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The effect of immediate dentin sealing on the bond strength of resin composite to dentin bonded with universal bonding agent: An *in vitro* study

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Abstract

Background: Dentin hypersensitivity is a common scenario encountered in dental practice. This issue can be treated by reducing dentin permeability and dentinal fluid flow. However, the desensitizing agents used may adversely affect the bonding of composite restorations to dentin.
Aim: To evaluate the shear bond strength of restorative composites to dentin treated with silver diamine fluoride and self-etch bonding agent bonded using a universal bonding agent.
Materials and methods: A total of 30 teeth were selected, and their occlusal surfaces were ground to expose a flat dentin surface. The teeth were then embedded in cold cure resin blocks. Depending on the treatment, the samples were randomly divided into three groups, with 10 in each. The samples in the group were untreated, in group 2 were treated with Silver Diamine Fluoride (SDF), and in group 3 with the sixth generation bonding agent (self-etch primer). After the treatment, the composite is bonded to the dentin surfaces and subjected to shear bond strength using the universal testing machine (UTM). The specimen was mounted on the custom-made jig and placed over the UTM. The load was applied at a cross-head speed of 1mm/min until debonding occurred at the dentin and composite interface, and the bond strength was computed in MPa. Overall comparisons were analyzed using the Kruskal-Wallis test. The Mann-Whitney U-test was used for pair-wise comparisons, and the significance level was set at $p < 0.05$.
Results: The lowest bond strength was observed with the dentin surfaces treated with silver diamine fluoride (Group 2), and the highest bond strength was for dentin treated with self-etch bonding agent (Group 3). Significant differences ($p=0.003$) were observed between the groups. In pair-wise comparisons, group 3 showed significant difference with group 1 ($p=0.007$) and group 2 ($p=0.002$). However, no significant difference was observed between groups 1 and 2 ($p=0.197$).
Conclusion: The shear bond strength varies with different desensitizing treatments. This study reported more SBS with sixth-generation bonding agent followed by untreated dentin and SDF.
Keywords: Dentin, Silver Diamine Fluoride, Dentin Hypersensitivity, Shear bond strength.

1. Introduction

Hypersensitivity is a multi-etiological clinical problem. Dentin hypersensitivity is a common and painful condition encountered in clinical practice. It is characterized by sharp, short pain triggered by thermal, tactile, chemical, evaporative, or osmotic stimuli on exposed dentin [1]. Various factors cause dentin hypersensitivity, including loss of enamel, denudation of root surface, gingival recession resulting from periodontal disease, inappropriate brushing habits, and periodontal treatment. In such cases, the underlying dentin is exposed to external stimuli, resulting in hypersensitivity. Hydrodynamic theory is the most widely accepted theory for explaining dentinal hypersensitivity. This states that pain is due to the deformation of sensory nerves in the pulp, caused by peripheral stimuli, which are generated by the movement of fluids or semi-fluid material in dentin tubules [2].

Traditionally home-use desensitizing toothpastes are considered the first choice because of their advantages of wide availability, cost-effectiveness and convenient application. However, they have a short life due to daily tooth brushing, saliva dissolving and an acidic diet [3]. Professional chair-side desensitizing solutions such as Silver diamine fluoride (SDF) [4] and self-etch bonding agents [5] as immediate dentin sealing (IDS) are commonly used to treat dentin hypersensitivity clinically. Immediate dentin sealing (IDS) is also called prehybridization, dual bonding technique, or resin coating technique [6]. This appears to achieve improved bond strength, fewer gap formations decreased bacterial leakage, and reduced dentin sensitivity [7].

Silver Diamine Fluoride (SDF) provides desensitization by precipitating proteins from dentinal tubules [8]. The use of self-etch adhesives for treating hypersensitivity has become increasingly popular in recent years. These systems use hydrophilic acidic monomers, which demineralize dentin and form a hybrid layer incorporating smear plugs which reduce post-operative sensitivity [9]. The recently introduced universal adhesive systems have gained popularity due to their ease of application in self-etch & etch and rinse modes. This adhesive also contains10-MDP (10-Methacryloyloxydecyl dihydrogen phosphate), which is a monomer with mild acidity and has water-insoluble salt formation capacity with dentin and adhesive versatile to bond resin composites to metals and ceramics [10,11]. Furthermore, short and medium-term clinical evaluations seem promising [12].

This study aimed to assess the adhesiveness of composite resin to surface-treated desensitizing agents. The impact of these desensitizing agents on the bond strength of adhesive restorations has been the subject of numerous studies, yielding inconsistent and sometimes contradictory results. So, the purpose of this study was to statistically analyze the shear bond strength of restorative composite resin to dentin after treatment with silver diamine fluoride and self-etch bonding agent, bonded using a universal bonding agent. The null hypothesis posted that desensitizing treatments would not affect the bond strength of resin composite to dentin.

2. Materials and methods

Thirty freshly extracted human molars were collected and thoroughly cleaned, with all hard and soft tissue residues carefully removed. The teeth were then preserved in saline solution until they were needed for the study. Only teeth extracted for periodontal or orthodontic reasons were included, while those with caries or visible cracks were excluded from the study. The materials used in the study are presented in Table 1.

2.1 Specimen preparation

The occlusal surfaces of the teeth were ground to expose a flat dentin surface. The flat dentin surface was polished with 600-grit silicon carbide paper to create a uniform smear layer and smear plug. Subsequently, they were embedded in cold-cure resin (Dental Products of India, India) blocks. The samples were organized into three groups of ten (n=10) each: Group 1 consisted of Untreated Dentin (UT), Group 2 was treated with Silver Diamine Fluoride (SDF), and Group 3 received a sixth-generation bonding agent (Self-etch Primer, Clearfil SE Bond, Kurary Japan).

2.1.1 Specimen preparation in Group 1 (Untreated dentin): A Universal bonding agent (Clearfil Universal, Kurary, Japan) was applied to the dentin surfaces for 10 sec. Air dried for 5 seconds and then light cured for 10 sec. Then, the Universal composite was placed using a mold of 4 X 5mm and light-cured for 40 seconds with an LED light curing unit (Woodpecker, Guilin, China).

2.1.2 Specimen preparation in Group 2 (Silver diamine fluoride): SDF was applied to the dentin surface using a micro brush and allowed to soak for 1 to 3 minutes. A Universal bonding agent (Clearfil Universal) was applied to the dentin surfaces for 10 sec. Mild air was blown for 5 sec and then light cured for 10 sec. Then, the Universal composite was placed using a mold of (4 X 5)mm and light-cured for 40 sec with an LED light curing unit (Woodpecker, Guilin, China).

2.1.3 Specimen preparation in Group 3 (Clearfil SE Bond): The primer was applied and left for 20 seconds on the prepared teeth as per manufacturer instructions. After drying, the bonding agent was applied and distributed evenly with mild airflow. Then, these samples were light-cured for 10 seconds. A Universal bonding agent (Clearfil Universal, Kurary, Japan) was applied to the treated dentin surfaces for 10 seconds. Then Universal composite was placed using a cylindrical mold light-cured for 40 seconds with LED curing light (Woodpecker, Guilin, China).

2.2 Evaluation of shear bond strength

The specimen was placed on a custom-made jig and was mounted on the universal testing machine (Instron, USA). The load was applied at the dentin-composite interface at a crosshead speed of 1mm per minute until debonding occurs. The debonding load was recorded in Newtons (N) and the shear bond strength (MPa) was calculated using the following formula:

Shear bond strength = Debonding load (N) / Bonded area (mm^2).

Table 1. Materials used in the study

Product name	Company
Silver Diamine Fluoride	E-SDF (Kids – e – Dental (LOT : JK138))
Sixth Generation Bonding Agent	Clearfil SEBond, Kuraray Co Ltd, Osaka, Japan (LOT : 620409)
Universal bonding agent	Clearfil Universal Bond, Kuraray Noritake Dental Inc., Kurashiki, Okayama, Japan (LOT: AU0054)
Universal Composite	Plafique Omnichroma, Toukyama Dental corporation, Tokyo, Japan (LOT: 2831).

2.3 Statistical analysis

Data analysis was done using the Statistical Package for Social Sciences (SPSS version 26.0, IBM Corporation, USA). Overall comparisons were analyzed using the Kruskal-Wallis test. Pair-wise comparisons were done using the Mann-Whitney U test. The level of significance was set at $p < 0.05$ for all tests.

3. Results

The overall comparison of SBS between the three groups is presented in Table 2. The highest bond strength was found with the group 3 specimens (0.51 ± 0.22 MPa), which were treated with the self-etch bonding agent. The control group demonstrated a mean SBS of 0.32+0.09 MPa. The lowest bond strength (0.26 ± 0.10 MPa) was observed with the dentin surface treated with silver diamine fluoride, Group 2. Significant differences (p=0.003) were found among the groups (Table 2). Pair-wise comparisons of SBS between the three groups are presented in Table 3. In pair-wise comparison, group 3 showed a significant difference with group 1 (p=0.007) and group 2 (p=0.002). However, no significant differences were observed between groups 1 and 2 (p=0.197).

Table 1. Overall comparison of shear bond strength (MPa) between three groups

Groups	Mean ± SD	Mean Ranks	Kruskal-Wallis Value	p-Value
Group 1	0.32 ± 0.09	13.75	11.783	0.003*
Group 2	0.26 ± 0.10	9.80		
Group 3	0.51 ± 0.22	22.95		

***Significant difference**

Table 2. Pair wise comparison of shear bond strength

Groups	Mean +SD	Mean Ranks	Mann-Whitney Value	p-Value
Group 1	0.32 + 0.09	12.20	33.000	0.197
Group 2	0.26 + 0.10	8.80		
Group 1	0.32 + 0.09	7.05	15.500	0.007*
Group 3	0.51 + 0.22	13.95		
Group 2	0.26 + 0.10	6.50	10.000	0.002*
Group 3	0.51 + 0.22	14.50		

***Significant difference**

4. Discussion

Dentin forms the major bulk of the tooth. It is traversed by dentinal tubules that extend from the pulp to the enamel–dentin or cement-dentinal junction. Dentin is a highly mineralized tissue and is permeable. Once the dentin is exposed, it causes sensitivity due to the permeability of dentinal tubules. Dentinal hypersensitivity is treated using different desensitizing agents. However, these agents may interfere with the bonding of composite restorations to the tooth. In this study, different desensitizing agents produced different shear bond strength values.

In the present study, the dentin surfaces treated with a self-etch bonding agent demonstrated more SBS followed by the control and the dentin treated with the SDF. In the control group, the composite was bonded to untreated dentin using UAS and the result was 0.32±0.09 MPa. The effective chemical interaction may occur between long-chain molecule MDP and hydroxyapatite forming a stable Nano layer that could form a stronger phase at the adhesive interface, which increases the mechanical strength of the adhesive. The results of this study are in accordance with previous studies [13]. In addition, stable MDP-Ca salt deposition along with Nano layering may explain the high bond stability, which has previously been proven by laboratory and clinical research [14]. According to the adhesion-decalcification concept, the MDP-Ca salt complex is highly insoluble, and stable, and forms strong molecular bonds to hydroxyapatite-based substrates.

SDF is a colourless alkaline solution with a pH between 9 and 10. 38% SDF solution contains 253,870 ppm silver and 44,800 ppm fluoride ions. In other words, a 38% SDF solution is composed of 25% silver ions and 5% fluoride ions dissolved in an 8% ammonia solution. The main disadvantage of SDF therapy is permanent black staining. SDF also stains the skin, working tables, dental instruments and clothes if handled carelessly. Patients must be well-informed before treatment to avoid patient dissatisfaction [15].

The bond strength of the SDF group was the lowest with an SBS of 0.26 ± 0.10 MPa. The SBS was 18% less in group 2 compared to group 1. This is because SDF can interfere with the penetration of primer and bonding into the intertubular and peritubular dentin which leads to less hybrid layer formation with the lower collagen matrix because of the formation of acid-resistant fluoro-hydroxyapatite crystals [16]. Silver ions have an inhibitory effect on cysteine cathepsin enzymes that degrade dentinal collagen matrix proteins, leading to bonding loss [17]. SDF produces desensitization by occluding dentinal tubules and promotes tertiary dentine formation. Silver precipitates as silver salts on the dentine surface and within the dentinal tubules after SDF application [18]. After SDF application the fluoro-hydroxyapatite is produced. This promotes remineralisation. This can block or decrease tubule diameter, resulting in relief of dentine hypersensitivity [19].

The dentin surface treated with the self-etch bonding agent showed the highest bond strength, 0.51 ± 0.22 MPa. The percentage increase in SBS from group 1 to group 3 was 66.9%. The percentage increase in SBS from group 2 to group 3 was 51%. The bonding mechanism of self-etch adhesives is based on changing the chemical composition of the substrate surface, commonly referred to as hybridization [20], the surface layer of dentin is partially dissolved and the resultant porosity is filled with resin. The self-etch adhesives dissolve the smear layer and preserve smear plugs [21]. The coagulation of plasma proteins by primer components contributes to the reduction in dentin permeability.

Previous studies suggested that doubling the number of adhesive layers improves bond strength by enhancing monomer penetration into hybrid layers and increasing chemical interactions [22]. Therefore, an additional layer application should be considered as a crucial clinical step. This also explains the highest bond strength of group 3. All universal adhesives were based on the functional monomer 10-MDP (methacryloyloxydecyl dihydrogen phosphate) imperative to obtain a stable nanolayer structure (10-MDP/Ca salts) in the hybrid layer and adhesive layer [23]. This study reported significant differences between the groups, so the null hypothesis was rejected.

This *in vitro* study had certain limitations, as it could not replicate in vivo conditions. Additionally, the sample size was limited, and only one type of adhesive and composite resin was tested. Thermal cycling and aging processes were not applied, and the reduction of dentin hypersensitivity was not assessed. Future research could address these limitations by incorporating larger sample sizes, multiple adhesives and composite resins, and including thermal cycling and aging protocols to better simulate clinical conditions. Evaluating the effect on dentin hypersensitivity could also enhance the clinical relevance of the findings.

5. Conclusion

Within the limitations of the study, it can be concluded that shear bond strength (SBS) differs across various desensitizing treatments. Results indicate that the sixth-generation bonding agent demonstrated superior SBS compared to both untreated dentin and Silver Diamine Fluoride (SDF).

Conflicts of interest: Authors declared no conflicts of interest.
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