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Effect of Dentine Pretreatment with 38% Silver Diamine Fluoride and CPP-ACPF on Micro-Shear Bond Strength of Resin Modified Glass Ionomer Cement

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The aim of the study is to evaluate the micro-shear bond strength and mode of failure of resin modified glass ionomer cement (RMGIC) placed on demineralized dentin pre-treated with 38% silver diamine fluoride (SDF) and casein phosphopeptide amorphous calcium phosphate (CPP-ACP). In order to mount the premolars in acrylic blocks, 30 caries-free human premolars were divided mesio-distally into two equal halves.. Then the enamel was removed to expose the dentin and immersed in demineralizing solution for 96 h, which were then randomly allocated into three groups: Group-1: pretreatment with 38% SDF + RMGIC; Group-2: pretreatment with CPP-ACPF + RMGIC; and Group-3: No pretreatment + RMGIC (control). After the pre-treatment, resin modified glass ionomer cement was placed over the dentin surface using cylindrical mold. Then the micro-shear bond strength was evaluated using universal testing machine and mode of fracture was analyzed with stereomicroscopy. The micro-shear bond strength was found to be higher for the control group (35.73 ± 4.15) followed by SDF (28.39 ± 1.64) and CPP-ACPF (23.00 ± 2.17) and this difference was found to be statistically significant (p = 0.001). On analyzing the mode of failure, the adhesive type of failure was most common in all the groups and the difference in the percentages of mode of failure between the groups was not significant (p = 0.337). Application of 38% SDF and CPP-ACPF on demineralized dentin samples has shown to reduce the micro-shear bond strength of resin modified glass ionomer cement. Adhesive failures were the most common type of failures in both pretreated and untreated groups.

Keywords: Resin, Glass ionomer cement, Diamine silver fluoride, Dental caries, CPP-ACP.

INTRODUCTION

Treatment of dental caries can be challenging in young children with limited coping ability since it requires cooperation. In such disadvantaged situations, non-caries removal technique with the application of cariostatic agents or remineralizing agents can be used to arrest the progression of caries lesions rather than the traditional surgical approach of caries removal [1]. Silver diamine fluoride (SDF) is widely used in dentistry from many years for its cariostatic action and supports its use in treating active lesions by lowering the load of cariogenic bacteria. Studies have evidenced that SDF applications exhibited a significant antimicrobial effect against cariogenic biofilm [2,3]. Hence applications of SDF prior to the placement of glass ionomer cement (GIC) may further be advantageous in non-caries removal technique.

Casein phosphopeptide amorphous calcium phosphate (CPP-ACP) is a proven non-fluoride remineralizing agent and acts as a calcium phosphate reservoir, buffering the free calcium and phosphate ions, thereby helping to maintain a state of super saturation, which halts the enamel demineralization and enhance the remineralization [4]. Addition of fluoride to CPP-ACP further increases the remineralization ability. Treating the caries lesion with CPP-ACPF prior to the placement of restorative material may be beneficial in arresting caries lesion.

Resin modified glass ionomer cement (RMGIC) was introduced in 1990s. Along with the inherent properties of GIC, resin modified glass ionomer cement (RMGIC) additionally has physico-chemical bonding to the tooth structure. It is also less sensitive to moisture and has superior bond strength compared to conventional glass ionomer cements [5]. Other advantages include ease of use, convenient setting time, good thermal properties, little microleakage [6], better aesthetics and translucency [7].

A perfect seal at the tooth restoration interface is essential for arresting the progression of caries lesions. Although using cariostatic agents is advantageous, their effect on bonding of restorative material to the dentinal hard tissue is questionable. Hence, an *in vitro* investigation was carried out with an aim to assess the micro-shear bond strength of resin modified glass ionomer restorations placed on demineralized dentin pretreated with 38% SDF and CPP-ACPF.

EXPERIMENTAL

The *in vitro* study was approved by the Institutional ethical committee (IECVDC/2021/PG01/PPD/IVT/35). The samples of human premolars extracted for orthodontic purposes were included in the study. Premolars with dental caries or any developmental defects were excluded.

The sample size was calculated based on the results of pilot study. Using G*power 3.1.9.2 software for power analysis, it was calculated to be 54 samples (corresponding to achieve 90% power with 95% confidence). However, a total of 60 samples were taken to compensate for procedural errors during sample preparation.

Group allocation: A total of 60 samples were randomly allocated into 3 groups of 20 each: Group-1: Pretreatment with 38% SDF + GIC; Group-2: Pretreatment with CPP-ACPF + GIC; and Group-3: No pretreatment + GIC (control).

Sample preparation: Thirty freshly extracted premolar teeth were collected and cleaned with 10% formalin solution. Tissue remnants and hard deposits on the teeth surface were cleaned with ultrasonic scaler tips and stored in double deionized distilled water till the procedure was initiated. Disinfected teeth were decoronated at the level of CEJ and sectioned into buccal and lingual halves using double faced diamond discs. Samples were mounted in blocks of self cure acrylic resin (30 mm × 20 mm × 15 mm) and the enamel was removed to expose the dentin, which was then polished sequentially using 320, 600 and 800 grit carbide papers.

The prepared samples were individually immersed in 12 mL of demineralizing solution to mimic carious dentin. After demineralization, the samples were kept under running water for 20 s and dried with blotting paper. A thin layer of dentine conditioner was applied over the demineralized dentin surface and left for 15 s, which was then rinsed with distilled water for 20 s. In test groups, the conditioned dentine surface was coated with respective cariostatic agents 38% SDF (kids-e-dental, Japan) and CPP-ACPF (GC tooth mousse plus, GC Corporation, Japan) for 20 s and left for 3 min, whereas in control group no pretreatment was done. Resin modified glass ionomer capsules (GC Fuji II LC, GC Corporation, Japan) were then activated and triturated for 10 s. Cement was loaded into cylindrical plastic mold of internal diameter 3 mm and height 2 mm which was placed over the pretreated dentin surface in test groups and conditioned dentin surface in control group. Then the cement was light cured for 20 s with LED curing light of wave length 470 nm as per manufacturer's instruction.

Evaluation of micro-shear bond strength and mode of failure: The bonded samples were subjected to three point bending test with the universal testing machine (Instron 8801, United Kingdom) at a cross-head speed of 0.5mm per min with a load cell of 500 N until debonding. The force required to debond the samples was recorded in newtons (N) and then converted to mega pascals (Mpa). After checking the micro-shear bond strength, the fractured samples were observed under stereomicroscope (Olympus SZX16, Japan) at 40× magnification to assess the failure mode as adhesive, cohesive or mixed.

The obtained data was entered in micro soft excel spread sheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0. As the data showed normal distribution, parametric statistical tests were used to analyze the data. Inter group comparisons were done using one-way ANOVA test followed by post-hoc tukey test for pairwise comparison and Chi-square test was done for intergroup comparison of modes of failure. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

The bonding of restorative material may be impacted by a variety of elements, including the substrate's structural, physical and chemical properties. Remineralizing agents were directly applied to the demineralized dentin in the current investigation, which might have an impact on the bonding of restorative material. Therefore, the current study explored whether remineralization pre-treatment of an artificially demineralized dentin would affect the microshear bond strength of the restorative material.

In present study, the samples pretreated with 38% SDF demonstrated less micro-shear bond strength values compared to the control group. On comparing mean micro-shear bond strength values of RMGIC samples placed on demineralized dentin, the samples in which no pretreatment (control) was carried out showed higher bond strength (35.73 ± 4.15) compared to pretreated samples. Samples treated with SDF (Group 1) (28.39 ± 1.64) has shown higher bond strength compared to CPP-ACPF (Group 2) (23.00 ± 2.17). The difference in micro-shear bond strength values between the groups is found to be statistically significant (p = 0.001) (Table-1).

TABLE-1
INTER GROUP COMPARISON OF MICRO-SHEAR BOND STRENGTH VALUES (MPa)

Groups	Samples (n)	Mean ± SD	F value	p value
Group-1 (SDF)	20	28.39 ± 1.64		
Group-2 (CPP-ACPF)	20	23.00 ± 2.17	99.441	0.001*
Group-3 (No pretreatment)	20	35.73 ± 4.15		

*Highly significant

On pairwise comparison, the micro-shear bond strength values between all the groups was found to be statistically significant ($p = 0.001$). However, the highest difference was observed between the samples with no pretreatment (control) and samples treated with CPP-ACPF (Group 2) (12.73 ± 0.90) (Table-2). Similarly, Markham *et al.* [8] also reported the negative effect of SDF application on the bonding of composite resin with universal adhesives to both enamel and dentin. The SEM images showed the remaining precipitate of SDF in dentinal tubules, which might be the cause of the decrease in bond strength [8].

TABLE-2
PAIRWISE COMPARISON OF MICRO-SHEAR BOND STRENGTH BETWEEN THE GROUPS

Groups	Mean difference ± SD	p value
SDF *vs.* CPP-ACPF	5.39 ± .90	0.001*
Control *vs.* SDF	7.34 ± .90	0.001*
Control *vs.* CPP-ACPF	12.73 ± .90	0.001*

*Highly significant

On analyzing modes of failure of RMGIC to pretreated dentin, samples pretreated with SDF have shown adhesive type (n = 15, 75%) of failure predominantly followed by mixed type (n = 3, 15%), whereas only 2 samples (10%) showed cohesive type of failure. The samples pretreated with CPP-ACPF (adhesive-80%, mixed-20%) and control group samples (adhesive-75%, mixed-25%) have also shown similar pattern of mode of failure. The difference in the mode of failure between the groups was found to be statistically not significant (p = 0.337) (Table-3).

The traditional management of dental caries involves complete excavation of caries tissue followed by the restoration. However, with the thorough understanding of the caries process, the traditional management approach has been changed. The development of the minimal intervention technique, which aims to maintain as much of the original tooth structure as possible involves the retention of inner caries affected layer of dentin. Application of remineralizing agents to the demineralized dentin may help in regaining the lost minerals and arresting the demineralization.

In current study, SDF and CPP-ACPF were used for pretreatment of dimineralized dentin. The SDF has been chosen since it contains high proportion of fluoride (44,800 ppm), moreover, it not only has anticariogenic property, but also has antibacterial property because of the presence of silver and fluoride ions [9-11]. The CPP-ACPF was taken as other remineralizing agent, since it maintains calcium and phosphate ion supersaturation apart from the fluoride incorporation into the biofilm, which eventually reduces demineralization and increases remineralization [4].

Elizabeth *et al.* [12] reported that the samples in which GIC was placed immediately following SDF application showed decreased bond strength (5 Mpa) compared to the samples, where GIC was placed 1 week after applying SDF (13.2 Mpa). It is possible that when SDF is not given sufficient time to fully solidify, a layer of unreacted remnants of SDF remains on the surface of the dentin and reduces the biomechanical bonding to GIC. The layer of aqueous SDF, with silver, ammonia and fluoride ions might have affected both mechanical interlocking and chemical bonding of the GIC.

In current study, the samples pretreated with CPP-ACPF have shown least micro-shear bond strength values compared to other groups. Dentin remineralized with CPP-ACP could be composed of a highly dense compaction of calcium phosphate and fluoride ions which might have interfered with the bonding of RMGIC to the dentin surface. In addition, the residual layer of CPP-ACP paste might remain on the dentine surface and affect the bonding between the hydrophilic HEMA resin and dentine surface [13,14].

In contrary to the present observations, Sattabanasuk *et al.* [14] and Mobarak *et al.* [15] reported an increase in micro shear bond strength with the dentine and enamel samples remineralized with CPP-ACP and CPP-ACPF, respectively. However, they used a bonding adhesive, which might be the reason for enhancement of the bond strength. Whereas in the present study, no adhesive was used and the RMGIC was applied directly on the remineralized dentin. Sattabanasuk *et al.* [14] observed a decrease in bond strength when sound dentin was treated with CPP-ACP for 5 min as well as for 5 days when etch and rinse adhesive *i.e.* optibond FL® was used. Another study showed that 15 min application of CPP-ACP for 5 consecutive days did not increase the microtensile bond strength when natural caries-affected dentin was coated with MI Paste and an etch-and rinse adhesive system. These outcomes might be the result of the formation of a CPP-ACP residual layer that inhibits the micromechanical interlocking of resin monomers from etch-and-rinse adhesives by reducing the phosphoric acid's etching effect [16].

In current study, the samples without any pretreatment have shown the highest bond strength compared to pretreatment groups. This might be because of clean interface between dentin hydroxyapatite and RMGIC, which allows the formation of resin tags that contribute to micro-mechanical inter locking. Also, the polyalkenoic acid carboxylate groups of RMGIC chemically binds to calcium ions in dentin [17,18]. Since RMGIC is placed immediately after conditioning the dentin, HEMA resin penetrates into the micropores and forms resin tags.

In present study, adhesive type of failure is predominantly seen in both pretreated and untreated groups. This suggests that

TABLE-3
MODE OF FAILURE OF RESIN MODIFIED GLASS IONOMER RESTORATIONS PLACED ON DEMINERALIZED DENTIN

Groups	Type of failure			p value
	Adhesive (n, %)	Cohesive (n, %)	Mixed (n, %)	
Group-1 (SDF)	15 (75%)	2 (10%)	3 (15%)	0.337
Group-2 (CPP-ACPF)	16 (80%)	0 (0%)	4 (20%)	
Group-3 (No pretreatment)	15 (75%)	0 (0%)	5 (25%)	

the adhesive bond between RMGIC and demineralized dentin is not strong. Similarly, Alshahrani [19] demonstrated that adhesive type of failures were pertinent in dentine specimens pretreated with 38% and 3.8% SDF bonded to RMGIC. He explained this type of failure can be attributed to a limitation in the material's mechanical characteristics. In contrary, the same author reported that cohesive failures were most common type of failures in RMGIC samples bonded to demineralized dentin subjected to polyacrylic acid cavity conditioner without any pretreatment. These cohesive failures might be because of the internal porosities of RMGIC that serve as stress points from where failure initiates.

Choi *et al.* [20] reported that the predominant failure modes of both Ketac-Fil (conventional GIC) and Photac-Fil (RMGIC) placed on demineralized dentin were mixed failures, which is a combination of adhesive and cohesive failures. This difference in the prominent failure mode might be related to the considerably lower bond forces of Ketac-Fil and Photac-Fil to demineralized dentin as well as lower tensile strength of Ketac-Fil material rather than its adhesive bond strength to demineralized dentin.

To summarize, the pretreatment groups have shown less bond strength when compared to samples without any pretreatment. However, in individuals with high caries risk, if the beneficial effects of SDF over weighs the reduction in bond strength, it can be considered for pretreatment. Since literature evidences strongly support the beneficial effects of SDF and CPP-ACPF, there is a further scope to test pretreatment with these agents along with the application of adhesives, which may improve the bond

Conclusion

Micro shear bond strength of resin modified glass ionomer cement (RMGIC) is reduced when the demineralized dentin is pretreated with 38% silver diamine fluoride (SDF) and casein phosphopeptide amorphous calcium phosphate fluoride (CPP-ACPF). However, the pretreatment with SDF displayed a higher bond strength compared to samples pretreated with CPP-ACPF. The adhesive failures are the most common type of failures in both pretreated and untreated groups.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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