International Journal of Oral Health Dentistry 2022;8(2):153–157

Content available at: https://www.ipinnovative.com/open-access-journals

International Journal of Oral Health Dentistry

Journal homepage: www.ijohd.org

Original Research Article

Evaluation of bond strength of posterior restorative material with tooth treated with silverdiamine fluoride – Invitro study

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ARTICLE INFO

Article history:
Received 12-02-2022
Accepted 15-03-2022
Available online 11-06-2022

Keywords:
Silver diamine fluoride (SDF)
Potassium Iodide (KI)
Push-out bond strength
Dental caries

ABSTRACT

Background: Silver diamine fluoride (SDF) solution is being used in arresting dental caries in countries throughout the world since the 1970s. The mechanism of action is that silver-salts promote dentin sclerosis/calcification, silver nitrate has anti-microbial effects, and fluoride helps in the process of remineralization and prevention. The aim of this study is to evaluate the bond strength of posterior restorative material with tooth treated with silver diamine fluoride using universal testing machine

Materials and Methods: 60 premolar tooth were sectioned transversally and each root was embedded in cold-cure epoxy resin. The labial tooth surface was wet ground using silicon carbide discs to prepare a flat superficial dentin. The tooth were conditioned using 10% polyacrylic acid, and divided accordingly. Two increments of resin composite were placed into the plastic tubes of size 5mm X 3mm and each increments were light polymerized for 40 seconds. The same procedure was followed for glass ionomer cement. All specimens were stored at 37^{o} in water for 24hrs before testing. The push out bond strength analysis was tested using the universal testing machine.

Results: The maximum push out bond strength is seen in GIC in dentin-21.85 N/mm^2, followed by the group with composite-19.27 N/mm^2 and with the lowest value in the group containing SDF+KI+GIC-3.601 N/mm^2.

Conclusion: Addition of Potassium iodide used to reduce the staining of the SDF does affect the bond strength of the restoration to dentin. GIC has the best bond strength with tooth, followed by composite among the groups.

1. Introduction

Secondary (recurrent caries) which refers to the carious lesions affecting the margins of an existing restoration is regarded as the most common reason for re-restoration of teeth in the long term. Studies shows that secondary caries contributes to greater than 25% of restoration replacements of both composite resin and amalgam.[1] This lead to the development of anti-cariogenic dental materials, containing fluoride. The enhancement of remineralization by Glass ionomer cement (GICs) through fluoride release and recharge are superior to othermaterials used for restorative purposes, such as compomers and giomers. Cariogenic bacteria's such Streptococci, Actinomyces naeslundii and Lactobacilli are found both in primary as well as secondary caries. Many studies have shown that the high antibacterial effect of Silver Diamine Fluoride (SDF) can inhibit the growth of multi-species cariogenic biofilms on tooth surfaces.[2] High concentration of SDF (38%) is used as a topical fluoride for preventing and arresting dental caries. In 2015, the United States Food and Drug Administration has approved SDF for its clinical use. A review concluded SDF as an effective, efficient, equitable and safe caries-Silver and fluoride ions penetrate ~25 microns into enamel and 50-200

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https://doi.org/10.18231/j.ijohd.2022.030

microns into dentin.[3]

With application twice per year, it outperforms all minimally invasive options including the atraumatic restorative technique – with which it is compatible, butits20 times less expensive. It shows a good success rate for 2 or more years while preventing future caries, while other fillings does not. SDF is the most effective primary preventative material available, except for dental sealants which are 10 times more expensive and requires periodic monitoring.[4]

In geriatric patients, arresting of caries progression is low, in comparison to young patients when we consider the role of saliva in SDF application. The higher caries rate in elders are due to less abundant and functional saliva. In pediatric patients, the buccal or lingual smooth surfaces and anterior teeth shows high caries rate.[5] In treated dentin, silver chloride is the main precipitant, but chloride is not a common component of SDF or dentin, so it may be present in the saliva.[6]

Among preschool children in arresting dentinal caries of primary teeth, 38% SDF solution is more effective when compared to 12% SDF.[4] Collagen destruction is decreased and mineral content loss is minimized by 38% SDF. Furthermore, it contains high concentrations of silver and fluoride ions, which can inhibit the growth of multi-species cariogenic biofilms.[7]

Root caries among elderly communities is of growing public health concern globally. This study investigates SDF and oral health education effectiveness in preventing and arresting of root caries. Among community-dwelling elderly subjects, annual application of SDF together with biannual OHE was effective in preventing new root caries and arresting root caries.[8] May Lei et al did a study and concluded that conditioning with 38% SDF increased the resistance of the glass ionomer cement and composite resin restorations to secondary caries. The success rate of direct restorations was improved when 38% SDF is incorporated into restorative therapy.[2]

The dentin bond strength of restoration is unaffected by using SDF in combination with resin based adhesives. A promising pulpal response and effectiveness in the formation of reparative dentine was found when SDF application was used under GIC restorations.SDF treatment increases the resistance of GIC restorations to secondary caries around the margins of cavity preparations. The black staining on teeth due to SDF use causes aesthetic concern is a significant disadvantage.[9] Saturated Potassium Iodide can be used to overcome the black staining caused by SDF application. Many studies shows that discolouration of the carious lesion can be avoided without changing the effect of SDF in caries arresting.[10] The formation of silver iodide is the reactionary product formed by the release of silver ions from SDF and iodide ions from KI. This is the best possible explanation for unaffected efficiency of SDF in arresting caries even though KI application is indicated for prevention of discolouration.[11] Both efficacy and efficiency of 38%SDF in prevention and arresting of caries has been shown in many studies.

Indications for treatment of dental caries with Silver Diamine Fluoride:

1. Extreme caries risk(Xerostomia or severe early childhood caries.
2. Behavioural or medical management which causes treatment challenges.
3. Multiple carious lesions where single visit treatment is impossible.
4. Dental carious lesions those are difficult to treat.

Therefore, the aim of this study is to evaluate the bond strength of posterior restorative material with tooth treated with silver diamine fluoride using universal testing machine. The hypothesis was there is no difference in the push out bond strength of restorative material when tooth is treated with SDF.

2. Materials and Methods

Sixty freshly extracted premolar teeth extracted for orthodontic purpose were collected from the department of Oral surgery of A.J Institute of Dental Sciences and other private clinics in Mangalore and were stored. After setting, the specimen was sectioned transversally using a water-cooled precision diamond saw, each root was then embedded in cold-cure epoxy resin. The labial surface was wet ground using a series of silicon carbide discs to prepare a flat superficial dentin. And then all the tooth were conditioned using 10% polyacrylic acid, and the samples were divided accordingly. Upon completion, standardised plastic tubes of 5mm height and 3mm diameter were placed onto the dentin surface. Two increments of resin composite was placed into the plastic tube and each increments was then light polymerized for about 40 seconds. The resin cylinder was then exposed by removing the plastic tubes and same procedure was followed for glass ionomer cement. All specimens were stored at 37degree in water for 24hrs before testing, to stimulate the oral environment. The push out bond strength analysis was carried out using the universal testing machine with crosshead speed of 1.0mm/min to each individual specimens taken from the storage

Group 1: The exposed dentinal surface was treated with SDF for 3 minutes, followed by a rinse for 30 seconds with distilled water then the dentin surface was treated with the same self-etch bonding system, composite is placed and light cured.

Group 2: The exposed dentin was treated with 38%SDF+KI. A layer of SDF was topically applied to the cavity, immediately followed by a saturated KI solution until a creamy white solution turned clear. The reaction products

were washed off with copious distilled water then the cavity was restored with Glass ionomer cement.

Group 3: The exposed dentin was treated with SDF+KI. Topical application of SDF was done to the cavity, followed by immediate application of saturated KI solution, until it turns clear. Distilled water was used for washing the reactionary products then the composite is placed, and light cured.

Group 4: The exposed dentinal surface was treated with 38% SDF for 3 minute followed by rinse for 30 seconds with distilled water. Then the surface was restored with glass ionomer cement.

Group 5: The exposed dentin was treated with an etch and rinse bonding system and composite was placed and light cured.

Group 6: The exposed dentin surface GIC was placed.

2.1. Specimen preparation for universal testing machine

To stimulate the oral environment all specimens were stored at 37 degree in water for 24hrs before testing. The push out bond strength analysis was carried out using the universal testing machine with crosshead speed of 1.0mm/min to each individual specimens taken from the storage. The push-out bond strengths were measured using a universal testing machine with loading time: 1mm/min. Maximum load application was denoted in Newton/mm^2.

2.2. Statistical analysis

Two way analysis of variance (ANOVA) and post hoc Tukey tests were performed to compare the effects of the SDF on bond strengths, with statistical significance set at p value<0.05, 95% confidence level and 85% power.

3. Results

The maximum push out bond strength was found in GIC 21.85N/mm^2, followed by composite 19.27N/mm^2. SDF treated tooth without potassium iodide and then followed by composite has a bond strength of 6.89N/mm^2 which is better than SDF treated tooth without potassium iodide and GIC i.e., 4.09 N/mm^2. The SDF treated tooth then application of potassium iodide with respect to composite has bond strength 4.51N/mm^2 which is better bond strength than GIC i.e.,4.09N/mm^2. The push bond strength among the groups was found statistically different. (p value <0.05).

4. Discussion

The American Academy of Paediatric Dentistry provided the guidelines regarding the use of silver diamine fluoride for dental caries management in children and adolescent including those with special healthcare needs. Silver fluoride (AgF) solution usage has been reported in 1970s by Craig et al, especially in dentistry. In early 1960s, SDF usage as the therapeutic agent was approved in Japan. It has an alkaline pH between 8 and 9. The stability of SDF is better than AgF solution and the need for reducing agent is avoided. So, it can be kept at a constant concentration. 38% of silver diamine fluoride was first used in dentistry.[12]

SDF at a concentration of 38% was chosen, as it is well-known that it is effective in preventing and arresting dental caries. Studies have shown that 38% SDF inhibits the growth of cariogenic biofilms through topical application. The inhibitory effect of 38% SDF towards the action of cathepsins and matrix metalloproteins is exponentially stronger. SDF treatment can enhance the carious lesion microhardness and can also influence in increase of mineral density. Clinical studies have shown that 38% SDF arrested coronal caries in children and prevented root caries in elderly patients.[13] Gao et al.in a systematic review reported that it is the most commonly used concentration and is effective in arresting caries.[14]

SDF potentially causes black staining of the tooth which is aesthetically not accepted by the patients. So, the additional application of saturated KI solution is indicated immediately after the application of SDF. The application of Ki solution leads to formation of a compound in bright yellow colour, i.e., silver iodide formed by the reaction caused by SDF and KI solution, which acts as a major contributor in reduction of the black staining of the teeth. In this study group, few teeth developed black staining even after the formation of yellow precipitate caused by KI application. The quantification of bonding of the restorative material to the tooth after KI application to remove the staining caused by SDF was not performed previously.[15] In this study, SDF + KI treatment led to discolouration of tooth surfaces although the intensity of the discolouration was less than that of SDF treatment.

One of the factor in this study is the rinsing of SDF, after application for 30 seconds and not including this step results in severely reduced bond strength and greatest adhesive failures according to Paul Lutgen et al.[15] The presence of excess SDF results in unstable bond to dentin. SDF application protocol suggests that the rinsing steps has a distinguishing factor in bonding after SDF. SDF interferes with the bonding agent and primer by reducing their ability to impregnate the peri and intra- tubular dentin to form a meshwork with the collagen matrix. Optimal bonding and longevity of the resin based composite can be achieved by rinsing of the excess SDF.[16]

It should be noted that the pH of SDF is around 10, so the bond strength can be reduced excessively if the excess SDF is not rinsed of, due to increase in alkalinity that hinders with the function of etchant and phosphoric acid.[17]

Preconditioning with 10% solution of polyacrylic acid was done in this study in accordance to the standard protocol. Dentine that has been conditioned or etched for up to 15 seconds shows no significant difference in bond

Table 1: Comparison of the push out bond strength

	N	Minimum	Maximum	Mean	Std. Deviation	p value
Group 1	10	2.90	10.82	6.895	2.56	0.00*
Group 2	10	0.78	5.30	3.601	1.430	
Group 3	10	2.83	7.18	4.512	1.426	
Group 4	10	.00	5.89	4.099	1.645	
Group 5	10	2.60	40.60	19.279	13.966	
Group 6	10	15.47	31.32	21.852	5.507	

* p value <0.05 – significant

strength according to Tay et al.[17] The surface bioload and smear layer are removed and the increase in permeation of AgF and KI into the dentine is done by the action of phosphoric acid unlike conditioning. Before the application of AgF and KI to GIC or to surface of dentin, washing or air drying the reaction products is recommended, which leads to the low bond strength.[18]

On the other hand, the aim of the study was to examine if self-etch or etch and rinse was recommended for adhesives to dentin pre-treated with SDF, since pre-treatment with 38% SDF did not result in significantly different bond strengths for self-etch vs etch-and-rinse groups. There are two types of explanation. Hydrofluoric acid exposure prior to phosphoric acid etching produces greater bond strengths. This was in accordance with this study that presented that pre-treatment with 12% SDF on dentin prior to etch and rinse outperforms self-etch adhesive.[19,20]

In light of this, so therefore etch-and-rinse adhesive was utilised in this study, following pre-treatment of dentin with SDF.[19] The usage of etch and rinse dentin bonding agent has no negative effect on the bonding, infact the use of selfetch and etch rinse (ER), only difference would be hybrid layer thickness formation.[18] The use of ER adhesives on dentin results in the formation of a continuous, uniform, and thicker hybrid layer; whereas, a thin hybrid layer is formed by the SE adhesives and is associated with the creation of droplets in between the adhesive and composite resin. This difference in the physical appearance of the hybridized complex, however, will not manipulate the bond strength of SE adhesives which remains optimal, to the uniform demineralization which was created beneath the dentin and impregnation of resin adds to the benefit of SE adhesives.[18] So therefore, the easy availability of the material, we chose etch and bond(ER) in the study.

Generally after the application of SDF and potassium iodide in a carious tooth, we need to restore the tooth to its normal anatomy, hence GIC and composite, the most widely used restorative materials, were used in this study. A good bonding between the restorative material and the tooth is vital for normal functioning of the tooth.[21]

The result showing in this study, shows that the GIC has a better bond strength with tooth, followed by composite. Tooth treated with only SDF without potassium iodide showed better bonding, than the tooth treated SDF with potassium iodide. According to Van Duker et al addition of Potassium iodide to reduce the discolouration will dramatically weaken the bond which can be due to blocking of dentinal tubules by formation of silver microwires and thus reducing the penetration of bonding agent into the dentinal tubules.[20]

A review of the longevity of posterior composite resin restorations states that annual failure rates of these restorations are 1.8% and 2.4% per year at 5 and 10 y, respectively. Rates are higher for subjects at high caries risk, with failure rates at 3.2% and 4.6% per year, respectively.[22] A submitted paper by Seto et al, described the penetration of SDF (called silver microwires) into the dentin tubules.[23] The phenomenon of cold sensitive dentin can be reduced by occlusion of dentinal tubules but the penetration of bonding agent may be blocked leading to reduction in bond strength of resin restoration.

By placing composite restoration in the carious lesion treated with SDF and adhesive usage, the clinical success rate of composite restoration is decreased due to lowering of bond effect with respect to adhesives. According to Selvaraj[23] and Quock et al[24] reported no decrease in the bond strength to SDF-treated dentin; whereas Kucukyilmaz et al. and Soeno et al.[25] reported a decrease in shear bond strength to SDF-treated dentin. Rinsing away the precipitates resulting from SDF application prevented a decrease in bond strength for autocured glass ionomer cement.[26] Whether the bond strength–decreasing effect is permanent after an application of SDF is unknown. This area requires more investigation before composite resin is applied after a SDF application.[26]

Within the limitations of the study it is suggested that a more detailed further study need to be done, in order to check for the adhesion and cohesion of the SDF and potassium iodide with tooth, both shear bond strength and micro leakage study need to be conducted for the proper detailed understanding of the study.

5. Conclusion

In this study, it can be concluded that:

Addition of potassium iodide used to reduce the staining of the SDF does affect the bond strength of the restoration to dentin.

The usage of SDF alone can yield better strength rather than addition of potassium iodide.

GIC has the best bond strength with tooth, followed by composite among all the group.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare no conflict of interest.

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Cite this article: Shetty S, Shetty B, Narayan N. Evaluation of bond strength of posterior restorative material with tooth treated with silverdiamine fluoride – Invitro study. *Int J Oral Health Dent* 2022;8(2):153-157.