ability inhibits enamel's softening progresion and fluoride's remineralize the soft enamel surface This indicates that the micromechanical interlocking is improving, resulting in greater bond strength. As a result, SDF might be used safely with GIFS to stop or prevent caries[29].

The effects of SDF and SDF/KI on the tensile bond strength of glass ionomer sealants have been studied in previous research. The present study demonstrated that using SDF and SDF/KI enhanced tensile bond strength and showed a significant difference, and these results were disagreed with other authors who reported that using SDF or SDF/KI either decreased tensile bond strength or had no impact[31][32][33]. While other studies agreed with the current results of this study and found that the impact of SDF or SDF/KI on the tensile bond strength of glass ionomer sealant either rise in the bond strength or no impact[23][34][35].

The formation of silver phosphate attaching to the carboxylic acid in the glass ionomer is thought to be the cause of enhanced tensile bond strength following the application of SDF alone[36]. It is also proposed that this increasing of TBS could be due to a hardened enamel surface[37]. Enamel with a higher microhardness may have better micromechanical interlocking with the glass ionomer[29][37].

It's fascinating to think about the chemical reaction proposed by Nguyen etal[24] while assessing the effects of SDF/KI on the tensile bonding strength of a glass ionomer to enamel:

$Ag(NH_3)2F + KI \rightarrow AgI + 2NH_3 + F^-$

The result of the current study after KI placement (Group C) showed an increase of the bond strength and was larger in numerical values but, not significant difference in statisticial program with other group was found, and this was disagreed with Knight and McIntyre[38] which concluded that the silver iodide precipitate generated when SDF was followed by KI resulted in lower tensile bond strength. Our findings are consistent with those of Gupta etal[36], who found an increase in bond strength when SDF/KI was employed. The carboxylic acid in glass ionomer may react with silver iodide precipitate on the enamel surface, resulting in a stronger link. Furthermore, it has been shown that applying SDF/KI to enamel before applying a glass ionomer sealant increases the depth and concentration of fluoride in demineralized enamel[37][39].This deep and excellent fluoride penetration may also help to increase tensile bond strength following SDF/KI treatment.

V. CONCLUSION

Within the limits of the current study, there was an increase in tensile bond strength of Glass ionomer fissure sealant after SDF and SDF/KI application in artificially demineralized enamel surface. The use of KI solution immediately after SDF treatment has no effect on the adherence of glass ionomer sealant to artificially carious enamel. Furthermore, KI therapy can help to decrease demineralized enamel discolouration induced by SDF.

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Table (1): ANOVA Test for TBS Mean Values Between The Variables in Each Group:

Tensile Bond Strength		Sum of square	DF	Mean square	F	sig
Glass Ionomer Sealant Matreial	**Between groups**	**2.614**	**2**	**1.307**	**8.559**	**.002**
	Within groups	**2.749**	**18**	**.153**		
	Total	**5.364**	**20**			

DF: Degree of Freedom. Showed statistically differences

Table (2): Mean Values, Standard Deviation and Duncan's Multiple Range Test Between Mean Values of TBS for the Teeth in Each Group:

Groups	Viarable	Glass ionimer sealant material
Group A (Demineralization) (baseline)	**Mean** **N** **Std. deviation**	**1.8214 a** **7** **.14416**
Group B (Demineralization +SDF application)	**Mean** **N** **Std. deviation**	**2.6829 b** **7** **.41141**
Group C (Demineralization +SDF application + KI application)	**Mean** **N** **Std. deviation**	**2.1914 b** **7** **.51783**

N: Number of the specimens**, Std. Deviation:** Standard Deviation**. Statistically significant differences within the same column (vertically) are shown by different small letters (p≤ 0.05).**