The Effect of Deproteinization of Dentin Surface on the Micro-Shear Bond Strength to Dentin

AMR F. GHONAIM, M.Sc.*; MOHAMED M. ABDELMOHSEN, DDS, Ph.D. **; DINA W. ELKASSAS, DDS, Ph.D. *** and AHMED F. ABO-EL-EZZ, DDS, Ph.D. *

The Department of Operative Dentistry, Faculties of Oral & Dental Medicine, Suez Canal* and Cairo**, Universities

Abstract

This study was carried out to study the effect of deproteinization on the micro-shear bond strength values of a nanofilled adhesive system. Two total-etch, one filled and the other unfilled were used. A total of 20 freshly extracted, sound, non-carious, human permanent first molars were selected and used in this study. The samples were divided into two main groups of twenty specimens each according to the dentin surface pretreatment. In the first group the teeth were used as control, while in the second group the dentin surfaces were deproteinized with NaOCl. The two groups were divided into two classes of five teeth each according to the presence or absence of filler particles in the adhesive system.

It was found that deproteinization of dentin substrate enhanced the bonding of etch and rinse adhesive (filled and unfilled). It was also found that the existence of filler didn’t affect bonding to sound dentin.

Key Words: Etch and rinse adhesive – Deproteinized dentin – Micro-shear bond strength.

Introduction

BONDING to enamel is a relatively simple process without major technical requirements or difficulties. On the other hand, bonding to dentin has been referred to as a less reliable technique due to the intrinsic characteristics of this substrate, especially when compared to enamel bonding [1]. This is not surprising given the fact that while enamel contains little protein, dentin is dynamic substrate that contains 17% collagen by volume. It also contains dentinal tubules containing dentinal fluid. The number and diameter of tubules varies depending on location and depth, with deep dentin having more tubules than superficial. Other factors such as age of teeth and type of dentin, can also affect dentin bonding [2].

The mechanism of dentin bonding to all adhesive systems is based on the hybridization concept. In the etch and rinse adhesive systems, the dentin surfaces are treated with acid etching agents that promote removal of the smear layer, dentin demineralization and exposure of the collagen fibril network. Adhesion is possible due to penetration of the adhesive monomers into the exposed collagen fibril network and subsequent hybrid layer formation [3]. However, any collapse of the collagen fibrils as a result of over-drying might prevent monomers from penetrating into deeper areas, increasing the risk of adhesive failures. On the other hand, excess water limits penetration and polymerization of the adhesive systems. Thus the technique sensitivity associated with these adhesive systems lies on how much wet should the dentin substrate be.

Enhancement of the dentin bonding can be done either by improving the physical properties of the bonding agent, or by modifying the dentin substrate to act as a foundation for the subsequent applied adhesive restoration. In an attempt to enhance the physical properties of adhesives, fillers were added to these adhesive systems [4]. Various types of fillers have been introduced such as conventional glass, ion leachable glass, silica and nanometer-sized aerosil silica fillers. It has been reported to improve marginal and internal seal of resin composite restorations and give the adhesive system sufficient radioopacity to be discernible on dental X-ray films [5].

Modification of the dentin substrate can be carried out via the use of proteolytic agents on acid etched dentin, known as dentin deproteinization. It aimed to eliminate the negative consequences related to the organic content of the dentinal substrate.
On the other hand some authors reported that deproteinizing the dentin substrate negatively affected the bonding procedure because the treatment of dentin with NaOCl solutions may not only remove the organic collagen matrix, but also some of the mineral content that renders dentin much weaker than normal [6].

The use of deproteinizing solutions (NaOCl or collagenase) alters dentin surface ultramorphology by dissolving the exposed collagen fibrils. Their action promotes the exposure of a lateral runway network and amplifies the dentin tubules, rendering dentin similar to etched enamel, which is a favorable characteristic for adhesion. This surface has shown multiple irregularities, with good mechanical retention of the adhesive in modified dentin substratum [7]. On the search for the most appropriate protocol of dentin bonding, this study was carried out to investigate the effect of deproteinizing dentin surface on the micro-shear bond strength values of filled and unfilled, etch and rinse and self etch adhesives.

**Material and Methods**

This study was carried out in the Faculty of Dentistry, Suez Canal University to study the effect of deproteinization on the micro-shear bond strength values of nanofilled adhesive systems. Two total-etch adhesive systems were utilized in this study, one filled and the other unfilled. A total of 20 freshly extracted, sound, non-carious, human permanent first molars were selected and used in this study. The samples were divided into two main groups of twenty specimens each according to the dentin surface pretreatment. In the first group the teeth were used as control, while in the second group the dentin surfaces were deproteinized with NaOCl. Each group of ten teeth each. The two groups were divided into two classes of five teeth each according to the presence or absence of filler particles in the adhesive system. Since each tooth received two composite microcylinders for micro-shear bond strength testing, ten specimens were tested in each class. This resulted in a total of forty specimens. In the control groups the adhesive systems were applied according to the manufacturer’s instructions. In the deproteinized groups, for the etch and rinse adhesive system group the dentin surfaces were etched with 35% phosphoric acid gel for 15 seconds. Sodium hypochlorite 5.25% was applied to the etched dentin surface for 2 minutes. The dentin surfaces were then rinsed and the adhesive systems were applied and cured according to the manufacturer’s instructions. After applying the adhesive system, two microcylinders were mounted on tooth surfaces in which the resin composite was packed. After one hour microcylinders were removed resulting in two composite microcylinders on the surface. The specimens were stored in water at 37ºC for 24 hours then micro-shear bond strength was measured.

**Results**

Table (1) and histogram (1) represent descriptive statistics and test of significance, using independent sample t-test. The data presented in Table (1) revealed that deproteinization of dentin surface had a significant effect on micro-shear bond strength of both filled and unfilled adhesives, while the introduction of filler to the adhesive system had no significant effect on it’s micro-shear bond strength to dentin whether normal or deproteinized.
The data presented in Table (1) reveals that etch and rinse unfilled adhesive showed the statistically highest micro-shear bond strength value (38.4) when used on deproteinized dentin. Meanwhile, etch and rinse unfilled adhesive showed the statistically lowest micro-shear bond strength value (19.7) when used on normal dentin. The micro-shear bond strength value for etch and rinse filled adhesive system with normal dentin was (24) and with deproteinized dentin was (36.4).

Table (1): µ-shear mean bond strength values and significance.

<table>
<thead>
<tr>
<th>Adhesive</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filled</td>
<td>24</td>
<td>6.4</td>
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</tr>
<tr>
<td>Unfilled</td>
<td>19.7</td>
<td>5.3</td>
<td>0.112</td>
</tr>
<tr>
<td>Filled deproteinized</td>
<td>36.4</td>
<td>7.2</td>
<td>0.53</td>
</tr>
<tr>
<td>Unfilled deproteinized</td>
<td>38.4</td>
<td>6.5</td>
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<td>Unfilled</td>
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<tr>
<td>Filled deproteinized</td>
<td>36.4</td>
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Discussion

The aim of this study was to investigate the effect of deproteinization of dentin surface on the micro-shear bond strength to dentin using filled and unfilled adhesive system. Two total-etch and two self-etch adhesive systems were utilized in this study, one filled and the other unfilled. Half of the specimens were left as control and in the other half deproteinization was performed using 5% NaOCl for 2 minutes. Micro-shear bond test was used to evaluate the bond strength.

Although the hybrid layer has been described being responsible for the restoration’s longevity, there is evidence that primer and adhesive resin may not always completely fully penetrate the demineralized dentin collagen layer. The discrepancy between depth of dentin demineralization after the acid-etching procedure and depth of resin infiltration allows the formation of microporous zones underneath and within the hybrid layer detectable by silver nitrate. The porosities can be a pathway for degradation of the interface by hydrolysis of collagen fibrils and/or polymerized resins [8,9].

The removal of collagen with NaOCl has been suggested as a suitable method to overcome this problem since it alters the composition of the dentin surface as it becomes similar to etched enamel, that is, a more predictable and hydrophilic substrate for bonding [10-12].

In the present study NaOCl was used as a deproteinizing agent. Several authors recommended its use because of its non-specific deproteinizing and disinfecting deproteinizing action [13].

The dissolution of organic tissues by sodium hypochlorite solutions is based on the action of chloride over the proteins, forming chloramines, which are soluble in water. Thus it alters the configuration or removes the organic components of dentin; especially, the collagen fibrils [14].

The results of the present study presented in Table (1) and Fig. (2), revealed that treating the dentin surface with NaOCl resulted in a marked improvement in the micro-shear bond strength values with both filled and unfilled total-etch adhesive system. It was also found from the data presented in Table (1) that there is no statistical significant difference in the micro-shear bond strength values in deproteinized dentin between filled and unfilled total-etch adhesives.

The improvement in the bond strength values could be attributed to that the dissolution of the collagen fibrils after acid etching may result in better monomer diffusion by increasing dentin permeability and changing its Composition. The action of NaOCl promotes the exposure of a lateral runway network and amplifies the dentin tubules, rendering a dentin similar to etched enamel, which is a favorable characteristic for adhesion. This surface has shown multiple irregularities, with good mechanical retention of the adhesive in modified dentin substratum [7].

The deproteinized dentin has higher hardness, modulus of elasticity, wettability, and permeability than the demineralized dentin. The dentin substrate is transformed, after deproteinization, in a very
porous structure with multiples irregularities and anastomoses, which could not be seen only by the normal demineralization process. These substrate characteristics could promote an increase on bond strength of adhesive systems applied over the deproteinized substrate [13].

These results were in agreement with [14] who studied the influence of sodium hypochlorite treatment of dentin on shear bond strength and interfacial morphology. They found that acetone containing systems demonstrated equivalent or higher shear bond strength when sodium hypochlorite was used following etching, as compared with normal procedures. They concluded that adhesive interacted strongly with the treated surface that contains a high mineral content.

This also was in agreement with [15-17]. They found that collagen fibrils were completely removed from the acid etched surface by NaOCl treatment. The diameter and size of the dentinal tubules and the number of the lateral branches of the tubules were increased following NaOCl treatment and also the resin tags were larger. They concluded that if acid etching is followed by NaOCl treatment, high bond strengths can be achieved via reverse hybrid layer formation.

The former statements were supported by [18], who concluded that the use of dilute NaOCl after acid-etching produced less porous resin-dentine interfaces. This dentin conditioning procedures improve the resistance of the resin-dentine bond sites to chemical degradation (12% NaOCl) and may result in more durable resin-dentine bonds.

This also was in agreement with [19], who concluded that deproteinization treatments resulted in greater bond strength in BisCem specimens while acid etching alone did not improve the performance of the material.

The results of this study were also in controversy with [6,19]. All these studies collectively found that collagen removal negatively influenced shear bond strength. This could be attributed to the difference in the testing parameters and to the use of a higher concentration of NaOCl as they found that the filled ethanol-based adhesive exhibited slightly better bond durability than unfilled acetone-based adhesive, but the difference between the two materials was not statistically significant.

On the other hand, the results of this study were in contrary to [22,23] as they found that filled adhesives were expected to act as an intermediate shock-absorbing elastic layer between composite resin and dentin, thus increasing the bond strength to dentin. This contradiction could be attributed to the use of adhesive system of different composition and to the difference in the testing parameters.

Conclusion:

Based on the results of the present study, the following conclusions can be obtained:

- Deproteinization of dentin substrate enhanced the bonding of total-etch adhesive (filled and unfilled).
- The existence of filler didn’t affect bonding to sound dentin either with etch and rinse or self-etch adhesive systems.

References


