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Original Research

An Evaluation and Comparison of Shear Bond Strength of Two Adhesive Systems to Enamel and Dentin: An *In Vitro* Study

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Abstract:

Background: To evaluate and compare shear bond strength of the two generations (6th generation- Clearfil SE Bond [Kuraray Co.] Osaka, Japan), (7th generation - Clearfil S3 Bond [Kuraray Co.] Osaka, Japan) of adhesive systems to non-carious surfaces of enamel and dentin in both maxillary and mandibular anterior teeth.

Materials and Methods: Total 60 teeth were selected for the study. They were assigned to Group A and B of 30 teeth each. Groups A and B were then randomly divided into two subgroups of 15 teeth each. The teeth were embedded in self-curing acrylic resin block up to the cervical level, with a labial surface positioned for surface treatment. Bonding agents were used according to manufacturers' direction. All specimens were bonded with composite resin (Z-350 XT hybrid composite resin system. A 1 shade 3M ESPE) and subjected to shear bond strength testing, using Instron universal testing machine.

Results: Shear bond strength of Group A1 is 26.82 MPa, for Group A2 - 24.68 MPa and for Group A3 - 20.71 MPa. Shear bond strength of Group B1 is 27.09 MPa, for Group AB - 26.42 MPa and for Group B3 - 22.46 MPa. Statistical analysis was done by applying Student's unpaired *t*-test, one-way ANOVA analysis with post-test (Tukey-Kramer multiple comparison tests), and Fisher's exact *t*-test.

Conclusion: Within the limitations of this *in vitro* study it can be concluded that Clearfil SE Bond resulted in the higher mean shear bond strength for dentin and for enamel compared with other group.

***Key Words**: Dentin bonding agents, self-etch adhesives, shear bond strength*

Introduction

Dentistry, as a science has witnessed so many rapid advances is the last century that the earlier restorative procedures have undergone marked variances over a period of time. It has become vital to understand and appreciate the biological, physical, and chemical principles that form the foundation of the clinical application of dental materials to avoid the misuse and abuse of the rapidly evolving dental materials, a goal which in the long run will be beneficial to the patient.[1]

The fundamental principle of adhesion to tooth substrate is based on an exchange process by which inorganic tooth material is exchanged for synthetic resin.[2]

This process involves two phases. One phase consists of removing calcium phosphates by which micro porosities are exposed at both the enamel and dentin tooth surface. The other hybridization phase involves infiltration and subsequent *in situ* polymerization of resin within the created surface microporosities.

This results in micromechanical interlocking which is primarily based on mechanisms of diffusion. While micromechanical interlocking is believed to be a prerequisite to achieving good bonding within clinical circumstances, the potential benefit of additional chemical interaction between functional monomers and tooth substrate components has recently gained new attention.[2]

In current times, development of new products is occurring at an unprecedented rate. Dentin adhesives are currently available as three-step, two-step, and single-step systems, depending on how the three cardinal steps of etching, priming, and bonding to tooth substrate are accomplished.[3]

The aim of this *in vitro* study is to evaluate and compare the shear bond strength of two adhesive systems to enamel and dentin.

Materials and Methods

Various materials used in this study are listed in Table 1. Non-carious intact human permanent maxillary and mandibular anteriors were included in this study. Carious, fractured, hypoplastic teeth were excluded.

Operative procedure

Total 60 teeth were selected for the study. They were assigned to Groups A and B of 30 teeth each. The enamel surfaces of Group A were ground with wet silicon carbide paper to make a flat enamel surface. The teeth of Group B were then ground on a model trimmer to expose adequate underlying dentinal surface.

The teeth were embedded in self-curing acrylic resin block up to the cervical level with a labial surface positioned for surface treatment and composite bonding.

The samples were stored in distilled water for 24 h at room temperature. Groups A and B were then randomly divided into two subgroups of 15 teeth each.
Group A1: Clearfil SE Bond (Kuraray Co.) Osaka, Japan.
Group A2: Clearfil S3 Bond (Kuraray Co.) Osaka, Japan.
Group B1: Clearfil SE Bond (Kuraray Co.) Osaka, Japan.
Group B2: Clearfil S3 Bond (Kuraray Co.) Osaka, Japan.

Bonding agents were used according to manufacturers' direction. All specimens were bonded with composite resin (Z-350 XT hybrid composite resin system. A 1 shade 3M ESPE) using the Teflon molds having a dimension of 2 mm × 2 mm and subjected to shear bond strength testing, using Instron universal testing machine.

Results

Table 2 shows the distribution of mean and standard deviation (SD) values of maximum load (N) and shear bond strength (MPa) in Group A1 and A2. Shear bond strength of Group A1 - 24.68 MPa and for Group A2 - 20.71 MPa.

Table 3 shows distribution of mean and SD values of maximum load (N) and shear bond strength (MPa) in Group B1 and B2. Shear bond strength of Group B1 - 26.42 MPa and for Group B2 - 22.46 MPa.

One-way ANOVA analysis with post-test (Tukey-Kramer multiple comparison tests) for comparison of maximum load (N) and shear bond strength (MPa) in Group A (A1 and A2) and Group B (B1 and B2). The Fisher's exact *t*-test i.e., *F* value were determined at 5% ($P = 0.05$) and 1% ($P = 0.01$) level of significance.

Discussion

The main objective of bond strength test is to establish a demonstrative value for how strong the bonding of an adhesive system is to dental hard tissues when composites are bonded. It has been stated that composite bond strength should be as high as 17-20 Mpa to resist this shrinkage stress.[4]

The shear bond strength of a 6th generation bonding agent versus 7th generation bonding agent is compared in the present study. There are reasons for the superior performance of two-step self-etch systems:

- The solvent present has low concentration[5]
- The hydrophilicity is low[5]
- Polymerization is to a greater degree[5]
- The underlined dentin undergoes limited etching and demineralization over a longer period of time.[6]

On the basis of pH of solution, the actual interaction depth of self-etch adhesives at dentin differs from a few hundreds of nanometers following an ultra-mild self-etch approach (pH >2.5), which sometimes is being referred as nano-interaction,[7] an interaction depth of around 1 µm for mild self-etch approach (pH = 2), an interaction depth between 1 and 2 µm for an intermediately strong self-etch approach (pH between 1 and 2) and to an interaction of several micrometers deep for a strong self-etch approach (pH <1).[8]

Table 1: Materials used for study.

Adhesive systems	Description	Manufacturer
Clearfil SE Bond (6th generation)	Primer: HEMA, hydrophilic dimethacrylate, MDP, N,N-diethatol-p-toluidine, D,L-camphorquinone, water Adhesive: Silanated colloidal silica, Bisphenol A diglycidyl-methacrylate, HEMA, MDP, hydrophobic dimethacrylate, N,N-diethatol-p-toluidine, D,L-camphorquinone	Kuraray Co. Osaka, Japan
Clearfil S3 Bond (7th generation)	MDP, Bis-GMA, HEMA, hydrophilic dimethacrylate, camphorquinone, ethyl alcohol, water, silanated colloidal silica	Kuraray Co. Osaka, Japan

MDP: 10-methacryloyloxydecyl dihydrogen phosphate, HEMA: Hydroxyethyl methylmethacrylate

Table 2: Distribution of mean values of maximum load (N) and shear bond strength (MPa) in Group A1 and A2.

Mechanical properties	Group A (ground with wet silicon carbide paper to make a flat enamel surface) Mean±SD	
	Group A1 (6th generation dentin bonding agent)	Group A2 (7th generation dentin bonding agent)
Maximum load (N)	98.61±16.23 (46.24-118.56)	83.02±6.59 (68.11-92.79)
Shear bond strength (MPa)	24.68±4.05 (11.68-29.19)	20.71±1.69 (17.02-23.33)

SD: Standard deviation

Table 3: Distribution of mean and SD values of maximum load (N) and shear bond strength (MPa) in Group B1 and B2.

Mechanical properties	Group B (Model trimmer to expose adequate underlying dentinal surface) Mean±SD	
	Group B1 (6th generation dentin bonding agent)	Group B2 (7th generation dentin bonding agent)
Maximum load (N)	105.38±9.75 (92.61-121.04)	89.56±8.56 (74.48-104.23)
Shear bond strength (MPa)	26.42±2.26 (23.15-30.26)	22.46±2.30 (18.23-26.19)

SD: Standard deviation

Deep mineralization equivalent to phosphoric acid etching is caused by high acidity for strong self-etch adhesives.[9] A substantial number of hydroxyapatite crystals remain within the hybrid layer when the mild self-etch adhesive dissolves the dentin surface only partially.[9]

The functional monomers are delivered into the hybrid layer by the organic solvents, ethanol and acetone which act as carriers and water chasers. Acetone is more volatile than ethanol because acetone has vapor pressure 200 mm Hg at 25°C where else ethanol has 54.1 mm Hg.[10]

Two bottles are involved in two-step, etching and priming and then bonding. To allow deeper penetration, the all in one adhesive needs to be acidic, and the formulations have become more hydrophilic.[5]

In the present study, Clearfil S3 (7th generation bonding agent) showed the lower shear bond strength value as compared to Clearfil SE (6th generation bonding agent).

The reason for low strength may be due to the fact that a very thin dentin hybrid layer is formed. This causes poor infiltration of resin monomer into demineralized dentin which leaves nano-spaces in the hybrid layer. This layer acts as a semipermeable membrane and may allow water to leach into the bonding resin resulting in swelling and plasticization.[11]

Another reason for the low bond strength of Clearfil S3 may be because of porosities (or blisters) occurring at the bonding interface because these simplified all-in-one adhesives behave as semipermeable membranes.

Generally, reduced immediate bond strength is recorded in comparison to that measured for multi-step adhesives. In addition, any kind of aging demonstrates a lower long-term bonding effectiveness. Moreover, numerous studies report on increased interfacial nanoleakage.

Etching, priming, and bonding both hydrophilic and hydrophobic monomers are combined in one step adhesives and are blended with a relatively high concentration of solvent to keep them in solution. To enable self-etching activity, water is also essential as an ionization medium. Serious limitations of all in one adhesive are: Continued demineralization of the adjacent dentin structure in the tubules and incomplete polymerization.[10]

The newer generation of "most simple to use one-step adhesives" is an intricate mixes of hydrophilic and hydrophobic components. These "difficult" mixtures should so far be considered as "compromise" materials that have consequently been documented with several shortcomings.[12]

Water is the solvent in this adhesive. After application of primer/adhesive, the solvent is kept within the interfacial structure. Such solvent surplus will directly weaken the bond integrity due to water sorption, provide channels for nanoleakage or may affect polymerization of the infiltrated monomers. The resultant interfacial structure becomes hydrophilic and thus, more prone to hydrolytic degradation.[2]

Conclusion

Currently, there are several adhesive systems available but little is known about their capacity to adhere to dental hard tissues. Since bond strength testing is used as a screening tool to help understand and predict the clinical behavior of adhesives, this *in vitro* study used to evaluate and compare the shear bond strength to enamel and dentin achieved with two different adhesive systems. Within the limitation of this *in vitro* study, the shear bond strength of Clearfil SE Bond is significantly higher compared to that of Clearfil S3 Bond on ground enamel and dentin. Further, long-term clinical evaluations are necessary to confirm and decide whether if these systems can be seen as a good and adequate alternative to 5th generation adhesives.

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