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COMPARATIVE EVALUATION OF THE SHEAR BOND STRENGTH OF SELF-ETCH ADHESIVE TO CARIES AFFECTED DENTINAL SURFACE TREATED WITH CONVENTIONAL METHOD AND CHEMO MECHANICAL METHOD" –AN *IN VITRO* STUDY.

Dentistry

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ABSTRACT

Aim: To evaluate the effect of two chemo-mechanical caries removal agent on bonding of self-etch adhesive to caries affected dentin in comparison to the standard rotary instrument's caries removal method. **Methods:** Sixty permanent molar teeth exhibiting frank moderate cavitation extending to at least half the distance from DEJ to pulp chamber were selected and embedded in acrylic resin up to the CEJ. These were grouped randomly into three experimental groups (n=20), Group I, caries infected dentin removed by tungsten-carbide diamond bur mounted in low-speed handpiece (NSK); Group II, caries removal by V-Carie-Solve (Vishal Dentocare) and Group III, caries removal by Carie-Fix (Dengen Dental). Gluma bond Universal (Kulzer) was applied as bonding agent in the self-etch mode. The three groups were further divided into two subgroups (n=10) based on the composite used, namely Neospectra ST Universal (Dentsply Sirona) and Fusion Flo (Prevest DenPro). Teeth were stored in distilled water at 37^{0}C for 24 h before subjecting to shear stress in Universal testing machine and bond strength values were recorded. Results collected were subjected to statistical analysis by One-way ANOVA test followed by Tukey's HSD Post hoc analysis. **Results:** Highest shear bond strength values were observed when caries was removed using V-Carie-Solve and restored using Neospectra ST Universal. The control groups utilizing conventional rotary instrumentation exhibited significantly lower bond strengths in comparison to the groups utilizing chemo-mechanical methods in both types of restorative treatments. Comparative analysis showed that although V-Carie-Solve produced slightly higher bond strength than Carie-Fix, the variation was not statistically significant. However, Neospectra ST Universal exhibited significantly higher bond strength values in comparison to Fusion Flo irrespective of the caries removal method used. **Conclusion:** Within the limitations of this study, it was concluded that chemo-mechanical caries removal technique can be effectively used as an alternative to rotary excavation methods.

KEYWORDS

Chemo-mechanical caries removal, caries affected dentin, self-etch, shear bond strength

INTRODUCTION:

Dental caries, the most common infectious disease in human, is managed through utilizing a variety of approaches, from removal through traditional surgical modes to minimally invasive dentistry procedures.[1] Out of the several minimally invasive dentistry procedures used for caries removal that includes sono-abrasion, air abrasion, laser and atraumatic restorative technique,[2] the use of chemo-mechanical caries removal (CMCR) agents is one of the most accepted methods in standard dentistry applications.[1,3] This method had gained particular relevance during the COVID-19 pandemic, as it was considered as a valuable alternative to conventional methods due to its reduced aerosol generation.[4]

CMCR systems are based on the principle of softening of carious tissue which makes it easier to remove. These are categorized as either sodium hypochlorite or enzyme-based agents.[5] The enzyme-based agents depend on the action of papain, which is a cysteine protease obtained from the fruits and latex of green papaya (*Carica papaya*). The enzyme facilitates proteolysis of damaged collagen and disintegration of fibrin mantle of the carious tissue without harming the intact dentin.[1]

Bonding to dentin is challenging due to various reasons like presence of smear layer, dentinal fluid, considerable amount of organic material compared to enamel and its close proximity to pulp. Universal adhesives allow for versatile applicability as they may be used as both total-etch or self-etch resulting in aesthetic restorations with optimum marginal seal.[6] However, bonding to caries affected dentin is not only challenging due to the complexity caused by marked changes in mineral content, loss of crystallization, and changing of the organic matrix, but is also considered one of the most controversial topics in adhesive dentistry.[7] Some studies have reported higher bond strengths of etch-and-rinse adhesives than self-etching adhesives to caries-affected dentin[8] while other studies have declared that acid etching might lead to loss of the inorganic content of the caries affected dentin[9] which results in reduced hybridization of the demineralized caries-affected dentin by adhesive resin. Different caries excavation methods may also affect the quality of remaining dentin and influence the bond strength of resin adhesives.[10] Therefore, in this study, the shear bond strength of Gluma Bond Universal bonding agent was tested following self-etch approach to caries affected dentin following caries removal with rotary and two chemo-mechanical agents, V-Carie-Solve and Carie-Fix and subsequent restorations with nano-ceramic composite (Neospectra ST) and a flowable composite (Fusion Flo).

MATERIALS AND METHODS:

Source and method of collection of samples

Sixty extracted non-restored human maxillary and mandibular molars with moderate occlusal dental caries, exhibiting frank cavitation extending to dentin, were selected from a bulk of extracted teeth collected from the Department of Surgery, Krishnadevaraya College of Dental Sciences. Teeth were stored in distilled water for a period less than a month following extraction. The teeth with moderate caries extending to at least half the distance from the DEJ to pulp chamber were included following assessment by radiovisiography (Fig 1). If the caries extent in the tooth was found to be either less than half-way into dentin or extending beyond dentin, into the pulp, it was excluded.

Fig. 1: Selected specimens (N=60) used in the study

Preparation Of Samples

Teeth were cleaned and scaled with a hand scaler to remove any surface deposits and stored in distilled water at room temperature. They were then embedded in standardized acrylic resin blocks using a mould with a dimension (2.5 cm x 2.5 cm) up to the CEJ. For embedding, cubical teflon mould with separating medium applied on its internal walls were taken and each tooth was embedded in the cold-cure acrylic resin placed in the mould. After acrylic setting, the block was removed from the mould, and examined carefully before further processing.

Grouping Of Samples And Caries Removal

Teeth were randomly divided into three equal groups (n=20) according to the caries removal method used (Fig. 2)

Group 1 (Control): Caries removal was performed using low speed hand piece (NSK) and tungsten carbide round bur (No. 2). The infected dentin was identified based on its soft texture and light colour and was removed. The deeper layer which was the affected dentin was identified by its darker colour and its higher resistance to removal and was left untouched.

Group II and Group III: Caries removal was performed using V-Carie-Solve in Group II and Carie-Fix in Group III (Table 1). In each group, 2-3 drops of the caries removing agents were applied to the carious dentin. The gel was left for 30 seconds prior to excavating using spoon excavator. It was rinsed with distilled water for 20 seconds and the process was repeated until the gel no longer appeared cloudy and the tooth surface felt hard. The cavity was then wiped with a cotton-pellet moistened with water and rinsed.

Before proceeding for bonding, all the specimens were grounded to get a flat surface using carborundum disc under water for ease of bonding. Care was taken to leave the deepest part of caries affected dentin untouched. Different groups were painted with different colour nail varnish on the acrylic, Group I: Pink, Group II: Red and Group III: Blue.

A B

C

Fig. 2: Caries excavation performed with: A: Bur (Group I: Control); B: V-Carie-Solve (Experimental Group II); C: Carie-Fix (Experimental Group III)

Table 1. Composition Of Chemo-mechanical Caries Removal Agents Used In The Experiments Of The Current Study.

Materials	Composition	Manufacturer
V-Carie-Solve	Papaya extract, chloramine, clove oil, permitted colours and preservatives	Vishal Dentocare, Ahmedabad, India
Carie-Fix	Papain (30K MW), Distilled water, Methylene Blue	Dengen Dental
Gluma Bond Universal Adhesive (pH 1.6-1.8)	Acetone, Urethane dimethacrylate (UDMA), Water, 4-methacryloyloxyethyl trimellitate anhydride (4-META), 10-Methacryloyloxydecyl dihydrogen phosphate (MDP), Glutaraldehyde	Kulzer GmbH, Leipziger, Germany
Neo spectra ST Universal	Urethane modified Bisphenol A Glycidyl Methacrylate (Bis GMA), trimethacrylate. Fillers: Barium aluminium borosilicate glass, ytterbium fluoride; Pigmentation and Stabilization: Iron oxide and Titanium dioxide; UV stablizers Filler content: 78-80% by weight in high viscosity version, has nanofillers which uses SphereTEC® technology	Dentsply Sirona
Fusion Flo	Bis GMA, Ethoxylated Bisphenol A dimethacrylate, UDMA, triethylene glycol dimethacrylate, radioopacifiers, Fillers: silanated barium glass powder, amorphous fumed silica; photoinitiators, pigments. Filler content: 70% by weight,	Prevest DenPro

Bonding Procedure

Each group underwent adhesive application using Gluma bond Universal (Kulzer) following self-etch strategy. Adhesive was applied with microbrush following manufacturer's instruction to all prepared areas of teeth samples and light-cured for 20 seconds using an LED light-curing device (Ivoclar Bluephase NM). Polyethylene moulds of fixed dimension (2mm x 4mm) were then placed on the dentin surface.

Each of the three groups were further divided into two subgroups (n=10) based on the composite used (Table 1):

Subgroup A: [Neospectra ST Universal (Dentsply)];
Subgroup B [(Fusion Flo (Prevest DentPro)].

The respective composites were placed in increments of 2 mm thickness and light cured for 20 seconds. Before testing, specimens were stored in distilled deionized water at 37^{0} C for 24 hours in the incubator.

Shear Bond Strength Testing

The bonded interface in the specimens were subjected to shear stress in universal testing machine (50kN/2.5kN, Make : FIE, Model : UNITEK 9450) at crosshead speed 1mm/min and values were recorded (Fig 3). The following formula was used to determine the shear bond strength values for each specimen: Shear bond strength (MPa) = Maximum Load (N)/cross-sectional area (mm^{2}).

Statistical Analysis

Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 was used to perform statistical analysis. One-way ANOVA test followed by Turkey's HSD Post hoc Analysis was used to compare the mean shear bond strength values between three groups (P<0.05).

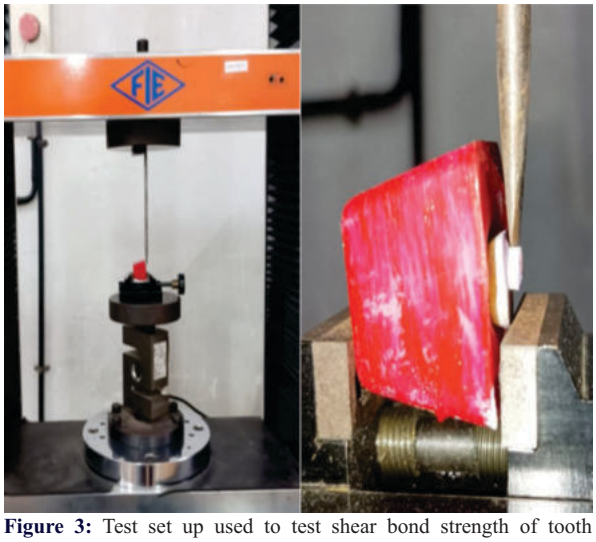

Figure 3: Test set up used to test shear bond strength of tooth specimens

RESULTS:

The mean shear bond strength values (Table 2) showed statistically significant variations in bonding efficacy ($p < 0.001$) by one way ANOVA test. The control groups utilizing conventional rotary instrumentation for caries excavation exhibited the lowest bond strengths in comparison to the groups utilizing chemo-mechanical methods in both type of restorative treatments. Tukey's post hoc analysis also revealed significant differences in shear bond strength between the two subgroups in all the three groups. Neospectra ST Universal showed better bonding than Fusion Flo in all the caries excavation methods. While V-Carie-Solve produced slightly higher bond strength than Carie-Fix, the variation was not statistically significant.

Table 2: Comparison Of Mean Shear Bond Strength (in Mpa) Between 3 Groups And Their 2 Sub Groups Using One-way ANOVA Test

Groups*		N	Mean	SD	Min	Max	p-value
Group I	Sub Group A	10	9.87	0.46	9.3	10.7	<0.001*
	Sub Group B	10	9.10	0.54	8.4	10	
Group II	Sub Group A	10	12.88	0.38	12.4	13.5	
	Sub Group B	10	12.21	0.23	11.9	12.6	
Group III	Sub Group A	10	12.61	0.42	12.2	13.4	
	Sub Group B	10	11.92	0.37	11.5	12.6	

* Group I: conventional rotary instrument, Group II: V-Carie-Solve, Group III: Carie-Fix; Sub Group A: Neospectra ST Universal, Sub Group B: Fusion Flo

DISCUSSION

The newer advancements and developments have led to the availability of wide variety of dental restorative materials which promises better aesthetics and durability. Hence, the management of dental caries at present is based on the newer concept of construction with conservation which includes more conservative tooth preparation with removal of infected carious dentin and preservation of affected dentin. CMCR holds a lot of promise in achieving this objective.[11]

In this study, two newer enzyme-based chemo-mechanical agents V-Carie Solve and Carie-Fix were used to test their efficacy and influence in bonding as no such reports are available in literature. These agents contain either papain or papaya extract which possess proteolytic enzyme action along with bactericidal and anti-inflammatory properties. Moreover, the healthy tissues are not damaged, while it accelerates the cicatricial process.[3]. It also possesses bactericidal and bacteriostatic properties.[12] The action of papain is limited only to carious tissues that lacks the plasmatic protease inhibitor, alpha-1-antitrypsin, whereas it does not act on healthy tissue which contains this substance.[3]

Earlier studies comparing the bond strength after caries removal with the conventional rotary method and CMCR method have shown controversial results. Certain studies have shown better results with CMCR,[13] other studies have shown no significant difference among these[14] while few others have shown better results with rotary than chemo-mechanical methods.[15] Hence, considering the limited amount of literature on newer CMCR agents and their bond strength to caries affected dentin substrate, the present study was undertaken.

In this study, the shear bond strength was chosen to measure the adhesion parameter, which is considered better than other testing parameters because it closely mimic real-world scenarios, providing more realistic shear strength values.[16] The results of the present study showed significantly better adhesion to dentin substrate with chemo-mechanical method of caries removal in comparison to rotary in all the sub groups tested. The better results obtained with CMCR could be due to several reasons: 1) The CMCR agents brought about deproteinization of smear layer.[13] 2) Pre-treatment with enzyme based CMCR agents might improve the quality of the hybrid layer in caries affected dentin using self-etch mode[18] 3) Dentinal substrate following CMCR demonstrated higher surface energy in comparison to conventional rotary excavated dentin, leading to greater affinity for adhesive materials and better bonding with chemo-mechanical method.[13] 4) Longer and denser resin tags were seen following chemo-mechanical caries excavation in comparison to conventional rotary technique[19]. The reason for lower bond strength with rotary could be due to the inferior quality of the resin tags which are shorter and less dense due to thicker smear layer occluding the dentinal tubules.[20] Another reason is that, there is a possibility for remnant infected dentin in rotary caries excavation, as this removal is based on clinician's evaluation, whereas with CMCR agents, there is self-limiting action due to collagenolytic activity limited only to infected dentin.

The results of this study are in accordance with other studies where CMCR have resulted in higher bond strength values in comparison to rotary,[7,13] but it also contradicts few earlier studies where rotary has given slightly better bond strength than CMCR agent.[15,16] The reason for this could be that sodium hypochlorite containing CMCR used in their studies increased the intrinsic pH of dentin which buffered the acidity of the ultra-mild one-step self-etch adhesives used in their study. Whereas, in the present study, the self-etching dentin bonding agent used, Gluma Bond Universal falls under intermediary strong self-etch adhesive[21] (pH=1.6-1.8). Hence the dentinal buffering action had minimal effect on the intermediary strong self-etching adhesion with a lower pH.

In the present study, nanoceramic composite gave slightly better bond strength than flowable composite. Bulk fill composites generally contain a higher proportion of filler particles than flowable composite. The granulated spherical fillers in Neo Spectra ST Universal, used in the current study, is part of the SphereTEC® technology, which is a standout feature of this composite. These nanoparticle fillers (15µ diameter) which is 76-80% by weight of the composite, contribute significantly to the mechanical strength and resistance of the material and allow better penetration and lower polymerization shrinkage.[22] Similarly, flowable composites due to their lower filler content and higher flexibility may have lower bond strength.

The laboratory character of the experiment, which limits extrapolating the results for clinical practice is the main limitation of this study. Moreover, the characterization of the dentin according to clinical aspects is very subjective, which may have influenced the teeth selection and carious dentin removal, which was based solely on the clinical properties. Further clinical studies are suggested to fill these gaps for better clarity on the topic. On the other hand, the present study is original, exposes important information, and contributes to developing the scientific literature as the first study to compare the newly introduced chemo-mechanical caries removal agents V-Carie Solve and Carie-Fix regarding their influence on adhesion of bonding agent and restoration.

Within the limitations of this study, it can be concluded that chemo-mechanical caries removal is an effective alternative to conventional techniques of caries removal.

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