

Micro-shear Bond toughness of Caries Affected Dentin Treated with Conventional, Smart Bur and Chemo-mechanical Technique: An in vitro study

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ABSTRACT

Background: Evaluation of Micro-shear Bond toughness of Caries Affected Dentin Treated with Conventional, Smart Bur and Chemo-mechanical Technique using in vitro model.

Materials and Method: Forty-five freshly extracted human maxillary and permanent mandibular teeth, due to periodontal reasons or impacted third molars, in which occlusal caries extending up to deep dentin but not involving pulp were collected and arbitrarily proportioned into three groups after sectioning along with caries removal was done, and a perpendicular 2-mm high resin composite rod was bonded using multi-mode adhesive and the bonded interface was tested for the micro-shear bond strength. The results, thus obtained, were statistically analyzed.

Results: One way (ANOVA) and Post hoc Tuckey's test were used for carrying out statistical analysis. The result showed variation in bond strength values for each of the groups, with the lowest for smart bur group.

Conclusion: Carie-care does not affect bond strength negatively and thus could be used as an alternative for caries excavation.

Keywords: Minimal invasive dentistry, Smart Bur, CMCR, DOM.

INTRODUCTION

In the past era when it was the beginning of operative dentistry and rules were established, the term –caries excavation|| was defined as a synonym for –cavity preparation”, which in turn consisted of –mechanical treatment of the injuries to the teeth produced by dental caries, as the remaining tooth should have a shape to best fit a filling. In practical terms, it means that excavation of carious dentin was performed to remove necrotic, soft material in order to best hold the filling material.¹ Over time, modern dentistry today believes in dealing with caries as an infectious disease for which operative intervention should be deferred as long as possible..

Minimally invasive dentistry's new model is hence “Extension for Prevention”.²

As caries removal is still the main step in order to get good-quality bonded restorations, the other question arises: What could be the endpoint of caries removal? Till now, there is a lack of clinical criterion to explain the caries removal limit than the “normal” hardness feeling of sound dentin when examined by hand instruments.¹

Caries excavation procedure can have the utilization of magnifying optical aids for example microscope

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which have different high and low power magnifications. Operating microscopes gives homogenous radiance without shadows and a three-dimensional site which included to add up an unclogged picture of the site.³ Removal of caries is conventionally performed by rotary or non-rotary mechanical techniques which induce pain, annoying sounds, vibration, and may remove sound tooth structure as well, rendering it less durable in the long run.⁴

Ideologies of dental therapy differ with time and now sufficient documents available by research for a reconsideration of the traditional approaches to caries management. The minimal intervention technique of CMC (Chemo-Mechanical Caries Removal) represents one such new approach to restorative dentistry.⁵

In light of the minimally invasive dentistry concept an effort was made to evolve a selective caries-removal rotating instrument, a “plastic” bur made up of a polyamide/imide (PAI) polymer, owning less mechanical properties than sound dentin.¹

The dissimilar methods now present for caries removal/cavity preparation create a different type of dentin substrates, and these differ in their receptiveness for adhesion. As well as the chemical formulation of the adhesive can also change the bond strength to caries affected dentin.¹ Hence, the purpose of this study was the evaluation of bond strength of caries affected dentin treated with a conventional, smart bur and chemo-mechanical technique in an in-vitro model.

MATERIALS & METHOD

Forty-five freshly extracted human maxillary and permanent mandibular teeth, due to periodontal reasons or impacted third molars, in which occlusal caries extending up to deep dentin but not involving pulp were collected. From the middle of the carious lesion, teeth were dissected in the mesiodistal plane using a diamond disk rotating at low speed, then the samples were (45 teeth after sectioning leading to 90 samples) randomly segregated into three groups of 30 each.

Group A: Bur group

Group B: Carie-care group

Group C: Smart bur group

Prepared specimens were mounted with a plastic ring (internal diameter 15 mm) using self-cure acrylic resin. The caries removal methods were used according to different groups, and the surfaces were observed under DOM (Dental Operating Microscope) Figure 1.



Fig 1: Group A -Caries Excavation Assessment Using a Dental Operating Microscope

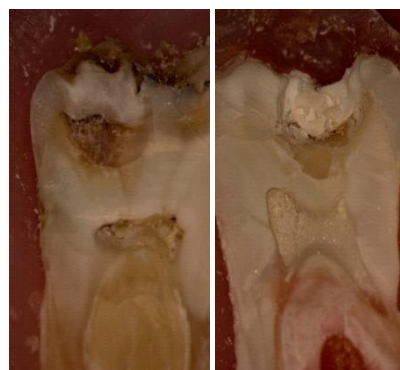


Fig 2: Group B- Caries Excavation Assessment Using a Dental Operating Microscope.



Fig 3: Group C- Caries Excavation Assessment Using a Dental Operating Microscope

Specimens were examined to find a flat surface suitable for testing. A perpendicular 2-mm high resin composite rod (diameter 0.97mm) was

bonded using a multi-mode adhesive over the flat surfaces selected.

Micro shear bond strength testing in an Instron Device (Instron, model no. 5544, Canton, Mass) was carried out for the bonded interface (Figure 2). A loop of ligature wire (Unitex, diameter 0.009 inches, TP Orthodontics, Leeds, UK) delivered a force parallel to the bonded surface at a crosshead pace of 1.0 mm/minute. The micro shear bond strength value in megapascals (MPa) at fracture was calculated for every specimen using the formula:

Micro shear bond strength (MPa) = Shearforce (N)/cross-sectional area (mm²). The results obtained were then analyzed statistically.



Fig 4: Microshear Bond Strength Testing Assembly

RESULTS

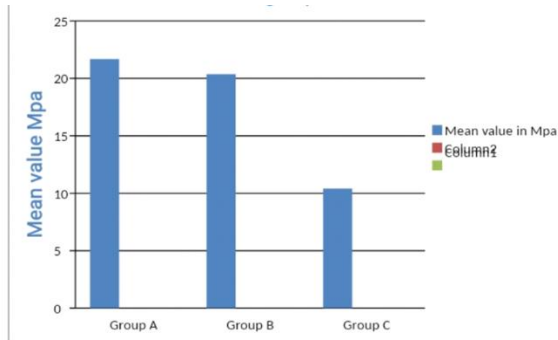
Statistical analysis was performed using One Way ANOVA and Post Hoc Tuckey's test. There is a difference in bond strength values for every group, which is lowest for smart bur II group and highest for bur group. Statistically, a significant difference is not seen with the carie-care group.

Table 1: One Way ANOVA

Descriptive							
Mpa							
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum
					Lower Bound	Upper Bound	
A	30	21.685333	3.3900053	.6189275	20.419485	22.951182	14.9900
B	30	20.365667	3.1421448	.5736745	19.192371	21.538963	12.2700
C	30	10.399667	2.6900820	.4911395	9.395174	11.404160	6.9900
Total	90	17.483556	5.9148834	.6234835	16.244707	18.722404	6.9900

Table 2: Post-Hoc-Tukey's Test

Multiple Comparisons						
Dependent Variable: mpa						
Scheffe						
(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	1.3196667	.7972418	.260	-.665864	3.305198
	3	11.2856667*	.7972418	.000	9.300136	13.271198
2	1	-1.3196667	.7972418	.260	-3.305198	.665864
	3	9.9660000*	.7972418	.000	7.980469	11.951531
3	1	-11.2856667*	.7972418	.000	-13.271198	-9.300136
	2	-9.9660000*	.7972418	.000	-11.951531	-7.980469



Graph 1: Comparison of mean value of different groups.

DISCUSSION

The outburst of recently developed techniques, materials and the entire understanding has changed dentistry from the early days of G.V. Black. Nonetheless, certain aspects of dentistry have evolved little over the big period of 90-plus years—such as the tooth preparation method for restoration. There have been some evaluations notably high-speed turbines, lasers and microabrasion—but, still, most of the clinical work is done by traditional handpiece by dentists.²

Conventional burs in the majority have a negative rake angle. To have the blade in contact with the tooth surface, downward pressure has to be applied. Hence causing a less-controlled movement of the instrument through the surface resulting in excessive dentin removal.⁶

On the contrary, the minimally invasive caries removal techniques are about excavating the layer which is outer and infected, denatured caries infected dentin. In this manner, the inner layer, which is bacteria free and remineralizable, which is called caries affected dentin, can be preserved.⁷ The exact method of enzymatic-based CMCR agents, which is the minimally invasive approach, is not clear. Bussaduri et al. stated that the enzymatic caries excavation process was based on the aspect that infected carious tissues lost the antiprotease a-1-anti-trypsin, which suppressed protein digestion in sound collagen-based tissues. However, no affirmation that a-1-antitrypsin could be identified in dentine.⁸

Carie care - a product that has been introduced has as its main active ingredient from papaya extract -

an end protein, chloramines and dye. It contains certain percentages of essential oils from plant sources, which has an anti-inflammatory and little anaesthetic effect. The formulation also contains distinct gelling agent which does not allow spilling of gel by giving it proper consistency.⁴ Carie Care is applied directly onto the tooth, having caries with a disposable applicator tip. After application, soon gel differentiates the color in the caries-affected area, and thus causes more breakdown of partially degraded collagen and other matrix components. They are then susceptible to enzymatic degradation, mainly by bacterial proteases and other hydrolases, by cleavage of the polypeptide chains in the triple helix. The polypeptide hydrolysis is due to endopeptidases which are extracted and purified from papaya extract and thus causes further degradation of partially degraded collagen.^{4,9}

After 1 minute, using the sharp spoon excavator, the gel along with dissolved caries is removed. Carie Care is in the form of single preparation, which can be stored at 4-degree centigrade for more than six months.⁹ Another novel, self-limiting concept in mechanical caries removal is that of a polymer bur (Smart Prep, SS White Burs, Inc., Lakewood, NJ, USA). This bur is paddle-shaped with unique flute design. It is made from a medical-grade polyetherketone- ketone, with a particular hardness and wears resistance. It is said to remove only the soft caries-infected dentin, leaving the caries-affected dentin intact.¹⁰

The hardness of sound dentin ranges from 54 to 65 KHN and carious dentin having a hardness of 20 KHN or less. The hardness of smart-prep bur is 50 KHN. Thus it removes only carious part of the dentin. It wears off when in contact with healthy dentin.⁷ The bur quickly dulls and vibrates when it comes in contact with calcified caries-affected dentin. It is used at low speed (500-800 rpm).

The bur blades are designed to primarily remove carious dentin by “plowing”, during which the carious dentin is first locally compressed by the blades then the compressed wall of softened carious dentin is pushed along the more sound dentin surface with rupture eventually occurring at this surface level, and the loosened fragments are carried to the surface. The ability of the polymer bur to remove infectious carious tissues and produce

optimal bonding substrates in the remaining dentin has not been established.¹¹

Hence in this in vitro study, the efficacy of care, smart bur II and diamond bur is compared to remove carious tissue, and their effect on the substrate's receptiveness for bonding is evaluated.

In this study micro shear bond strength test is preferred over macro shear test because it permits efficient screening of adhesive systems, a significant advantage over μ TBS is that the μ SBS specimen is pre-stressed prior to testing only by mold removal.¹² The visual and tactile criterion was used because it is the most widely used clinical criterion to evaluate complete caries removal¹³ also to enhance visual experience Dental Operating Microscope was used as Operating microscopes offer homogeneous illumination without shadows and a 3-dimensional view, which allow clear visualization of the examination site.¹⁴

Previous laboratory studies of several universal adhesives have evaluated their bond strength in total-etch and self-etch modes. For enamel, several authors reported the bond strength of a universal adhesive was significantly improved in the total-etch mode, however, for dentin, other studies reported no difference in the immediate bond strength of pre-etched and self-etched dentin with several universal adhesives.¹⁵

Bulk fill composite (Tetric N-Ceram bulk fill Ivoclar Vivadent) used to fill the PVC tube in only one increment (2mm) avoiding incorporation of air bubbles in the composite cylinder. Different caries removal techniques may affect the surface characteristics and structural integrity of dentin which can affect the bond strength of dental materials.¹ The results (Graph 1) obtained in the present study support the hypothesis that there are differences among the bond strength values of different caries removal techniques. Bond strength (mean) for the bur group (25.220 Mpa) is highest, maybe because bur tend to excavate infected dentin as well as affected dentin and resin adhesion is more for normal dentin as compared to caries affected dentin.¹⁶

CONCLUSION

Hence the conclusion is that Carie-care does not affect bond strength negatively and thus could be

used as an alternative for caries excavation. Carie-care and smart bur II both are minimally invasive methods, but smart bur is not effective in removing carious portion thus showed the lowest bond strength. Diamond bur can be used for caries excavation as it showed highest bond strength but should be used cautiously. However, the bond strength of different generation adhesives, as well as different caries removal methods, requires further in-vivo studies and clinical trials to validate the laboratory experiments.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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