

# A microtensile bond strength evaluation of a single-bottle adhesive to caries-affected dentin in conventional versus minimal invasive caries removal techniques: An *in-vitro* study

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## Abstract

**Background and Objective:** The current dental restorative concepts are characterized by an increased effort towards a less invasive treatment of carious lesions. Minimally invasive cavity preparation techniques are intended to preserve as much sound enamel and dentin as possible, during the treatment of carious lesions. The objective of this *in vitro* study is to evaluate the microtensile bond strength of single-etch adhesives (Adper Easy one) on caries-affected dentin, following three different caries removal techniques, namely, Carisolv, Conventional carbide bur at slow speed, and aqueous calcium hydroxide. **Materials and Methods:** A total of 30 teeth were divided into three groups and arranged with 10 samples in each group - round bur (Group A), Carisolv (Group B), Aqueous calcium hydroxide (Group C). Following caries excavation by using the three above -mentioned techniques, application of the bonding agent and composite buildup was done. Following sectioning of the samples with the help of a hard tissue microtome, Group A, B, and C were again trimmed into an hour-glass shape, maintaining a width of 1.2 mm in the center of an hour glass. These were debonded under a microtensile load at failure, using the Instron Universal Testing Machine. **Results:** There was a significantly lower microtensile bond strength in the group where the caries was removed by the round bur, as compared to the group where the caries was removed by using Carisolv and calcium hydroxide, which showed higher microtensile bond strength, that is, the significant pairing of Groups were Group A to Group B and Group A to Group C, exhibiting statistically significant difference with a  $P < 0.001$ . However, there was no statistically significant difference between Group B and Group C. **Interpretation and Conclusion:** Carisolv and aqueous calcium hydroxide have proven to be good methods of caries removal for achieving a higher microtensile bond strength of the single-bottle self-etch adhesive on dentin.

**Keywords:** Aqueous calcium hydroxide, Carisolv, round bur, self-etch adhesive, microtensile bond strength

## INTRODUCTION

The techniques used in carious dentin removal have developed since G V Black initially proposed the principle of 'extension for prevention' in the operative treatment of carious lesions, in 1893. The current dental restorative concepts are characterized by an increased effort toward less invasive treatment of carious lesions.

The concept of conserving healthy tooth structures during cavity preparation has gained popularity with the advent of adhesive resin bonding systems.<sup>[1]</sup> Minimally invasive cavity preparation techniques are intended to preserve as much sound enamel and dentin as possible during the treatment of carious lesions. Traditional means of cavity preparation is based on the physiology of extension for prevention and includes a high speed handpiece and slow rotating instruments. In children and patients with dental anxiety, caries removal by means of conventional instruments is often associated with discomfort. A possible rise in temperature

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during excavation,<sup>[2,3]</sup> which might cause irreversible damage to the pulp tissue, will pose as an additional problem.<sup>[4]</sup> Of late, chemomechanical systems have been discussed as an alternative to conventional rotary systems for caries removal.<sup>[5]</sup>

A new product, Carisolv is one of the chemomechanical agents that is composed of three amino acids (leucine, lysine, and glutamic acid) and sodium hypochlorite with an alkaline pH. The antimicrobial effects of the aqueous preparations of calcium hydroxide have been demonstrated in the past. Calcium hydroxide, when dissolved in water, dissociates into calcium and hydroxide ions. The presence of hydroxide ions in a solution makes it alkaline, and thus, antimicrobial. Therefore, an aqueous preparation of calcium hydroxide can potentially maintain its high pH for a long time.<sup>[6]</sup>

Hence, it is possible to use Carisolv and aqueous calcium hydroxide for caries excavation.

Adper Easy One (3M ESPE) is a new single-bottle self-etch adhesive. Today, little is known about the performance of dentin adhesives on caries-affected dentin, excavated with these new minimally invasive systems.<sup>[5]</sup>

The purpose of this *in vitro* study is to evaluate the influence of the various caries excavation techniques, such as, Carisolv, Conventional carbide bur at slow speed, and aqueous calcium hydroxide on the bonding of self-etch adhesives to dentin.

## MATERIALS AND METHODS

A total of 30 samples of extracted human permanent molars with coronal dentin caries were used in the study, for convenience, with the dentin caries approximately halfway through the dentin, which was obtained by grinding them with a 600-grit silicon carbide (SiC) paper, under running water, according to the combined criteria of hardness to a sharp excavator, visual examination, and staining with a caries detector solution. After preparation, the specimens were washed in deionized water for one minute and all the teeth were stored at 4°C in physiological saline, to which several crystals of thymol were added. These samples were randomly divided into three groups.

Group A: Ten teeth were used, in which the caries was mechanically removed by using the round carbide bur in a contra-angled handpiece with slow speed.

Group B: Ten teeth were used in which caries excavation was done by using Carisolv gel. The

caries lesion was covered with Carisolv gel and left for 30 seconds. When the gel was cloudy it was removed gently by scraping with the appropriate spoon excavator, after which additional fresh gel was applied on the excavation site. Removal of carious dentin was continued until the gel was no longer cloudy. The gel was then removed and the cavity was wiped with a moistened cotton pellet and rinsed.

Group C: Ten teeth were used in which caries excavation was done by using the mixture of calcium hydroxide and distilled water. The carious lesion was covered with this mixture and left for 30 seconds. After 30 seconds, the carious lesion was gently scraped using a spoon excavator until no more carious dentin could be removed with the spoon excavator. The cavity was wiped with a moistened cotton pellet and rinsed.

### Bonding procedure

Adper Easy One-Self etch adhesive was applied on the caries removed dentin surfaces with an applicator for 20 seconds and then light cured for 10 seconds.

### Microtensile bond strength assessment

Following the application of adhesive, using Filtek Z350 composite resin, the surface was built up in three to four increments, to a height of 6 mm and by curing each increment for 20 seconds. This restoration was placed after complete removal of the caries using three different caries removal techniques. The roots of the molar samples of all the groups were cut from the crowns using a diamond disk. The samples were then mounted buccolingually on an acrylic block, measuring about one inch in diameter, with a thickness of one inch, exposing half the tooth structure.

The teeth were sectioned longitudinally, along the cavity and restoration interface, using a Hard Tissue Microtome. These specimens were then trimmed to an hour-glass shape of 1.2 mm width in the center, using a fine cylindrical diamond bur in a high-speed handpiece, under a water spray coolant.

The specimens were then attached to the wooden jig with a cyanoacrylate adhesive and subjected to microtensile load in an Instron testing machine at a crosshead speed of 1 mm/minute.

## RESULTS

The microtensile bond strength values (Mpa) were calculated by dividing the force at failure by the cross-sectional area.

Results are expressed as mean ± SD.

The statistical analysis used for group-wise comparison was the One-Way Analysis of Variance (ANOVA) followed by the post-hoc test.

The P value was calculated for statistical significance,

**Statistical analysis**

Table 1: Shows values of the different samples in the groups, with regard to the microtensile bond strength, in Mpa.

GROUP A: The microtensile bond strength of caries dentin after caries removal with a round bur in Mpa, with a maximum of 7.905 and a minimum of 3.895.

GROUP B: The microtensile bond strength of caries dentin after caries removal with Carisolv in Mpa, with a maximum of 13.916 and a minimum of 7.121.

GROUP C: The microtensile bond strength of caries dentin after caries removal with Aqueous Calcium hydroxide in Mpa, with a maximum of 12.85 and a minimum of 7.186.

Table 2 and Figure 1: Exclusively show the Range, Mean microtensile bond strength scores, and their standard deviation among the test groups.

The Mean ± SD of Group A is 6.07 ± 1.24.

The Mean ± SD of Group B is 10.62 ± 2.33.

The Mean ± SD of Group C is 9.80 ± 1.73.

Table 3 and Figure 1: Show a comparison of the microtensile bond strength observed in different groups. The results showed that Group A demonstrated lower microtensile bond strength and Groups B and C demonstrated higher microtensile bond strength.

The significant pair of Groups were, Group A and Group B and Group A and Group C. They exhibited a statistically significant difference, with a P value of <0.001. However, there was no statistically significant difference between Group B and Group C.

**DISCUSSION**

The microtensile bond strength testing method is selective when testing very low bond strength, particularly when the trimming method is used.<sup>[7]</sup> The cross-section of these dumbbell-shaped specimens

is the smallest at the adhesive interface and the stresses are directed to it so the fracture of the specimens initiates at the weakest region of the tested interface.<sup>[8]</sup> This method eliminates most of the cohesive resin or dentin fractures seen in the more traditional tensile strength testing procedures that are due to non- uniform stress distributions.<sup>[6]</sup>

Although most bond strength testing is done on normal dentin, for convenience, clinically most

**Table 1: Microtensile bond strength**

	Group A (round bur) (Mpa)	Group B (carisolv) (Mpa)	Group C (aqueous calcium hydroxide) (Mpa)
Sample 1	6.86	11.302	11.544
Sample 2	3.895	8.493	10.302
Sample 3	6.794	7.84	11.132
Sample 4	6.59	11.106	9.518
Sample 5	7.905	7.121	9.93
Sample 6	5.4	11.433	7.97
Sample 7	7.186	11.76	8.996
Sample 8	6.2	13.916	7.186
Sample 9	4.57	9.473	8.538
Sample 10	5.22	13.72	12.85
Mean	6.07	10.62	9.80

**Table 2: Means of microtensile bond strength observed in different groups**

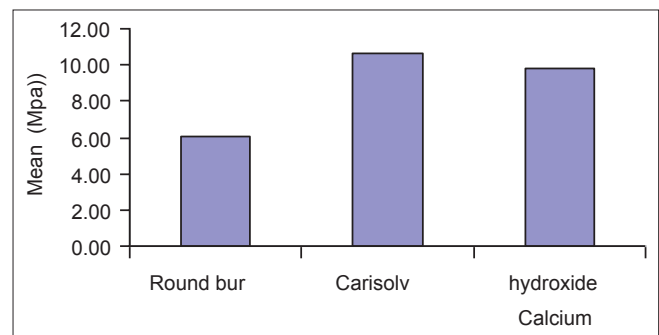
Study groups	Range	Mean	SD
Group A (round bur)	3.895-7.905	6.07	±1.24
Group B (carisolv)	7.121-13.916	10.62	±2.33
Group C (aqueous calcium hydroxide)	7.186-12.85	9.80	±1.73

SD: Standard deviation

**Table 3: Comparison of microtensile bond strength observed in different groups**

Study groups	Mean	F value	P* value	Significant pairs**
Group A (round bur)	6.07	17.68	<0.001	A and B,
Group B (carisolv)	10.62		HS	A and C
Group C (aqueous calcium hydroxide)	9.80			

\*One-way analysis of variance test, \*\*Post-hoc test. HS: ???



**Figure 1: Microtensile Bond strength of three groups**

bonding substrates are not normal dentin, but rather are caries-affected dentin or sclerotic cervical dentin. Bonding of an adhesive to the dentin is complex and bond strength is one of the important performance parameters of dentin adhesives.<sup>[9,10]</sup> The adhesive systems' bonding strength values to dentin may change depending on the location of the bonding area.<sup>[11]</sup> Caries-affected intertubular dentin is partially demineralized due to the caries process. Thus, the weakest link in the resin-caries affected dentin assembly may be the cohesive strength of caries-affected dentin.<sup>[12]</sup>

Many studies have reported that the bond strength of self-conditioning systems seems to be markedly reduced on caries-affected dentin.<sup>[13]</sup> However, these self-etching systems also offer advantages, such as, reduced application time and lower technique sensitivity.<sup>[14]</sup> Although, studies have shown that the highest bonding values are achieved when the caries-affected dentin is first conditioned by phosphoric acid followed by application of the bonding system.<sup>[15]</sup> However, this study has been carried out to evaluate whether there is a difference in the microtensile bond strength after caries excavation using aqueous calcium hydroxide, as compared to caries excavation using round bur or Carisolv.

The results of this study indicate that the dentinal caries excavation using round bur resulted in significantly lower bond strength in comparison to Carisolv and Aqueous calcium hydroxide.

This could be due to the cutting action upon dentin causing compaction and spreading of the dentin chips over the moist cavity surface. The compacted dentin debris occluded the tubules, which could limit the mechanical bonding capacity of the adhesive materials to the cut dentin surface.<sup>[16]</sup>

However, dentinal caries excavation using Carisolv showed slightly more microtensile bond strength when compared to Aqueous calcium hydroxide, but their microtensile bond strength was not statistically significant.

Further studies testing the microtensile bond strength of single-bottle self-etch adhesive after different caries removal techniques *in-vivo* are warranted, to determine whether the amount of microtensile bond strength is the same as in the *in-vitro* study, and whether the observed amount of bond strength, if present, is clinically relevant. However, it is important to realize that the technique is more important than the material. A careful and comprehensive clinical evaluation and understanding of the requirement of an individual case should be accounted for, before attempting the procedure.

## CONCLUSION

Within the limitations of this study conducted and the results obtained, it can be concluded that: Out of the three groups, the round bur, when used as a caries removal technique, showed lower microtensile bond strength between the dentin and resin. However, the microtensile bond strength between the dentin and resin was slightly more when caries excavation was done using Carisolv as compared to Aqueous calcium hydroxide solution. However, the difference was not statistically significant.

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