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

[1]Awab M. Khaleel, B.D.S. and [2]Raya Jasim Al-Naimi, B.D.S. ,M.Sc. ,Ph.D.
[1]B.D.S. ,M.Sc. student, Directorate of Health/Ninavah, Ninavah, Iraq
[2]Department of Preventive Dentistry, College of Dentistry, University of Mosul,Ninavah, Iraq
** Corresponding author at Department of Preventive Dentistry, College of Dentistry, University of Mosul, Mosul, Iraq*

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ABSTRACT: Objectives:the aim of the current study to determine the effectof silver diamine fluoride and potassium iodide on shear 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 shear bond strength of glass ionomer sealant with a crosshead speed of (1mm/min). Data 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 SBS test. There were increase shear bond strength after SDF application (group B), followed by group C, while group A (baseline) showed the lower shear bond strength.

Conclusion**:**There was an increase in shear 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, Shear Bond Strength.

I. INTRODUCTION

Dental caries is a widespread problem that poses a public health challenge; this develops as a result of the weakening of the hard tissues of the teeth and the creation of cavities [1]. This multifactorial disease can be prevented or reversed in its initial phase[2]. Early caries in enamel can be remineralized, which is an important step in the principles of minimally invasive dentistry. Fluorides were considered as pioneers in the remineralization technology, but over the years a series of new and novel remineralization strategies have been commercialized other than fluoride and has proved to be effective in hard tissue reminerlization [2]. From these novel materials is silver diamine fluoride (SDF) is used worldwide since the early 1970s [3] in a concentration of 38% (44,800 ppm fluoride) to arrest or prevent caries lesions because of cariostatic properties of SDF.

SDF has also been utilized to inhibit and prevent the formation of cariogenic biofilms as an anti-hypersensitivity and anticariogenic agent. Furthermore, it prevents dentine demineralization [4][5], boosts remineralization and preserves the dentine collagen from further dissolution [6][7]. However, because of the silver components in SDF, it caused staining of the caries lesion as a primary unfavorable or side effect, so the use of potassium iodide (KI) to reduce the negative effect of SDF [8][9][10].

Sealants of varied or distinct kinds were put in molar tooth fissures, either primary or permanent, to prevent and arrest caries formation by preventing plaque and pellicle from settling in the fissure [11]. As far back as 1974, glass-ionomer was suggested for this purpose. Recently, the discovery of high-viscosity glass-ionomers has given a material with much improved retention rates[12][13]. As a result, its usage in fissure sealing is expected to continue in the future [11]. The current study's goal is to determine the impact of silver diamine fluoride and potassium iodide application in vitro on shear bond strength of 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 were extracted because of impaction and were obtained from professional dentistry centers and private clinics. Teeth had to be free of restorations, caries, and hypomineralization, as well as developmental anomalies, enamel hypoplasia, cracks, and fractures. The enamel surface was unaffected by chemical agents like acid etching. Only intact samples were used in this study. Teeth were collected, cleaned, and preserved in a 0.1 percent thymol solution to prevent germs from growing until the test (approximately a month) [14][15][16]. 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 [16][17].

All of the tooth specimens were put in an acrylic block that had been created by pouring acrylic material into plastic ring for shear bond strength measurement (SBS) according to the machine design, 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[16]. The exposed surfaces of the teeth on the rings were polished out one by one with fine grit silicon carbide sheets (600, 800, and 2400 grit). Finally, deionized water was used to clean all samples before they were stored until the process began[15]. Teeth samples were randomly divided into three groups, each having (7) teeth samples. A demineralizing solution was used to immerse all of the samples, which consisted of $CaCl_2$ (2.2 mM), NaH_2PO_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[18]:

• **Group A (Demineralization only) (Baseline):**Demineralization of enamel surfaces was achieved by immersing the samples in an artificial caries solution (demineralization solution) for 96 hours at 37°C, followed by rinsing and drying the teeth with deionized water. Finally, the GIC sealant (GC Fuje Triage type, Tokyo, Japan) was applied to the enamel of buccal surfaces of teeth, and the shear bond strength of the samples was measured [18].

• **Group B (Demineralization + SDF):**As previously mentioned, the buccal enamel surfaces were demineralized, and then the teeth buccal surfaces were exposed to silver diamine fluoride (SDF) solution (e-SDF 38% / Manufactured by Globus Medisys / India) with a small brush for 1 minute (according to the clinical application instructions), GIC sealant (GC Fuje Triage type, Tokyo, Japan) was placed, and the procedure of measuring the shear bondstrength of samples was performed [15][18].

• **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)[19] until the creamy white solution turned clear. The reaction products were thoroughly rinsed away with distilled water. The GIC sealant (GC Fuje Triage type, Tokyo, Japan) was then applied, and the shear bond strength of the samples was tested[18] [20].

After that, a hollow polyvinyl tube with a diameter of 3 mm (internal diameter) and a height of 5 mm is put on the buccal surface of the teeth. It was sealed with sealant material from that group and was about in the center of the specimen [16][21]. The sealant material was then condensed to a thickness of 4 mm and wait until setting. Following complete setting, polyvinyl tubes were cut and removed. 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)[16].

Shear Bond Strength Measurement (SBS):

A universal testing equipment with a flat-edge loading head was used to conduct the SBS test. At a distance of 1 mm between the enamel surface and the loading head, a perpendicular shear stress was applied to the GIC cylindrical button. The loading head moved at a constant speed of one millimeter per minute. The force required to debond GICs was measured in Newtons. By multiplying the load at failure by the bonded surface area in square meters, the bond strength was calculated in mega-Pascals (MPa)[18] [22].

Statistical Analysis:

Statistical analysis was carried out using a software program (IBM SPSSversion 22). The findings of the readings were statistically investigated using (One Way-ANOVA Test) to determine the presence or absence of a significant difference between groups at the 0.05 level of significance,

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and Duncan's Multiple Range-Test to establish the significant difference between groups.

III. RESULTS

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

IV. DISCUSSION

Our study, evaluated the shear bond strength of glass ionomer sealant material to artificially demineralized enamel surface, SDF-treated and SDF/KI treated artificial carious surface. GIFS' shear bonding strength to SDF and SDF/KI-treated sound and artificially demineralized enamel has been proven in studies. The clinician can use the shear bond strengths to determine how to restore a region that may have been artificially demineralized and previously treated with SDF. The maximum shear bond strength values were discovered in GIFS, according to this study after SDF treatment (Group B) followed by SDF/KI treatment (Group C) but not statistically significant shear bond strengths between each other, and show the lowest shear bond strength values on demineralized enamel surface (Group A) which have statistically significant shear bond strengths with group B. The effect of KI application (Group C) showed larger values than (Group A) but not showed significant difference in statistic programs between each other. Multiple investigations have discovered that GIS to SDF-treated enamel has proportionately greater bond strength values than sound enamel controls, although not at a significant level ($P>0.05$)[23][24].

The findings of this study, however, contradict those of Kucukyilmazet al[25], who found that SDF treatment reduced binding strength in intact and demineralized tooth surfaces. These findings can be explained by a number of reasons, including the above-mentioned influence of enamel demineralization on the decrease of SBS of glass ionomer sealants, as well as the detrimental effect of fluoride on adhesion processes to the tooth structure. Fluoride remineralization alters the surface of the enamel, reducing GIS adherence to the tooth enamel [26]. These phenomenons may have occurred in this investigation, as William etal [27] found a substantial reduction in SBS of GIS on demineralized enamel.

The current study results agreed with Favaro etal[28] results who concluded that when applied the anticaries agent (SDF and silver nano particles) on undamaged or artificially demineralized tooth enamel, these anticaries agents did not diminish the SBS of GIS. As a result, the anticaries agents evaluated in this study can be utilized as a pretreatment agent, helping to avoid caries.

Chemical connections between free negatively-charged hydrophilic carboxyl groups in GI and positively-charged calcium in hydroxyapatite in enamel were the mainstay of GI bonding[11][24].

When SDF is applied to enamel, it causes remineralization and the combining of different ions, which occurs most commonly in previously demineralized enamel. Mei etal[6] used micro computed technology to show that applying SDF to carious enamel led in a highly remineralized zone rich in calcium and phosphate ions, which might be the case with our work on demineralized enamel.

Chemical bonding, rather than micromechanical bonding, is used in GIFS. Furthermore, introducing a greater concentration of positively-charged silver ions and silver deposits into SDF-treated artificially demineralized enamel might result in chemical interactions forming with the negatively-charged carboxyl groups of GI [24], which may explicate the maxiumum shear bond strength values of GI after SDF and SDF/KI treatment in this study.

When considering the therapeutic implications, our findings suggest that GI may have larger or better bond strengths if SDF was utilized to cure or prevent a carious lesion. This might be due to silver precipitate from SDF perforating demineralized enamel, causing binding strength in materials that are dependent on micromechanical retention being disturbed. It might possibly be owing to increased chemical bonding of GI to ions deposited by SDF in artificially demineralized enamel [24].

Glass ionomer sealants are widely regarded as one of the finest fluoride-releasing materials, with continuous fluoride release and recharge considered superior than compomers and giomers [18]. And so on, the fluoride release and antimicrobial properties of glass ionomer sealants are typically restricted and insufficient. Hence, the enamel surfaces pretreated with SDF or SDF + KI before GI sealant has been suggested by other researchers [18] to boost antimicrobial and remineralizing capability of GIS. Zhao etal[18] found that pretreatment with SDF or SDF + KI had no negative impact on GI adherence to enamel, which is consistent with prior laboratory results [29][30]and these studies were agreed with the result of the present study. However, another study revealed that after treating the tooth surface with SDF, the adhesive characteristics of fissure sealants improved [31]. Various processes and procedures, as well as different properties of dental substrates, might explain the variations in results.

V. CONCLUSION

There was an increase in shear bond strength of Glass ionomer fissure sealant following SDF and SDF/KI application on artificially demineralized enamel surface within the limits of the current study.The use of KI solution following SDF treatment has no influence on glass ionomer sealant adhesion to artificially carious enamel. Additionally, KI therapy can aid in the reduction of demineralized enamel discoloration caused by SDF.

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Table (1): ANOVA Test for SBS Mean Values Between the Variables in Each Group

Shear Bond Strength		**Sum of square**	**DF**	**Mean square**	**F**	**sig**
Glass Ionomer Sealant Material	**Between groups**	**5.017**	**2**	**2.509**	**3.307**	**.050**
	Within groups	**13.654**	**18**	**.759**		
	Total	**18.672**	**20**			

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

Groups	**Viarable**	**Glass ionimer sealant material**
Group A (Demineralization) (baseline)	**Mean** **N** **Std. deviation**	**2.3414 a** **7** **.81673**
Group B (Demineralization +SDF application)	**Mean** **N** **Std. deviation**	**3.4343 b** **7** **.53712**
Group C (Demineralization +SDF application + KI application)	**Mean** **N** **Std. deviation**	**3.3114 b** **7** **1.14899**

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