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The effects of dentin and chemomechanical caries removal on the shear bond strength of dentin adhesive: An in vitro study

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ABSTRACT

Aims: to measure the shear bond strength of composite restoration in vitro. Materials and Methods: The adhesion ability of dentin after chemomechanical method (Carisolv™) was measured compared to conventional one (bur) with the sound group which acts as a control. Three age groups (primary, young and old permanent teeth), in addition to two systems of adhesives (All Bond 2 and Optibond FL) were used. After the trimming and polishing of dentin surfaces to expose flat occlusal surfaces of the teeth, the carious lesion was removed by Carisolv™. Sixty teeth were used in this method, also 60 teeth were used in bur method, which are compared to 60 sound teeth. The composite resin was applied to the confined area of bonding measuring 3 mm in diameter, and two layers of composite core measuring 4 mm in height were applied to the rubbery mould. After thermocycling, the samples were stored in distilled water with crystals of thymol for 24 hours before testing. The interfaces between composites and dentin surfaces were loaded with a knife edge rod perpendicular to the long axis of the tooth by the Universal Testing Machine at across head of speed of 1mm/min., the load required to dislodge the restorations and modes of failure were recorded. **Results**: the primary teeth in sound group have the highest value of shear bond strength than Carisolv and bur treated surfaces with both dentin adhesives. **Conclusion**: Chemomechanical caries removal has no adverse effects on bonding to caries-affected dentin when modern bonding systems are used and old teeth dentin shows lower bond strength compared to young permanent teeth dentin.

Key Words: Carisolv™, Chemo-mechanical caries removal, Method of caries removal.

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INTRODUCTION

Conventional cavity preparation and caries removal are based on, Black's principle of extension for prevention. This principle requires the removing of healthy tooth structure, which is destructive and leads to excessive tissue loss. The efforts have focused on new techniques, such as sono–abrasion, air-abrasion, air–polishing, laser and chemomechanical procedures for caries removal.(1)

A new product, Carisolv™ (Medi–Team, Sävedalen, Sweden) has been introduced as a successor to the Caridex™ system. Both solutions claim to exploit the proteolytic effect of sodium hypochlorite, which partially disrupts denatured collagen fibers in the carious dentin.(2,3)

This caries removal system consists of a red gel and a transparent liquid, the components of the red gel are 0.1 mole amino acids (glutamic acid, leucine and lysine), sodium chloride (NaCL), sodium hydroxide (NaOH) , erythrosine and purified water, the transparent liquid contains sodium hypochlorite (NaOCL–.5% w/v).(4) The aim of chemomechanical caries removal is to remove the outer, permanently damaged layer of carious (infected) dentin, but to leave the demineralized (affected dentin which can be healed(5)).

The purpose of this study was to measure the adhesion ability of various dentin substrates of primary, young and old permanent teeth after different methods of caries removal with two types of dentin bonding agents.

MATERIALS AND METHODS

The carious and non–carious primary teeth were collected from serial extraction (the patients ages ranged from 9 – 11years), the sound upper first and second permanent premolars were collected from extraction for orthodontic reasons with carious teeth were also collected (The patients ages ranged from 11–16 years), and the lower carious and non – carious first and second permanent premolars and molars extracted from patients with periodontal problems were also collected (The patients ages ranged from 55–60 years). All teeth were stored in distilled water at 37°C with thymol crystals.

One hundred eighty carious and non–carious primary and permanent teeth were selected. Teeth were embedded in poly vinyl plastic cylinders of 20 mm height and 12 mm diameter using autopolymerizing acrylic resin with the crowns left exposed at a level of 1 mm above the cementoenamel junction. Specimens were randomly divided into three main groups, each containing (60) teeth, (40 carious and 20 non–carious teeth). Each group was subdivided into two subgroups (each subgroup containing 30 teeth), (10) sound (control) teeth, (10) carious teeth treated with bur and (10) carious teeth treated with Carisolv™.

The occlusal surfaces of all sound teeth were ground by water coolant trimmer (Stone grinding Wheel, Manfredi, Italy) to expose flat dentin surfaces perpendicular to the long axis of the teeth, then the flat surfaces were abraded by 180 and 600 grit abrasive carbide papers (Water proof, Aluminum oxide) mounted on a grinding wheel of polishing machine, with copious amounts of water to create a standardized dentin surface. The carious teeth had an occlusal caries, not extending half the way from dentinoenamel junction to the pulp.

The occlusal surfaces of the teeth were removed perpendicular to the long axis of the teeth to expose flat occlusal surfaces by water coolant trimmer, the carious lesion was removed chemomechanically with Carisolv™ multi–mix gel (Medi Team, Göteborg, Sävedaln Sweden) and used according to the manufacturer's instructions. The gel was applied to the lesion for about 30 seconds, and the carious dentin was removed with specially designed hand instruments, more gel was applied and caries removal was continued until, the gel was no longer cloudy and the surface was firm to probing when checked with dental explorer.

The remaining surface of the teeth were lapped down using 180 and 600 grit abrasive papers mounted on a grinding wheel with copious amounts of water until, the normal dentin that surrounded the cavity was at almost the same level, as the exposed cavity floor (where possible a flat surface was obtained across the whole of the tooth surface in order to act as a standardized surface). Care should be taken not to touch the Carisolv™ treated surface by frequently checking the dentin surface during polishing of the surrounding normal dentin. The carious lesion in the bur group was removed mechanically using a contra–angle speed reducing handpiece (W&H Austria), with round steel burs (No.8) (ISO # 0.05 Komet, Germany), until the dentin was being firm to probing with a blunt dental explorer, and there were no discoloration when checked visually, then the surrounding non –carious dentin was removed using 180 and 600 grit silicon carbide papers mounted on a grinding wheel until, the normal dentin was at the same level as the base of the excavated carious lesion.

A rubbery mould with opening of 3mm in diameter and 4mm in height was applied to the treated dentin surface. Each mould was split vertically in one place through its entire thickness using a surgical blade to ensure that its later removal from around the composite was facilitated without putting stress on the composite. The rubbery mould was firmly attached to the acrylic resin block by sticky wax. The groups of teeth that were bonded with All Bond 2 and Optibond FL were accomplished according to the manufacturer's instructions. The samples were thermocycled for (300 cycles). Then, the samples were returned to distilled water and stored for 24 hours prior to shear bond testing.

RESULTS

The experimental statistical design is factor analysis of variance (ANOVA) and Complete Randomized Design (CRD).

The mean shear bond strength in primary teeth showed in Table (1) indicated that the primary teeth in sound group have the highest value of shear bond strength than Carisolv and bur treated surfaces with both dentin adhesives.

Table (1): The mean shear bond strength Duncan's multiple range test of the interaction between methods and materials used in primary teeth dentin.

Method	**Shear Strength Mean ± SE (Mpa),**		
Materials	**Sound**	**Carisolv**	**Bur**
All Bond 2	8.66 ± 0.12 a	6.98 ± 0.08 c	5.54 ± 0.11 e
Optibond FL	7.75 ± 0.13 b	6.57 ± 0.10 d	6.30 ± 0.10 e

Different letters mean significant differences; SE: standard error.

The mean shear bond strength in young permanent teeth showed in Table (2) indicated that the young permanent teeth in sound group have the highest shear bond strength than Carisolv and bur treated surfaces with All Bond 2 and Optibond FL dentin adhesives. Table (3) showed that the mean shear bond strength of old permanent teeth in sound group have the highest mean shear bond strength than Carisolv and bur treated surfaces with both dentin adhesives.

Table (2): The mean shear bond strength and Duncan's multiple range test of the interaction between methods and materials used in young permanent teeth dentin.

Method	**Shear Strength Mean ± SE (Mpa)**		
Materials	**Sound**	**Carisolv**	**Bur**
All Bond 2	10.69± 0.24 a	9.10 ± 0.17 c	7.53 ± 0.10 d
Optibond FL	9.72 ± 0.15 b	7.80 ± 0.16 d	6.97 ± 0.18 e

Different letters mean significant differences; SE: standard error.

Table (3): The mean shear bond strength and Duncan's multiple range test of the interaction between methods and materials used in old permanent teeth dentin.

Method	**Shear Strength Mean ± SE (Mpa)**		
Materials	**Sound**	**Carisolv**	**Bur**
All Bond 2	9.08 ± 0.16 a	7.95 ± 0.15 c	6.52 ± 0.10 d
Optibond FL	8.53 ± 0.10 b	5.43 ± 0.09 d	5.50 ± 0.09 e

Different letters mean significant differences; SE: standard error.

Table (4) Showed the mean shear bond strength in Mpa ± SE and Duncan's multiple range test of the interaction between age, methods and materials used for each tested groups. Table (5) Showed modes of Failure According to Dentin Substrates (in percentage). Table (6) Showed modes of Failure According to Methods of Caries Removal (in percentage).

Table (4): The mean shear bond strength and Duncan's multiple range test of the interaction between age, methods and materials used for each tested groups.

Method	**Age**					
	Primary		**Young**		**Old**	
	Shear Bond Strength Mean ± SE(Mpa)					
Material	**All Bond 2**	**Optibond FL**	**All Bond 2**	**Optibond FL**	**All Bond 2**	**Optibond FL**
Sound	8.66±0.12d	7.75±0.13ef	10.69±0.24a	9.72±0.15 b	9.08±0.16c	8.53±0.10d
Carisolv	6.98±0.08g	6.57±0.10h	9.10±0.18 c	7.80±0.16ef	7.95±0.15e	6.43±0.09 h
Bur	5.55±0.11i	5.31±0.10i	7.53±0.10 f	6.97±0.18 g	6.52±0.10h	5.50±0.09i

Different letters mean significant differences; SE: standard error.

Table (5): Modes of Failure According to Dentin Substrates (in percentage).

Groups	**Modes of Failure**		
	Adhesive	**Cohesive within adhesive**	**Mixed failure**
Primary	75	20	5
Young	10	70	20
Old	55	40	5

The values resemble the percentages of occurrence that were approximated to the nearest sound number.

Table (6): Modes of Failure According to Methods of Caries Removal (in percentage).

Groups	**Modes of Failure**		
	Adhesive	**Cohesive within adhesive**	**Mixed failure**
Sound	20	70	10
Carisolv	30	45	25
Bur	27	40	33

Percentages of occurrence values were approximated to nearest sound number.

Table (7) Showed modes of Failure According to Bonding Agents (in percentage). Figure (1) Represented a histogram representing the mean shear bond strength of the interactions between methods of caries removal and bonding agents used in primary teeth dentin. Figure (2) represented a histogram representing the mean shear bond strength of the interactions between methods of caries removal and bonding agents used in young permanent teeth dentin. Figure (3) Represented a histogram representing the mean shear bond strength of the interactions between methods of caries removal and bonding agents used in old permanent teeth dentin.

Table (7)**:** Modes of Failure According to Bonding Agents (in percentage).

Groups	Modes of Failure		
	Adhesive	**Cohesive within adhesive**	**Mixed failure**
All Bond 2	26	68	6
Optibond FL	43	50	7

Percentages of occurrence values were approximated to nearest number.

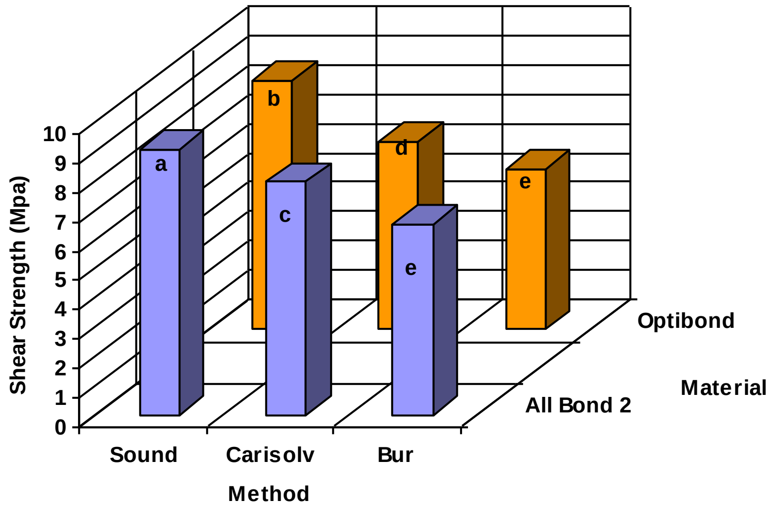

Figure (1)**:** A histogram representing the mean shear bond strength of the interactions between methods of caries removal and bonding agents used in primary teeth dentin.

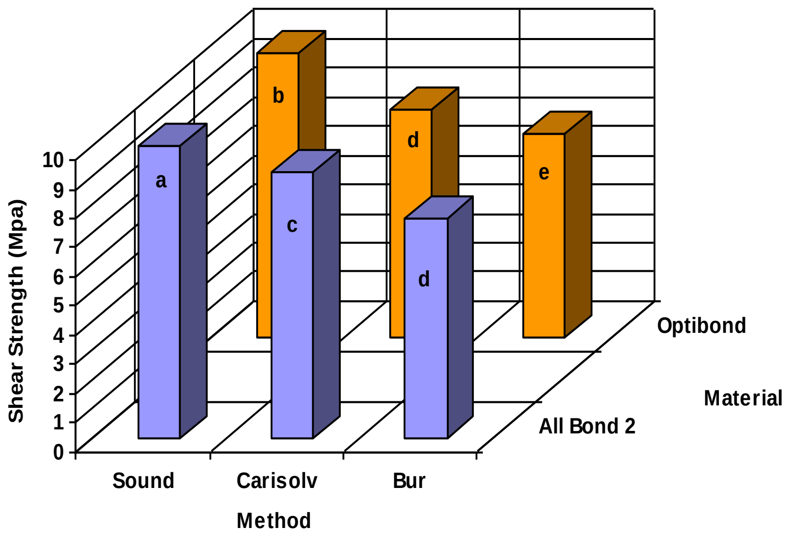

Figure (2): A histogram representing the mean shear bond strength of the interactions between methods of caries removal and bonding agents used in young permanent teeth dentin.

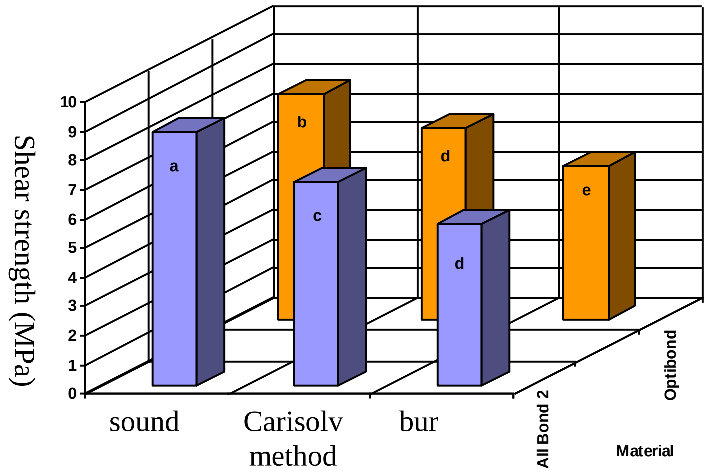

Figure (3): A histogram representing the mean shear bond strength of the interactions between methods of caries removal and bonding agents used in old permanent teeth dentin.

Mode of failure:

The debonded surfaces were examined using visual examination and a lens (X 20) magnification as shown in Table (5,6 and 7).

DISSCUSION

This study compared the shear bond strength between primary, young and old permanent teeth. There is generally a significant difference between primary and permanent teeth and between young and old permanent teeth. There is significantly higher bond strength with All Bond 2 than Optibond FL dentin adhesive and higher bond strength with Carisolv (chemomechanical method) than bur (mechanical method) compared with the sound teeth which have the highest value of bond strength. Several studies have compared the bond strength between primary and permanent dentin and the results are varied. They indicate: no significant difference of bond strength between primary and permanent dentin[6,7] or higher bond strength to primary dentin[8,9], and significantly lower bond strength to primary dentin[10,11,12], this result agree with the finding of the present study.

It was demonstrated that the hybrid layer is thinner in sclerotic dentin than in primary and young teeth dentin. Calcified deposits inside the dentinal tubules can prevent the formation of resin tags or diffusion of resin inside dentinal tubules and lateral channels so, less bond strength was found in old permanent teeth dentin in contrast to young permanent teeth dentin.[13]

The chemomechanical caries removal has no adverse effect on bonding of modern adhesive systems to dentin.[14,15]

The bond strength to caries–affected dentin after Carisolv removal was higher than the bond strength after bur removal, the mean values of the bond strength after Carisolv and bur removal were as follows: (8.4 $\pm$ 3.3 and 6.4 $\pm$ 5.3) Mpa respectively.[16]

Carisolv gel has shown a thicker demineralized layer than that obtained when rotary instruments was used and the interfibrillar spaces in conditioned dentin were greater in Carisolv–treated teeth compared with normal dentin and this was believed to be the reason for observing thicker hybrid layer.[17]

Another possible explanation of decrease bond strength of Carisolv–treated surface compared to normal dentin is the remnants of carious dentin, since Carisolv may not remove carious dentin completely in the clinical situation.

This region probably contains a significant amount of water, which may affect bonding of the more hydrophobic bonding systems and fracture modes.[4] Finally the type of the dentin (young, old, sclerotic, caries–affected, normal) and site (superficial and deep) have been reported to have an effect on the thickness of the hybrid layer and bond strength, which will affect the modes of fracture. Also, the type of caries (acute or chronic) may be associated with the thickness of hybrid layer created.[18-21]

CONCLUSION

Lower bond strength to primary dentin compared to permanent one and a significant difference in shear bond strength between primary and permanent dentin and the mode of caries removal influences bond strength to carious substrate.

Chemomechanical caries removal has no adverse effects on bonding to caries–affected dentin when modern bonding systems are used and old teeth dentin shows lower bond strength compared to young permanent teeth dentin.

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