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Original Research

Shear Bond Strength of Superficial, Intermediate and Deep Dentin *In Vitro* with Recent Generation Self-etching Primers and Single Nano Composite Resin

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Abstract:

Background: This *in vitro* study is intended to compare the shear bond strength of recent self-etching primers to superficial, intermediate, and deep dentin levels.

Materials and Methods: All teeth were sectioned at various levels and grouped randomly into two experimental groups and two control groups having three subgroups. The experimental groups consisted of two different dentin bonding system. The positive control group consisted of All Bond 2 and the negative control group was without the bonding agent. Finally, the specimens were subjected to shear bond strength study under Instron machine. The maximum shear bond strengths were noted at the time of fracture. The results were statistically analyzed.

Results: Comparing the shear bond strength values, All Bond 2 (Group III) demonstrated fairly higher bond strength values at different levels of dentin. Generally comparing All Bond 2 with the other two experimental groups revealed highly significant statistical results.

Conclusion: In the present investigation with the fourth generation, higher mean shear bond strength values were recorded compared with the self-etching primers. When intermediate dentin shear bond strength was compared with deep dentin shear bond strength statistically significant results were found with Clearfil Liner Bond 2V, All Bond 2 and the negative control. There was a statistically significant difference in shear bond strength values both with self-etching primers and control groups (fourth generation bonding system and without bonding system) at superficial, intermediate, and deep dentin. There was a significant fall in bond strength values as one reaches deeper levels of dentin from superficial to intermediate to deep.

Key Words: Self-etching primers, shear bond strength, Universal Testing Machine

Introduction

Adhesive restorations have been widely accepted for both anterior and posterior use in restorative dentistry. Patient's demands for esthetic restorations have caused a recent increase in the use of tooth colored restorative materials. To achieve clinical success with such restorations, good adhesion between restorative materials and tooth substrates is of crucial importance in order to ensure good marginal sealing, reinforcement of the tooth structure, and longer life of the restoration.

The adequate hybrid layer formation is believed to be essential to create a strong and durable bond between resin and dentin. It is very well understood that the density of dentinal tubules varies with dentinal depth and as well as the water content of dentin is lowest in superficial dentin and highest in deep dentin. This is probably because the amount of hypermineralized peritubular dentin increases at about the same rate as the amount of intertubular dentin decreases leaving average mineral content very similar, in superficial and deep dentin. The amount of collagen per unit volume of dentin decreases from superficial to deep dentin. This is probably due to the fact that deep dentin has larger tubules than superficial dentin and hence has less intertubular collagen than superficial dentin. The permeability of bonding substrates to monomers and the monomer diffusibility into the substrate are essential factors for the hybridization of resins in dental substrates. The permeability increases in an apical coronal direction and from superficial to deep dentin. While the permeability of inner radicular dentin is only 1:5 of the crown, this value descends to 1:20 in the outer radicular dentin. As of today no studies are available to indicate the effectiveness of new generation self-etching primers against superficial middle and deep dentin. The aim of this study was to test the hypothesis that there is a correlation between dentin depth permeability and bond strength of adhesive resins.

Materials and Methods

Forty-eight freshly extracted human molar teeth, non-carious and without having cracks were collected.

All teeth were sectioned at various levels using a carborundum disc:

Superficial dentin: Dentin within 0.5-1 mm of dentin-enamel junction

Intermediate dentin: Dentin 0.5-1 mm deeper to superficial dentin

Deep dentin: Dentin within 0.5 mm of the pulp chamber

The specimens were grouped randomly into two experimental groups having three sub groups consisting of four teeth each and two control groups having three subgroups consisting of four teeth each. The occlusal surfaces of teeth were ground on a water-cooled trimming wheel to prepare flat dentin surfaces (Figure 1).

Figure 1: Prepared Samples.

Dentin bonding agents:

1. Clearfil Liner Bond 2V (Kuraray) – light and self cure dental adhesive (Figure 2)
2. Xeno III (Dentsply) – Self etching primer (Figure 3)
3. All Bond 2 (Bisco) – Dual cured universal dental adhesive (Figure 4)
4. Filtek Z350 (3M) – Nanotechnology light cure composite (Figure 5)
5. Spectrum 800 (Dentsply) – Light curing device (Figure 6)

Figure 2: Clearfil Liner Bond 2V.

Group I	Xeno III
Group II	Clearfil liner Bond 2V
Group III	All Bond 2
Group IV	No Bonding Agent

Each group was subdivided into three subgroups of 4 teeth each:

Sub Group I	Superficial dentine
Sub Group II	Intermediate dentine
Sub Group III	Deep dentine

Experimental group

Group I	Xeno III+Nanocomposite	12 specimens
Group II	Clearfil liner Bond 2V+Nanocomposite	12 specimens

Control group

Group III	All Bond 2+Nanocomposite	12 specimens
Group IV	No bonding agent+Nanocomposite	12 specimens

Figure 3: Xeno III.

Methodology

Group I

Xeno III was applied to 12 specimens and left undisturbed for 20 s and the excess solvent was removed with a gentle stream of air. Light curing was done for 20 s using a visible light curing unit. After curing the bonding agent, nanocomposite resin was placed, and light cured layer by layer.

Group II

Clearfil Liner Bond 2V was used, the primer liquid A and B were mixed and applied onto 12 samples. It was then dried with the mild air stream and left for 30 s, the primer was not washed. Bonding agent was applied, and light-cured for 20 s. After curing the bonding agent, nanocomposite resin was placed.

Group III

All Bond 2 was applied to 12 samples; etchant was applied for 15 s and washed. It was then dried with mild air stream and primer was applied and left for 30 s. Then primer was not washed. Bonding agent was applied, and light-cured for 20 s.

After curing the bonding agent, nanocomposite resin was placed and cured according to manufacturer's instructions.

Group IV
No bonding agent was applied, and light-cured for 20 s. Nanocomposite resin was placed and cured according to manufacturer's instructions.

Figure 4: All Bond 2.

Figure 5: Filtek Z350 Composite.

Figure 6: Spectrum 800 Light Cure Unit.

All the 48 specimens were transferred to the Instron testing machine individually and subjected to shear bond strength study.

Results
According to the results analyzed:

- Comparing the shear bond strength values of Group I, II and Group III (positive control), All Bond 2 (Group III) demonstrated fairly higher bond strength values at different levels of dentin (Graph 1) ($P < 0.05$). Generally comparing All Bond 2 with the other two experimental groups revealed highly significant statistical results (Graph 1).
- At the superficial level with the All Bond 2, we could record a mean shear bond strength value of 37.34 MPa while at the intermediate and deep dentin shear bond strength value reduced substantially to 26.86 and 20.86 MPa respectively ($P = 0.007$) (Tables 1 and 2).
- With the Clearfil Liner Bond 2V, we could record shear bond strength values at the superficial up to 31.79 MPa while at intermediate and deep dentin level we could record only up to 18.73 and 15.99 MPa respectively ($P = 0.01$).
- With Xeno III the other experimental group, a self-etching primer, shear bond strength values at the superficial dentin was 25.02 MPa and at intermediate and deep dentin reduced down to 21.72 and 15.17 MPa respectively ($P = 0.038$) (Table 1).

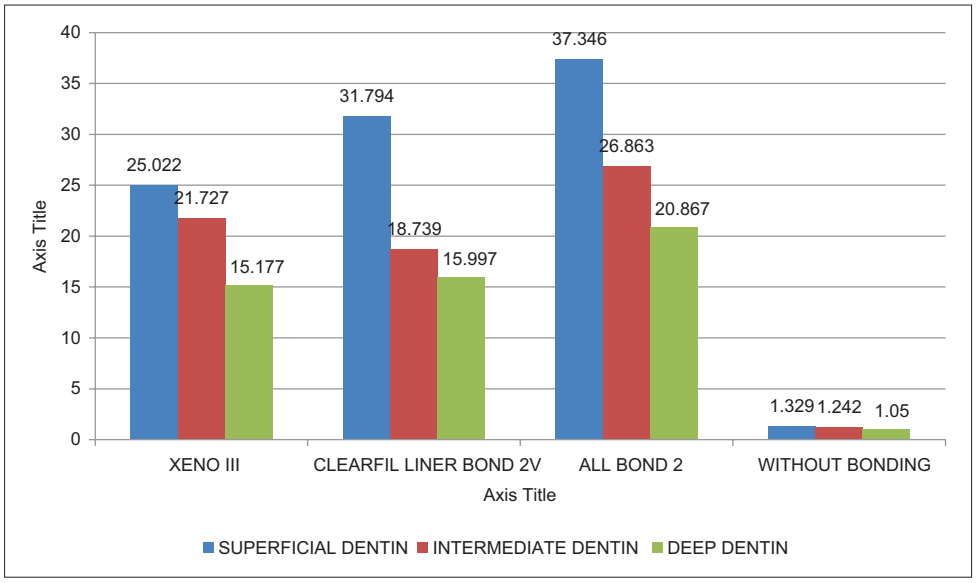
Table 1: Shear bond strength in MPa among different levels of dentin.

	N	Mean	SD	*H*	*P*
Xeno III					
Superficial dentin	4	25.0222	4.89495		*P*=0.038
Clearfil Loner 2V					
Intermediate dentin	4	21.7269	3.19814	6.27	
Deep dentin	4	15.1767	5.05068		
Superficial dentin	4	31.7944	7.96824		
Intermediate dentin	4	18.7389	1.04269		
Deep dentin	4	15.9972	1.96641	9.27	*P*=0.01 sig
All Bond 2					
Superficial dentin	4	37.3458	5.36945	9.92	0.007 hs
Intermediate dentin	4	26.8633	0.11087		
Deep dentin	4	20.8667	0.06573		
Without bonding agent					
Superficial dentin	4	1.3289	0.08887		
Intermediate dentin	4	1.2417	0.05000		
Deep dentin	4	1.0500	0.06573	8.58	0.014 sig

hs: Highly significant, sig: Significant

Table 2: Shear bond strength of bonding agent.

	Superficial dentin	Intermediate dentin	Deep dentin
Xeno III	25.022	21.727	15.177
Clearfil liner Bond 2V	31.794	18.739	15.997
All Bond 2	37.346	26.863	20.867
Without bonding	1.329	1.242	1.050



Graph 1: Comparison of shear bond strength.

Discussion

Adhesion to acid-etched enamel was proposed by Buonocore in 1955. Long-lasting adhesion between enamel and resin has been proven by *in vitro* studies and clinical researches for over five decades. However, bonding to dentin is far more challenging compared to enamel bonding of composite resin, which has a long track record. The enhanced bonding between resin and dentin was established by dentin hybridization. Basically, the hybrid layer formation creates the composite structure of resin, collagen and hydroxyapatite or the functionally graded material between the resin and the dentin. Dentin is a dynamic tissue. It represents a challenge as regards resin based adhesives while the bond strength of enamel has been studied extensively, bonding to dentin with the generation of bonding systems has Tagami *et al.* (1990)[1] attributed this either to differences in chemical composition or regional differences in wetness (dentin permeability). Thus there are several factors that may contribute to high coefficient of variation that is often reported in dentin shear bond strength studies.

Pashley *et al.* (1993)[2] studied the bond strengths to superficial, intermediate and deep dentin *in vivo* with four dentin bonding systems and demonstrated higher bond strengths in superficial dentin and progressively lower bond strengths in deep dentin.

Tao and Pashley (1988)[3] investigated shear bond strengths to dentin: effects of surface treatment, depth, and position. They demonstrated that there were significant differences in bond strengths at different depths of dentin after etching the surface but not if the smear layer was left undisturbed.

Tagami *et al.* (1990)[1] attempted to establish a relationship between dentin permeability and dentin depth and confirmed the results of the previous work on human dentin that permeability increases as dentin becomes thinner. This is possibly due to an increase in tubule diameter and increase in tubular dentin as dentin is thin toward the pulp chamber. The relationship between shear bond strengths of All Bond 2 system and self-etch primers against different levels of dentin depth provided interesting observations. There was a strong correlation between the All Bond 2 and self-etch primer group and dentin depth.

Suzuki and Finger (1988)[4] studied the efficacy of dentin bonding systems based on the site of dentin with reference to the observation of Causton that bond strengths to deep dentin were considerably lower than those to superficial dentin. This study has confirmed the observation of Causton that the efficacy of dentin adhesives depends on the dentin surface from superficial to deep dentin in the tooth tested. Different from etch and rinse adhesives, self-etch adhesives do not require a separate etching step as they contain acidic monomers that simultaneously condition and prime the dental substrate. Consequently, this approach has been claimed to be user-friendlier and less technique sensitive, thereby resulting in a reliable clinical performance though this appeared very product dependent. User friendlier because of shorter application time and less steps and less technique sensitive because no wet bonding but simple drying. Comparatively with the self-etch adhesives there is a lower incidence of post-operative sensitivity experienced by the patient. This should to a great extent be attributed to the less aggressive and thus more superficial interaction with the dentin leaving tubules largely obstructed with smear layer.

Van Meerbeek *et al.* (2011)[5] observed that at enamel, an etch and rinse approach using phosphoric acid remains the choice of preference since it not only guarantees the most durable bond to enamel but also seals and thus protects the more vulnerable bond to dentin against degradation. The most recent research investigated to which extent this compromised enamel bonding obtained with mild self-etch adhesives could

be attributed to enamel during cavity preparation. The lower bonding effectiveness of self-etch adhesives to enamel should be ascribed most likely in the first place to less potential for micro-mechanical interlocking but also to a lower chemical reactivity.

Triolo and Swift (1992)[6] in their *in vitro* study tested the shear bond strengths of nine third generation dentin bonding systems and concluded that bond strengths are generally less to deep dentin than superficial and intermediate dentin.

Pegado *et al.* (2010)[7] compared the effect of different bonding strategies on adhesion to deep and superficial dentin and concluded that bond strength obtained in superficial dentin was significantly higher than that in deep dentin for all adhesives tested. They further concluded that the bond strengths of dentin bonding agents at any depth is dependent on the area occupied by resin tags, the area of intertubular dentin that is infiltrated by the resin and the area of surface adhesion.

Van Meerbeek *et al.* (2011)[5] recommended that for further optimization of the self-etch approach, synthesis of functional monomers tailored to exhibit good chemical bonding potential following a mild self-etch approach. The approach appears to guarantee the most durable bonding performance at dentin provided that it deals adequately with the debris smeared across the surface by the bur. Micromechanical interlocking is still the best strategy to bond to enamel. Selective phosphoric acid etching of enamel cavity margins is therefore today highly recommended followed by applying a self-etch procedure to both the earlier etched enamel and un-etched dentin. Such mild self-etch adhesives should contain functional monomers with a high chemical affinity to hydroxyapatite.

Conclusion

In vitro investigation was conducted to determine the bond strength of superficial, intermediate and deep dentin with self-etching primers (Clearfil Liner Bond 2V and Xeno III) and fourth generation bonding system (All Bond 2) and single composite resin. The final conclusions were drawn:

- In the present investigation with the fourth generation (All Bond 2), higher mean shear bond strength values were recorded compared with the self-etching primers (Clearfil Liner Bond 2V and Xeno III).
- When intermediate dentin shear bond strength was compared with deep dentin shear bond strength, statistically significant results were found with Clearfil Liner Bond 2V, All Bond 2 and the negative control.
- There was a statistically significant difference in shear bond strength values both with self-etching primers and control groups (fourth generation bonding system and without bonding system) at superficial, intermediate and deep dentin.
- There was a significant fall in bond strength values as one reaches deeper levels of dentin from superficial to intermediate to deep.

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