EVALUATION OF TENSILE BOND STRENGTH WITH TWO DIFFERENT ADHESIVE SYSTEMS AFTER USING A PAPAIN-BASED GEL FOR CHEMO MECHANICAL CARIES REMOVAL

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Abstract

Background-aim of this study is to evaluate and compare the tensile bond strength with two different adhesive systems on sound and demineralized dentin after using a Papain-based gel (Carie-care) for chemo-mechanical caries removal.

Materials And Methods: Forty recently extracted human molars were collected. Teeth were mounted longitudinally up to CEJ in self-cure acrylic and divided into four groups Group 1: Mechanical removal of caries with fifth-generation total-etch adhesive (Adper Single Bond 2, 3M ESPE) Group 2: Mechanical removal of caries with seventh-generation universal adhesive (One Coat 7 universal, Coltene) Group 3: chemo-mechanical excavation of carious dentin was conducted using the papain-based gel with fifth-generation total-etch adhesive (Adper Single Bond 2, 3M ESPE). Group – 4: chemo-mechanical excavation of carious dentin was conducted using the papain-based gel with seventh-generation universal adhesive (One Coat 7 universal, Coltene). Nanohybrid Composite (Filtek™ Z350 XT Universal Restorative) was used to build composite cylinders. A tensile bond strength test was performed on Universal Testing Machine and the modes of failure were determined after sectioning with hard tissue microtome under Scanning Electron Microscope.

Results: The data were submitted to two-way ANOVA and Tukeys multiple post hoc tests test ($p \leq 0.05$). Irrespective of caries removal method, Adper Single Bond 2 presented significantly higher bond strength than One Coat 7 Universal. Adhesive failures were observed more under scanning electron microscope.

Conclusion: The mechanical method of caries excavation resulted in better values of tensile bond strength than the chemo mechanical method with Carie care gel. Total etch bonding agent system proved to be better than all-in-one system.

Keywords: Carie-care, Dental caries, dentin adhesives; Papain, tensile bond strength, Chemo mechanical.

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1. Introduction

The traditional caries removal involves the use of burs in low-speed hand pieces which holds the disadvantage of removing healthy, non-infected altered, and infected dentin due to the cutting efficiency of the bur, resulting in over-extended cavity preparation. Moreover, the incidence of pulpal alterations due to the pressure or heat generated by the burs has been reported. The chemo-mechanical caries removal methods appeared as an alternative, overcoming some of the inconvenient aspects, such as pain and discomfort, eliminating or diminishing the need for local anesthesia, and eliminating the noise during carious tissue removal. [1]

The Carie-Care solution has been used as a method of chemo-mechanical caries removal. Carie-Care is an enzyme based natural product which has an endoprotein as its main active ingredient. This Papain based gel is said to have bactericidal and disinfectant properties. [2]

Adhesive dentistry is based on the penetration of ambiphilic molecules into acid etched enamel and dentin, requiring phosphoric acid as the common etchant prior to the application of a fluid adhesive resin. Bonding on conditioned enamel is reliable and durable, whereas it is a challenge to obtain effective interactions between adhesive systems and the dentin substrate. Indeed, several parameters can affect the bonding quality to dentin. [3] To reduce the technique sensitivity and the parameters influencing the bonding effectiveness to dentin, changes have focused on simplification of primer adhesive systems. [4]

Adper™ Single Bond 2 Adhesive (3M ESPE), is a total-etch, visible-light activated dental bonding agent incorporating 10 percent by weight of 5nm diameter silica filler. [5]

One Coat 7 Universal (Coltene), a seventh-generation bonding agent, is light-cured, one-component bonding agent used with the self-etching, selectively etching or total-etch technique for adhesive restoration. [5]

The aim of this in-vitro study is to assess the impact of method of caries removal on adhesion of composite to dentin by evaluating the tensile bond strength of two different adhesive systems on demineralized dentin after using a papain-based gel for chemo-mechanical caries removal.

2. Methodology

Forty recently extracted human molars with caries were collected and stored in 0.1% thymol solution for 24 hours and later stored in distilled water until use. All the teeth were mounted in acrylic blocks of size 1.5 × 2 × 1.5 cm. The occlusal surface of each tooth was reduced with the help of a diamond disc and with high speed (#245 carbide bur) under constant water spray in order to expose the flat surface of dentine. All the specimens were randomly divided into four groups accordingly.

Group – A: Mechanical caries removal with total-etch adhesive

Caries affected dentin was removed with water-cooled, tungsten carbide bur following which it was etched for 15 seconds with 37% phosphoric acid etching gel, rinsed with water for 10 seconds, and excess water was dried by blotting with absorbent paper. Adper single bond 2 adhesive was applied in 2 consecutive coats and light-cured for 40 seconds. A cylindrical shaped plastic tube with an internal diameter of 4 mm and height of 4mm was used as a circumferential matrix for placement of nanohybrid composite resin (Filtek™ Z350 XT Universal Restorative). Then composite resin of 2 mm increments was placed inside the mould and condensed. A twisted 26-gauge ligature wire with a loop was placed inside the 2 mm of composite resin, held straight and light-cured with a QHL75 curing light for 40s. Another 2 mm thickness of composite resin

was placed and light-cured incrementally. The cylindrical-shaped plastic matrix was separated from the polymerized resin by giving a vertical cut along the side.

Group – B: Mechanical caries removal with universal adhesive

Caries affected dentin was removed with water-cooled, tungsten carbide bur following which the surface was blotted with an absorbent paper. Seventh generation universal adhesive (One Coat 7 universal, Coltene) was applied, rubbed onto the surface for 20 secs and gently air-dried for 5 secs followed by another application and light-curing for 10 secs as per manufacturer's instructions. Composite restoration is done according to the technique described in group – A.

Group – C: Chemo-mechanical caries removal with total etch adhesive

Caries affected area was treated with Carie-Care gel. After 60 s in contact with the dentin, the gel was removed using a stainless-steel spoon excavator, till no remnants of the gel could be visually detected. This procedure was carried out three times, with no rinsing between each application followed by application of Adper single bond 2 adhesive and composite restoration as described in group – A.

Group – D: Chemo-mechanical caries removal with universal adhesive

Caries affected area was treated with Carie-Care gel. After 60 s in contact with the dentin, the gel was removed using a stainless-steel spoon excavator, till no remnants of the gel could be visually detected. This procedure was carried out three times, with no rinsing between each application followed by the application of seventh generation universal adhesive (One Coat 7 universal, Coltene) as described in group – B.

All the specimens were stored in distilled water for 24hrs at 37°C and were subjected to tensile bond strength test in Universal testing machine at a crosshead speed of 0.1 cm/min. The tensile bond strength in Mega Pascals (MPa) was calculated from the peak bond at failure divided by the specimen surface area using the formula:

Tensile bond strength = load/ area

Further the specimens were collected and sectioned with hard tissue microtome. The fractured interfaces of the specimens were examined under a light microscope at 20× magnification to assess the failure modes.

Fracture mode was designed according to the following criteria:

• Resin cohesive - if the resin part was noted on tooth specimen.

• Adhesive - if the adhesive layer was noted on both the specimens.

• Dentin cohesive - if the dentinal part was noted on resin specimen.

• Mixed - if the resin/adhesive parts were noted on tooth specimen

Statistical Analysis:

After checking for the normality of the data, statistical analysis was performed using two-way ANOVA test and Tukey's post hoc test with confidence limits set at 95% ($p = 0.05$).

3. Results

The highest bond strength was recorded in Group A (8.13 ± 0.57 Mpa) (Table 1). Total etch groups showed better results than self-etch adhesive groups. Mechanical Caries removal showed better result than Chemo mechanical caries removal groups in terms of bond strength. Tukey's post hoc test revealed that the difference between Group A and Group C is not statistically significant ($p > 0.05$). Among all modes of failures, adhesive failures dominated (Table 2).

4. Discussion

The best way to ensure maximum life for the natural tooth is to respect the sound tissue and protect it from damage by using minimally-invasive techniques in restorative dentistry. [6] Procedures for caries removal include the conventional mechanical method, air abrasion with aluminum oxide, chemo-mechanical methods, atraumatic restorative therapy (ART), and most recently, laser treatment. Independent of the technical procedure employed, the removal of infected dentin is of great importance during restorative caries treatment. The main objective of infected dentin removal is the elimination of the softened, infected, and necrotic tissue to control the lesion progression and to support the restorative procedure. [7]

Conventional caries removal has potential adverse effects on the pulp, exposing it to heat, pressure, and vibration. Preparation often removes healthy tooth parts as well as the decayed areas. This weakens the tooth, which becomes less durable in the long-term. [2] The chemo mechanical method of caries removal was first introduced in 1975 by Habib et al. by using 5% sodium hypochlorite (NaOCl), followed by introduction of GK101 in 1976 by Goldman et al. [8] In the present study, a new product called Carie-Care gel was used as a chemo mechanical caries removal agent. It contains papaya extract (Eranda karkati/carica papaya), clove oil (shreesangnam/syzygium), colouring gel, sterile water, excipients (chloramine & sodium chloride), sodium methyl paraben & sodium propyl paraben. This product is claimed to be a unique gel with natural enzyme fractions in it, which selectively softens the affected carious dentin in few seconds that can be scraped by gentle excavation using a spoon excavator, leaving sound tooth structure behind. Thus, this gel is effective in dental restorative procedures with added advantage of natural anti-inflammatory and analgesic compound in it which will reduce the pain perception during the operative procedure. [2]

It acts by breaking the peptide bonds and involves deprotonation of Cys-25 by His-159. Papain in papaya extract acts as a debris-removing agent, with no detrimental effect on sound dental tissues. Because of the enzyme specificity, it acts only on affected tissue, which lacks the alpha 1-anti-tripsine plasmatic anti-proteases that inhibit proteolysis in healthy tissues. The chloramines have potential of dissolving carious dentin by chlorination of the partially degraded collagen. This mechanism affects the collagen structure, dissolves the hydrogen bonds and thus facilitates tissue removal. This compound is comprised of chlorine and ammonia which present bactericidal and disinfectant properties. [9] Clove oil act as a natural analgesic and antiseptic as it contains minerals such as calcium, hydrochloric acid, iron, phosphorus, sodium, potassium and vitamin A, C. [2,9]

Treatment of a carious tooth does not end with the removal of infected tissue; it should be followed by a successful restoration. One of the most important factors determining the success of a restoration is the adhesion between tooth structure and the restorative material as it will allow for the development of strong durable bonds between dental material and tooth substrate. Dentin presents a serious challenge as substrate because of the presence of fluid-filled channels and less inorganic content when compared to enamel. To overcome these challenges, dental adhesive systems have evolved through several generations with changes in chemistry, mechanisms, number of bottles, application techniques and clinical effectiveness. Stronger the adhesion potential, greater is the resistance of restoration to stress. [10]

Total etch adhesive system showed better result when compared to all-in-one systems and the reason could be attributed to the fact that these universal adhesives contain both hydrophilic and hydrophobic components in a single bottle. Although hydrophilic

components enhance the deeper penetration by increasing the affinity with hydrophilic dentin substrate, water acts as a major interfering factor in polymerization which leads to unpolymerized acidic and aggressive monomers to continue etching the dentin, thereby leading to a detrimental impact on the bond. [10,11] Bengtson AL stated that neither of the chemo mechanical methods had influence on the bond strength of the adhesive system to healthy or carious dentin. This indicates that neither of the products seems to potentially alter the dental substrate which could diminish the bond strength. The lower bond strength to caries-affected dentin was probably due to the presence of altered dentin rather than the chemo mechanical method. [1]

Also, the difference in the tensile bond strength of mechanical and chemo-mechanically treated specimens with total etch bonding agents did not show any significance statistically. This could be implied clinically while treating any deep carious lesions to prevent any accidental pulpal exposures by mechanical methods of caries removal.

Arvidsson A stated that the biochemical method removes the smear layer completely and exposes dentinal tubules. [12] Nonetheless, no significant influence on bond strength to dentin was noted in various other studies as well. [13,14]

However, the reason for the decreased bond strength in chemo mechanically treated specimens might be because of the following cause. The biochemical agent for removal of caries involves cleavage of polypeptide chains and/or hydrolysis of collagen cross-linkages. These cross-linkages which give stability to the collagen fibrils become weaker and thus more prone to degrade when exposed to the gel. Since these fibrils will later be a part of the resin-dentin inter diffusion zone, a hybridization of poor quality could be a possible outcome. [15]

The reason for the poor performance of chemo-mechanically treated dentin with all-in-one adhesive system as bonding agent could be as follows. Conventional system involves water rinsing step after acid-etching, thus complete removal of the papain-based product from the tooth surface can be expected. On the other hand, as the self-etching system is not comprised of the rinsing step and thus the smear layer is not removed but only partially demineralized, remnants of the gel could be stagnated on the dentin surface, and could potentially interfere with the bonding mechanism. [9]

Under SEM examination of gel-excavated dentin, Banerjee et.al. [13] described the presence of surface globules, which could be linked to remnants of the gel that had not been washed away. [6] Moreover, during caries excavation an effervescent surface activity occurs on application of the papain-based gel, which could be an indication of oxygen release, potentially affecting the polymerization mechanism of the bonding resin. [1,13]

The predominance of adhesive failures for the carious dentin groups is probably related to the difficulty of the bonding resin in completely infiltrating into the exposed, altered collagen mesh. [15]

5. Conclusion:

Within the limitations of this study, it can be concluded that mechanical method of caries excavation resulted in better values of tensile bond strength than the chemo mechanical method with carie-carie gel. However, chemo mechanical caries removal when used judiciously with total etch system of bonding agents provided comparable results.

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Table 1: Tensile bond strength (Mean ± SD) MPa of experimental groups

Group	**Tensile bond strength (Mean ± SD) MPa**
Group – A	8.13 ± 0.57
Group – B	6.32 ± 0.67
Group – C	7.07 ± 0.67

Group – D	5.25 ± 1.23

Table 2: Failure modes of experimental groups

Material		**Caries treatment**	
		Mechanical	Chemo mechanical
Total etch	Adhesive	70%	60%
	Cohesive	10%	20%
	Mixed	20%	20%
Self etch	Adhesive	60%	60%
	Cohesive	20%	20%
	Mixed	20%	10%