ejpmr, 2024, 11(8), 288-293

SJIF Impact Factor 7.065

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Research Article

ISSN 2394-3211

EJPMR

SHEAR BOND STRENGTH OF COMPOSITE RESIN ON PERMANENT TEETH DENTIN PRETREATED WITH VARIOUS SILVER DIAMINE FLUORIDE CONCENTRATIONS: AN IN-VITRO STUDY

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Article Received on 09/06/2024 **Article Revised on 30/06/2024** **Article Accepted on 20/07/2024**

ABSTRACT

Background: The current study aimed to investigate the impact of different concentrations (12%, 30%, and 38%) of Silver diamine fluoride on the shear bond strength of composite resin to artificial caries-affected dentine. **Materials and methods:** Forty extracted premolars were demineralized to mimic caries-affected dentine They were randomly allocated for pretreatment (n = 10 per treatment), Group 1: (Control group) without pretreatment of SDF, Group 2 : 12% SDF pretreatment, Group 3: 30% SDF pretreatment, Group 4: 38% SDF pretreatment. All samples were immersed in artificial saliva for 24 hours after the treatments. Subsequently, all dentine samples were bonded with Composite resin. The shear bond strength was then measured using a universal testing machine and was analyzed using a one-way ANOVA test. **Results:** A statistically significant difference in mean SBS was found between control group (25.7 ± 1.7) and group 2 (11.5 ± 1.2), group 3 (17.1 ± 1.3) and group 4 (18.9 ± 1.9), but no significant difference was found between group 3 and group 4. Moreover, there was a statistically significant difference in mean SBS between group 2 with group 3 and group 4. **Conclusion:** The application of SDF to dentin immediately before composite resin restoration adversely affects Shear bond strength.

KEYWORDS: Silver diamine fluoride, shear bond strength, universal testing machine.

INTRODUCTION

Dental caries, a widespread disease globally, is a localized pathological condition influenced by multiple factors. It involves the softening of dental hard tissues and progresses to the development of cavities.[1] In recent years, advancements in restorative materials and our understanding of the caries process have enabled the practice of minimally invasive dentistry.[2] Minimally invasive dentistry (MID) is an approach that integrates prevention, remineralization, and minimal intervention for restoration replacement. It employs the least invasive surgical methods to meet treatment objectives, preserving as much healthy tissue as possible.[3] Silver Diamine Fluoride (SDF) exemplifies the MID concept. It uniquely eliminates bacteria and hardens teeth, thus halting and preventing caries. SDF is almost twice as effective as fluoride varnish in preventing caries.[4] It reduces dentin demineralization, enhances dental remineralization, raises biofilm pH, and possesses antibacterial properties against cariogenic bacteria.[3,5]

Silver Diamine Fluoride (SDF) has gained popularity as an alternative when conventional complex treatments are impractical.[6] It is a simple, affordable, non-invasive, and quick method that effectively manages pain and infection in young children with minimal caustic effects.[7] The distinctive benefits of SDF stem from the combined actions of its components.[6] Silver and fluoride ions work synergistically on both hard tissues and bacteria. Fluoride primarily enhances remineralization,[8] At the same time, silver ions exert a strong antibacterial effect,[9] In addition to preventing collagen degradation, SDF forms insoluble compounds and granular spherical grains that precipitate in the inter-tubular areas. This increases microhardness and reduces dentinal sensitivity by blocking dentinal tubules.[5] Ammonium hydroxide is added to maintain a stable level of alkalinity, which is essential for halting the progression of caries.[8] SDF is available in various commercial concentrations, including 12%, 30%, and 38%. These concentrations, ranging from 10% to 38%, are used to prevent and halt caries. The 38% concentration is the most commonly used due to its significant effectiveness in arresting active caries and preventing new ones.[10]

Despite its benefits, SDF has several limitations, including causing black staining of dental substrates due to the formation of metallic silver.[11] To mitigate this, alternatives such as adding potassium iodide (KI) to SDF have been proposed, allowing KI to react with any residual silver ions.[1] Ammonium hexafluorosilicate was proposed as a possible alternative, but neither option proved as efficient as SDF in slowing down the progression of lesions.[12] The limitations of SDF in meeting both aesthetic and functional requirements underscore the importance of combining caries arrest with the application of a permanent restorative material whenever cavitated lesions are present. This approach will ensure proper sealing against bacteria and enhance the tooth's cleanability.[2]

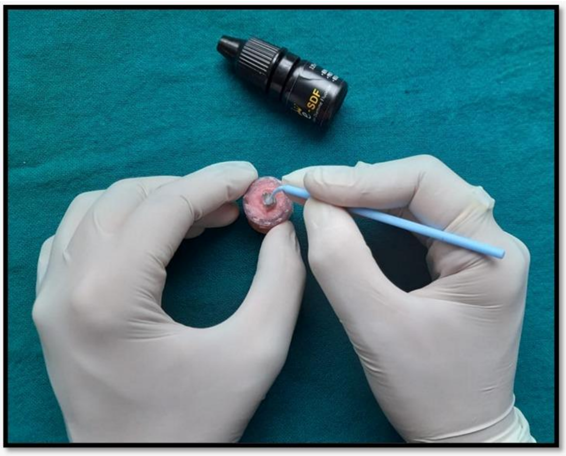
Tooth-colored fillings, such as resin-based composites, are commonly utilized in dentistry because they can achieve full setting quickly.[13] Bulk-fill composite has been developed with a curing depth of up to 5 mm to reduce polymerization shrinkage, enhance the restoration's marginal integrity, and expedite restorative procedures, making it a preferred option.[14]

Despite the significant advantages provided by combining SDF with a composite restoration, to date no studies have examined the effects of composite restoration after applying different SDF concentrations, i.e 12%, 30% and 38% on Shear bond strength of the final restoration. Therefore, the current study aimed to investigate the impact of different concentrations (12%, 30%, and 38%) of SDF on the SBS of composite resin. The null hypothesis being tested was that SDF application had no effect on the SBS of universal adhesives bonded to the dentin of permanent teeth.

MATERIALS AND METHODS

The current research was carried out at the Department of Pediatric and Preventive Dentistry, Kothiwal Dental College and Research Centre, Moradabad, Uttar Pradesh. Sample testing was conducted at I.T.S. Engineering College, Greater Noida, following approval from the institutional ethical and review board.This study included 40 sound-extracted human premolar teeth. The teeth were cleaned right after extraction and inspected for caries, defects, or cracks. The samples were then kept in normal saline until the start of the experiment. All forty teeth were embedded in acrylic resin, positioned with their long axis perpendicular to the upper surface of the mold. A slow-speed diamond disc with water coolant was used to flatten the occlusal enamel, followed by smoothing the surfaces with silicon carbide paper to expose a flat dentin surface. After this preparation, all samples were immersed in a demineralizing solution. (pH 4.4, 50 mM acetate, 2.2 mM KH_2PO_4, 2.2 mM $CaCl_2$) for 7 days. They were then allocated to four groups (n = 10 per group).

Group I: (**Control group)** The demineralized surfaces received no pretreatment.
Group 2: **12% SDF** (Kids E Dental, Mumbai, India) Solution was topically applied to the Demineralized surface
Group 3: **30% SDF** (Kids E Dental, Mumbai, India) Solution was topically applied to the demineralized surface.
Group 4: **38% SDF** (Kids E Dental, Mumbai, India) Solution was topically applied to the demineralized surface.



Application of SDF

After 30 minutes, all samples were immersed in the artificial saliva for 24 hours. Subsequently, a flat dentin surface was etched with 37% Phosphoric acid gel for 15 s and rinsed with water for 10 sec. Excess water was blot dried using tissue paper then, Prime and Bond UA were applied on the exposed dentin surface using a microbrush applicator and light cured for 10 seconds. Teflon tubes with 3 mm diameter and 4mm height were placed perpendicular to the previously etched, pre-treated, bonded dentin surface. A nanohybrid resin composite (Filtek Z350 XT, Body Shade B1; 3M ESPE Dental Products) was filled into the precut tubes in 2mm increments. Each increment was light-cured for 20 seconds using an LED Curing Unit (Waldent Smart-LED). After bonding, the Teflon tubes were gently cut and carefully removed using a scalpel. After bonding, samples were stored in 100% humidity at 37 °C for 24 hours.

SHEAR BOND STRENGTH TEST

A universal testing machine with a flat edge loading head was used to perform the shear bond strength test. A force was applied perpendicular to the composite cylindrical button at a distance of 1 mm from the dentin surface to the loading head. The loading head moved at a fixed rate of 1 mm/minute. The load necessary to de-bond composite was recorded in Newtons and expressed in Mega-Pascals by dividing the load at failure by the bonded surface area in square mm.

Shear Bond Strength Test in Universal Testing Machine

STATISTICAL ANALYSIS

All data analyses were carried out using IBM SPSS for Windows (Version 23.0), and the significance level was set at p-value < 0.05. The means of Shear bond strength (MPa) between groups was tested by one-way ANOVA followed by the Post Hoc Tukey test.

RESULT

Table 1 illustrates the dispersion of the mean ± standard deviation, as well as the maximum and minimum values of SBS (Mpa) across the groups. Group I exhibits the highest maximum value, while Group II displays the lowest minimum value. Table 2 shows the results of the comparison of means of SBS (MPa) among the groups by one-way ANOVA, the value of F= 141.542, and p <0.01 is highly significant. Therefore, the mean difference of shear bond strength (MPa) is significant among the groups. Table 3 shows the multiple comparison of mean of Shear bond strength among various groups by Post Hoc Tukey test. Upon comparison, with group 1 (control group), a statistically significant difference in SBS was observed in group 2, group 3, and group 4, but no significant difference was seen between group 3 and group 4. Whereas group 3 and group 4 show significant difference with group 2.

The maximum SBS was noted with the control group (no pre-treatment with SDF), followed by 38% SDF, 30% SDF, and the least values were noted with 12% SDF, The Shear bond strength dropped significantly when the composite resin was bonded immediately after SDF pretreatment.

Table 1: Mean shear bond strength of each group.

Group	Mean	N	Std. Deviation	Minimum	Maximum
1	25.666000	10	1.6921728	23.2500	28.5000
2	11.453000	10	1.2178766	9.8500	13.7400
3	17.096000	10	1.2808608	15.3500	19.0800
4	18.949000	10	1.9277762	14.5000	20.8000
Total	18.291000	40	5.3527634	9.8500	28.5000

Table 2: Comparison of Mean shear bond strength of each group by one way ANOVA.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1030.099	3	343.366	141.542	.000
Within Groups	87.332	36	2.426		
Total	1117.431	39			

Table 3: Multiple pair wise comparison of mean shear bond strength of various groups using Post Hoc Tukey test.

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	12% SDF	14.2130000*	.6965486	.000	12.337037	16.088963
	30% SDF	8.5700000*	.6965486	.000	6.694037	10.445963
	38% SDF	6.7170000*	.6965486	.000	4.841037	8.592963
12% SDF	Control	-14.2130000*	.6965486	.000	-16.088963	-12.337037
	30% SDF	-5.6430000*	.6965486	.000	-7.518963	-3.767037
	38% SDF	-7.4960000*	.6965486	.000	-9.371963	-5.620037
30% SDF	Control	-8.5700000*	.6965486	.000	-10.445963	-6.694037
	12% SDF	5.6430000*	.6965486	.000	3.767037	7.518963
	38% SDF	-1.8530000	.6965486	.054	-3.728963	.022963
38% SDF	Control	-6.7170000*	.6965486	.000	-8.592963	-4.841037
	12% SDF	7.4960000*	.6965486	.000	5.620037	9.371963
	30% SDF	1.8530000	.6965486	.054	-.022963	3.728963

*. The mean difference is significant at the 0.05 level.

DISCUSSION

This in-vitro study aimed to assess how pre-treating dentin with varying concentrations of silver diamine fluoride (SDF) influences the bond strength of composite resin. Shear bond strength (SBS) measures the adhesive strength at the interface between the restoration and the tooth. This interface is critical as it experiences the forces of mastication, akin to shearing, leading to a complex stress distribution during clinical load-bearing scenarios.[15]

SDF has gained popularity as an alternative for managing dental caries and was approved by the US Food and Drug Administration (FDA) in 2014 for dental applications. Nonetheless, there are concerns regarding its effect on the bond strength of restorative materials to dentin.[16]

The results of this study indicated that the shear bond strength of composite resin significantly decreased when applied immediately after SDF application compared to the control group. (p-value <0.001). This is consistent with the results obtained by Markham et al.[17] ,Koizumi et al.[18] who used KI/SDF as a pretreatment, Kucukyilmaz et al.[19] who used SDF and ammonium hexafluorosilicate on intact and demineralized dentin and Lutgen et al. who pretreated sound dentin.[20] In contrast, Favaro et al.[21] and Quock et al.[2] found no negative impact of SDF on composite micro-shear bond strength and micro-tensile bond strength, respectively. Pérez-Hernández et al.[22] even observed improved retention of fissure sealants when applied after SDF treatment. These conflicting results can be attributed to the inherent differences between enamel and dentin, resulting in distinct effects of SDF and etching on each substrate.

The reaction of SDF with hydroxyapatite forms a silver phosphate (Ag3PO4) layer,[23] and the pretreatment causes silver particles to obstruct the dentinal tubules.[24] This impermeable layer and the inter-tubular precipitate act as a barrier, hindering the intimate resin impregnation needed for an optimal hybrid layer, thereby affecting the shear bond strength (SBS) of the composite resin.[13] Additionally, considering that SDF is highly alkaline (pH 10-12.5),[25] it serves as both physical and chemical barrier to adhesion, which requires a dry, acidic environment to facilitate adhesive resin bonding.[20]

Several in-vitro studies have explored the impact of SDF on the bond strength of restorative materials. Zhao et al. demonstrated that pre-treatment with SDF did not impair the adhesion of glass ionomer cement (GIC) to caries-affected dentin.[1] Likewise, Wu et al. found that applying 38% SDF on primary dentin did not impact the bond strengths of composite resin to sound primary molars.[26] On the contrary, Sa'ada et al. found that pre-treating sound primary dentin with SDF significantly enhanced the shear bond strength (SBS) between resin-modified glass ionomer cement (RMGIC) and primary dentin.[27] Fröhlich et al., in their systematic review, indicated that the impact of SDF on dentin bonding varied depending on the material used: they found no effect on the adhesion of glass ionomer cement (GIC), but they observed a significant decrease in bond strength when adhesive systems were used.[28] Aboulsaood et al. demonstrated in their study that postponing the application of composite resin for one week after pretreatment resulted in a significant enhancement in shear bond strength (SBS) compared to immediate application after pretreatment. This improvement is likely due to silver ions penetrating deeper into the dentinal tubules during this time interval. Silver ions inhibit matrix metalloproteinases (MMPs) and cysteine cathepsin enzymes, which degrade dentinal collagen matrix proteins, thus preventing bond loss. The remineralizing and inhibitory properties of SDF suggests that further extending the time interval may enhance the SBS of composite resin.[29]

In this study, various concentrations of SDF, namely 38%, 30%, and 12%, were utilized. Clinical research has confirmed the efficacy of the 38% concentration in preventing and stopping early childhood caries (ECC). However, because the 38% concentration contains a high fluoride content of 44,800 ppm, which increases the risk of dental fluorosis, lower concentrations of 30% and 12% have been introduced to reduce such complications.[30]

The results of this study shows that the mean difference of SBS (MPa) between 38% and 30% SDF is not significant. But, on comparing 38% and 30% with 12% SDF the results significantly deteriorated. However, on comparing with control group, all the concentrations shows a significant drop in shear bond strength. Which suggest that the application of Different concentrations of SDF to dentin immediately before composite resin restoration adversely affects shear bond strength. Therefore, SDF pretreatment one week prior to composite resin restoration is can be done to minimize the risk of bonding failure. Moreover, Further studies are necessary with 30% and 12% concentrations of SDF, as the supporting evidence for these concentrations is currently insufficient. Based on the findings of this study, null hypothesis was rejected.

The main limitation of this study is that SDF is mainly used in primary teeth. However, in this study, permanent premolars were used instead of primary teeth. The differences in the dentinal tubules' structure may also be a factor affecting the action of SDF on the natural tooth and the subsequent restorative material. Another limitation could be that the bond strength of teeth affected by clinical caries may differ from artificially induced caries. However, despite these limitations, the findings of this study can provide valuable insights for ongoing research investigating the impact of SDF pre-treatment on the physical properties of dental materials.

CONCLUSIONS

Within the limitations of this in-vitro study, it can be concluded that the application of Silver Diamine Fluoride to dentin immediately before composite resin restoration adversely affects Shear bond strength.

Conflict of interest – None

SOURCE OF FUNDING - None

REFERENCES

1. Zhao IS, Chu S, Yu OY, Mei ML, Chu CH, Lo EC. Effect of silver diamine fluoride and potassium iodide on shear bond strength of glass ionomer cements to caries-affected dentine. International dental journal, 2019 Oct 1; 69(5): 341-7.
2. Quock RL, Barros JA, Yang SW et al. Effect of silver diamine fluoride on microtensile bond strength to dentin. Oper Dent., 2012; 37: 610–616.
3. Osama S, Badran AS, Awad BG. Effect of silver diamine fluoride on the microleakage of flowable resin composite and glass ionomer cement restorations to carious primary dentin: an-in vitro study. BMC Oral Health, 2024 Jan 16; 24(1): 91.
4. Rosenblatt A, Stamford TCM, Niederman R. Silver diamine fuoride: A caries "Silver-Fluoride Bullet." J Dent Res., 2009; 88(2): 116–2.
5. Mei ML, Ito L, Cao Y, Li QL, Lo ECM, Chu CH. Inhibitory efect of silver diamine fuoride on dentine demineralization and collagen degradation. J Dent., 2013; 41(9): 809–17.
6. Crystal YO, Niederman R. Evidence-Based Dentistry Update on Silver Diamine Fluoride. Dent Clin North Am., 2019; 63: 45–68.
7. Sharma G, Puranik MP, K RS. Approaches to Arresting Dental Caries: An Update. J Clin Diagn Res., 2015; 9: Ze08-11.
8. Zhao IS, Gao SS, Hiraishi N, Burrow MF, Duangthip D, Mei ML, Lo EC, Chu CH. Mechanisms of silver diamine fluoride on arresting caries: a literature review. Int Dent J., 2018; 68: 67–76.
9. Horst JA, Ellenikiotis H, Milgrom PM. UCSF Protocol for Caries Arrest Using Silver Diamine Fluoride: Rationale, Indications and Consent. Pa Dent J (Harrisb), 2017; 84: 14, 16–26.
10. Fung MHT, Duangthip D, Wong MCM, Lo ECM, Chu CH. Randomized clinical trial of 12 and 38% silver diamine fuoride treatment. J Dent Res., 2018; 97(2): 171–8.
11. Lou YL, Botelho MG, Darvell BW. Reaction of silver diamine fluoride with hydroxyapatite and protein. J Dent., 2011; 39: 612–618.
12. Peng JJ, Botelho MG, Matinlinna JP. Silver compounds used in dentistry for caries management: a review. J Dent., 2012; 40: 531–41.
13. Fröhlich TT, Botton G, Rocha RO. Bonding of Glass-Ionomer Cement and Adhesives to Silver Diamine Fluoride-treated Dentin: An Updated Systematic Review and Meta-Analysis. The journal of adhesive dentistry, 2022; 24: 29–38.
14. Akman H, Tosun G. Clinical evaluation of bulk-fill resins and glass ionomer restorative materials: A 1-year follow-up randomized clinical trial in children. Niger J Clin Pract., 2020; 23: 489–497.
15. Aldowsari MK, Alfawzan F, Alhaidari A, Alhogail N, Alshargi R, Bin Saleh S, Sulimany AM, Alturki M. Comparison of Shear Bond Strength of Three

Types of Adhesive Materials Used in the Restoration of Permanent Molars after Treatment with Silver Diamine Fluoride: An In Vitro Study. Materials, 2023 Oct 24; 16(21): 1-10.
16. Jiang, M.; Mei, M.L.; Wong, M.C.M.; Chu, C.H.; Lo, E.C.M. Effect of silver diamine fluoride solution application on the bond strength of dentine to adhesives and to glass ionomer cements: A systematic review. BMC Oral Health, 2020; 1-10.
17. Markham MD, Tsujimoto A, Barkmeier WW, Jurado CA, Fischer NG, Watanabe H, Baruth AG, Latta MA, Garcia-Godoy F. Influence of 38% silver diamine fluoride application on bond stability to enamel and dentin using universal adhesives in self-etch mode. Eur J Oral Sci., 2020; 128: 354–360.
18. Koizumi H, Hamama HH, Burrow MF. Effect of a silver diamine fluoride and potassium iodide-based desensitizing and cavity cleaning agent on bond strength to dentine. International Journal of Adhesion and Adhesives, 2016; 68: 54–61.
19. Kucukyilmaz E, Savas S, Akcay M, Bolukbasi B. Effect of silver diamine fluoride and ammonium hexafluorosilicate applications with and without Er:YAG laser irradiation on the microtensile bond strength in sound and caries-affected dentin. Lasers Surg Med., 2016; 48: 62–69.
20. Lutgen P, Chan D, Sadr A. Effects of silver diammine fluoride on bond strength of adhesives to sound dentin. Dent Mater J., 2018; 37: 1003–9.
21. Favaro JC, de Mello Peixoto YCT, Geha O, Dias FA, Guiraldo RD, Lopes MB, Berger SB. Can silver diamine fluoride or silver nanoparticle-based anticaries agents to affect enamel bond strength? Restor Dent Endod., 2021; 46: e7.
22. Pérez-Hernández J, Aguilar-Díaz FC, Venegas-Lancón RD, Gayosso CAÁ, Villanueva-Vilchis MC, de la Fuente-Hernández J. Effect of silver diamine fluoride on adhesion and microleakage of a pit and fissure sealant to tooth enamel: in vitro trial. Eur Arch Paediatr Dent., 2018; 19: 411–416.
23. Li Y, Liu Y, Psoter WJ, Nguyen OM, Bromage TG, Walters MA, Hu B, Rabieh S, Kumararaja FC. Assessment of the Silver Penetration and Distribution in Carious Lesions of Deciduous Teeth Treated with Silver Diamine Fluoride. Caries Res., 2019; 53: 431–440.
24. Sulyanto RM, Kang M, Srirangapatanam S, Berger M, Candamo F, Wang Y, Dickson JR, Ng MW, Ho SP. Biomineralization of Dental Tissues Treated with Silver Diamine Fluoride. J Dent Res., 2021; 100: 1099–1108.
25. Sayed M, Matsui N, Hiraishi N, Inoue G, Nikaido T, Burrow MF, Tagami J. Evaluation of discoloration of sound/demineralized root dentin with silver diamine fluoride: In-vitro study. Dent Mater J., 2019; 38: 143–149.
26. Wu, D.I.; Velamakanni, S.; Denisson, J.; Yaman, P.; Boynton, J.R.; Papagerakis, P. Effect of Silver Diamine Fluoride (SDF) Application on Microtensile Bonding Strength of Dentin in Primary Teeth. Pediatr. Dent., 2016; 38: 148–153.
27. Sa'ada, M.M.; Khattab, N.M.; Amer, M.I. Effect of Silver Diamine Fluoride Pretreatment on Shear Bond Strength of Resin Modified Glass Ionomer Cement to Primary Dentin. Open Access Maced. J. Med Sci., 2021; 9: 243–247.
28. Fröhlich, T.T.; Rocha, R.O.; Botton, G. Does previous application of silver diammine fluoride influence the bond strength of glass ionomer cement and adhesive systems to dentin? Systematic review and meta-analysis. Int. J. Paediatr. Dent., 2020; 30: 85–95.
29. Aboulsaood EH, Bakry NS, Zeitoun SI, Aboulgheit SA. The effect of delaying composite resin restoration after silver diamine fluoride pretreatment on the Shear Bond Strength of the final restoration: An in-vitro study.
30. Tolba ZO, Hamza HS, Moheb DM, Hassanein HE, El Sayed HM. Effectiveness of two concentrations 12% versus 38% of silver diamine fluoride in arresting cavitated dentin caries among children: a systematic review. Egyptian Pediatric Association Gazette., 2019 Dec; 67: 1-7.