Original Article

To compare and evaluate the shear bond strength of sixth-, seventh-, and eighth-generation dentin bonding agents: An *in vitro* study

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Abstract

Context: Bonding agents have developed from a multistep bonding process to simplification, i.e. self-etch and single bottle system.

Aims: The aim of this study is to compare and evaluate the shear bond strength (BS) of sixth-, seventh, and eighth-generation dentin bonding agents.

Settings and Design: This was an *in vitro* study.

Materials and Methods: Three sets of 75 permanent mandibular premolars that had been removed were chosen. A universal testing machine operating at a cross-head speed of 1 mm/min. examined the shear BS of the samples after they had been stored in deionized water for an entire day.

Statistical Analysis Used: "One-way analysis of variance and Bonferroni test *post hoc* analysis" were used for statistically analyzing the data.

Results: The sixth-generation group shear BS was noticeably stronger.

Conclusions: The sixth-generation dentin bonding agent demonstrated the greatest mean shear BS to dentin because the solvent present had low concentration and low hydrophilicity, polymerization was more extensive, and dentin underlined underwent limited etching and demineralization over an extended period of time.

Keywords: Composite; shear bond strength; universal testing machine

INTRODUCTION

The development of enamel bonding in response to the growing need for restorative and nonrestorative cosmetic procedures, along with the addition of fluoride, has revolutionized the field of operative dentistry.[1]

Modern adhesive dentistry was founded by Buonocore, who in 1955 discovered that enamel's surface could be modified with acids to increase its receptiveness to adhesion.[2]

Because of the structure and makeup of enamel, bonding to enamel is a safe and straightforward process. Conversely, the tubular nature of dentin (which contains the cytoplasmic extensions of odontoblasts) and its composition of water and organic compounds make attaching to dentin difficult.[3] The main issue with dental adhesives is their poor adhesion to 2 distinct surface types.[4]

Over generations, dental adhesive systems undergone variations in their mechanism of action, chemistry, and

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number of steps, their clinical efficiency, application, and techniques.[5] Modern adhesives have streamlined the application process and reduced the number of clinical stages for simplicity of usage.[6] From a multistep bonding procedure, bonding agents have evolved to simpler methods including self-etching and single-bottle systems. A perfect bonding agent would stick to both enamel and dentin, have a strong enough bond, and be biocompatible. The development of nanocomposites and nanoadhesives containing fillers at the nanoscale is a result of advancements in nanotechnological dentistry.[7] Self-etching systems consist of aqueous mixtures of acidic functional monomers, generally phosphoric acid esters with a pH higher than phosphoric acid. Currently, self-etching approach of dental adhesives uses acidic resin monomers that allow simultaneous de-mineralization and infiltration of the partially desmineralized substrate with resin monomer.[8] There are various dentin bonding systems available with their pros and cons.

MATERIALS AND METHODS

Seventy-five removed human mandibular premolars were chosen for this investigation. Intact crown and root, orthodontic extractions, and periodontal extractions were the inclusion criteria. Teeth exhibiting hypoplasia, fracture, fluorosis, and caries were not included [Figure 1a].

The samples were polished using a pumice and water slurry after being cleansed with saline [Figure 1b]. Teeth were trimmed of their roots, and only the coronal section was imbedded in cold cure acrylic resin using a specially designed 2 cm × 2 cm cylindrical metallic mold [Figure 1c].

The teeth were positioned horizontally, and each tooth buccal surface was decreased by 1.5 mm utilizing a #245 carbide bur (SS White) and a high-speed handpiece while continuously misted with water. Three groups of 25 specimens each were randomly selected from the prepared samples [Figure 1d]. These groups were as follows:

- Group 1: "Sixth-generation dentin bonding agent (One Coat, Coltene, Whaledent) [Figure 2a]
- Group 2: Seventh-generation dentin bonding agent (One Coat 7.0, Coltene, Whaledent) [Figure 2b]
- Group 3: Eighth-generation dentin bonding agent (Futurabond DC, Voco, Germany) [Figure 2c].

The exposed tooth surface was dried and then etchant (Frost) was applied for 15 s and then it was rinsed and blot dry. A bonding agent was applied onto the surface with a microbrush and light-cured as per the manufacturer's instructions. The composite resin Polofil Supra (Voco) was placed in 2-layer increments and light-cured (VLC, Ivoclar) for 40 s. Each composite cylinder was cured for an additional 40 s after the removal of the mold. All specimens were stored in distilled water for 24 h before shear bond testing."

The u.t.m. was utilized to mount the specimens. It applied force in a compressive mode "at a crosshead speed of 1 mm/min to each specimen using a blade positioned parallel to the adhesive-dentin contact. At the point where the composite and dentin" meet, the shearing blade of the horizontally oriented composite cylinder is kept at a 90° angle. Every ready specimen was loaded till it broke. The amount of shear power required to debond the specimen was recorded [Figure 2d].

Statistical analysis

The mean values of dentin-bonding agents from the sixth, seventh, and eighth generations were compared using a one-way analysis of variance. To look at group differences, the Bonferroni test *post hoc* analysis was employed. sixth-, seventh-, and eighth-generation dentin bonding agents exhibit a substantial variation in shear bond strength (BS) at the level of 0.05, given the restrictions of this experiment.

RESULTS

Table 1 and Graph 1 shows that sixth-generation group shear BS was noticeably stronger.

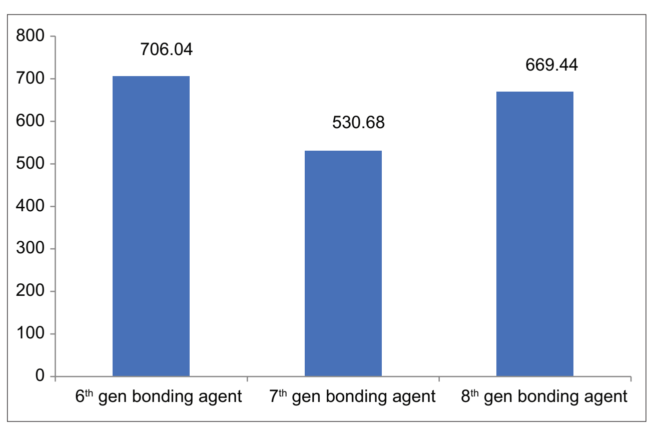
DISCUSSION

In 1955, Buonocore gave teeth acid treatment to make

Table 1: Comparison between Mean, Standard Deviation, Bonferroni Test of 6th, 7th, and 8th Generation Dentin Bonding Agents

	n	Mean	SD	SE	95% CI for mean	
					Lower bound	Upper bound
6th-generation dentin bonding agent	25	706.04	136.298	27.260	649.78	762.30
7th-generation dentin bonding agent	25	530.68	149.467	29.893	468.98	592.38
8th-generation dentin bonding agent	25	669.44	254.926	50.985	564.21	774.67
Total	75	635.39	200.324	23.131	589.30	681.48

SD: Standard deviation, SE: Standard error, CI: Confidence interval



Graph 1: Illustrating that there was a significant difference in 6th, 7th, and 8th-generation dentin bonding agents

the surface more amenable to adhesion.[8] Acid etching increases the surface-free energy of enamel by converting its smooth surface to an uneven one. By means of capillary action, a fluid resin-based substance seeps into the irregularly etched surface when it is applied. The substance becomes entangled with the enamel surface when the monomers in it polymerize. The creation of resin micro tags on the enamel surface is the basic process underlying the adhesion between resin and enamel.[1]

Self-etch approaches are divided into two categories: one-step or two-self-application processes. They are divided into three groups based on how acidic they are mild, moderate, and aggressive.

Dentin is only demineralized to a depth of 1 μm in a mild self-etch method, leaving any remaining hydroxyapatite adhered to collagen. Enough surface porosity is produced to enable hybridization to produce micro-mechanical interlocking.[5]

In contrast to strong self-etch or the etch-and-rinse method, the hybrid layer thickness in moderate self-etch is substantially reduced. Therefore, the binding strength of mild self-etching adhesives is stronger.[5]

Lower acid concentrations are recommended by Gwinnett and Buonocore because they avoid the production of precipitate, which could impede adhesion.[9] Researchers: Silverstone *et al.* discovered that phosphoric acid applications ranging from 30% to 40% produced enamel surfaces that were retentive.[10]

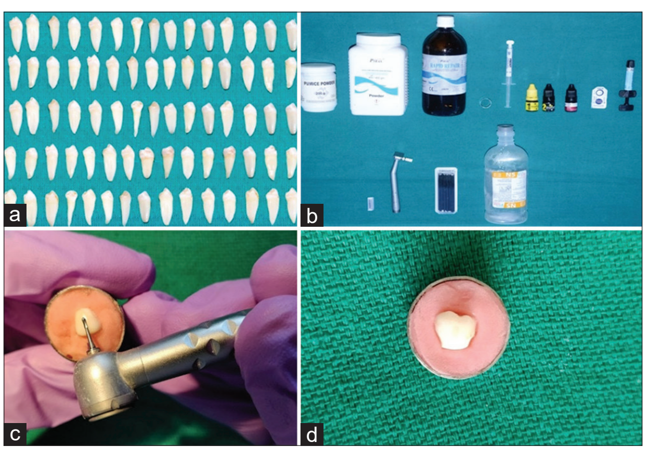


Figure 1: (a) Extracted mandibular premolars, (b) Armamentarium from left to right- Pumice Powder, Cold Cure Resin, Metallic Mould, Etchant, Sixth Generation Bonding Agent (One Coat), Seventh Generation Bonding Agent (One Coat 7.0), Eighth Generation Bonding Agent (Futurabond DC, Voco), Composite Resin, #245 Carbide Bur, Airrotor, Applicator Tips, Normal Saline, (c) Cavity Preparation, (d) Prepared Sample

The process of exchanging inorganic tooth material with synthetic resins is the foundational idea of bonding to the dental substrate. There are 2 phases to this process: The 1st includes removing the Ca+ phosphate, which exposes the microporosities on the surfaces of the dentin and enamel.[11]

The 2nd stage, known as the hybridization phase, entails the penetration of resin into the surface microporosities that are then generated, followed by *in situ* polymerization.

This leads to a mechanism of diffusion-based micromechanical interlocking.[11] The performance of dentin bonding has increased despite the fact that adhesion to dentin is not as dependable as adhesion to enamel. Previous multistep systems had application techniques that were more intricate, time-consuming, and technique-sensitive. There are universal adhesive methods available today that can adhere to porcelain, metal, amalgam, enamel, and dentin.[11]

Evaluating BS primarily aims to determine how effectively a bonding agent adheres to the hard structure of the tooth. The goal of recent developments in dentin bonding agents is to reduce application time and improve bonding quality.[12]

The adhesive ability and shear BS of restorative/adhesive compounds are evaluated using a universal testing machine.[13]

A "few variables that impact the *in vitro* dentin BS test include tooth type and age, dentin mineralization level, the dentin surface being bonded, shear/tensile BS test type, storage medium, relative humidity" in the substrate environment, testing procedure complexity, system manipulation sensitivity, and replacement material (composite).[14]

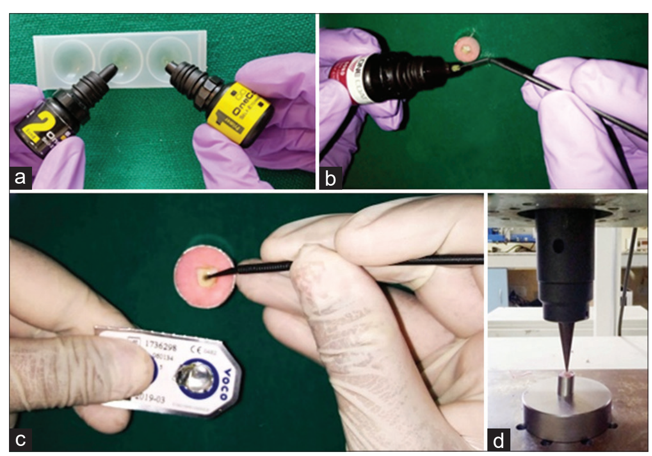


Figure 2: (a) Application of Sixth Generation Bonding Agent, (b) Application of Seventh Generation Bonding Agent, (c) Application of Eighth Generation Bonding Agent, (d) Universal Testing Machine

"Gangurde *et al*. discovered that in an *in vitro* study, the Excite dentin bonding agent showed the greatest shear BS when compared to Single Bond and Prime and Bond NT."[15]

The "tensile BS of UniFil Bond and iBond were evaluated in an *in vitro* study conducted by Chopra *et al.* The results showed that Unifil Bond (Multibottle system–sixth generation type I) outperformed iBond (Single Bottle System–seventh generation)." Reduced contraction of polymerization may be the cause of this. Additionally, a low interfacial stress was indicated by the configuration factor of 0.33.[2]

In a study published in 2015, Kamble *et al.* assessed the tensile BS of dentin bonding agents from the sixth, seventh, and eighth generations (Adapter SE plus), and concluded that the dentin adhesives from the eighth generation (Futurabond DC, Voco) demonstrated better tensile BS than those from the sixth and seventh generations. This could be attributed to the dentin adhesives nano-sized cross-linking fillers.[7]

In the present study, three generations of dentin bonding agents were examined in this study: One Coat, Coltene, and Whaledent, which is the sixth generation; One Coat 7.0, Coltene, and Whaledent, which is the seventh generation; and Futurabond DC, Voco, Germany, which is the eighth generation. Comparing sixth-generation dentin bonding agents (One Coat, Coltene, Whaledent) to seventh- and eight-generation adhesives, this study found that the former had the highest mean shear BS. The findings of our study indicate that sixth-generation adhesives outperformed seventh and eighth-generation bonding agents ($P < 0.004$). This could most likely be due to the low concentration and hydrophilicity of the solvent present, as well as the increased degree of polymerization and limited etching and demineralization of the underlined dentin over an extended length of time.[16]

Contrary to these findings, several studies claim that the single-bottle approach outperformed the two-step self-etch system. Yaseen, Subba Reddy (2009)[17] found that the shear BS of permanent teeth was highest with the seventh generation (Clearfil S3) bonding agent and lowest on primary teeth with the sixth generation (Contax) bonding agent.[7] In comparison to sixth-generation (Adaper SE plus) bonding agents, Nair *et al*. found that seventh-generation (Adaper Easy one) bonding agents had a stronger shear bond.[5]

Factors influencing the *in vitro* BS to dentin include tooth type and age, degree of dentin mineralization, dentin surface being bonded, type of BS test (shear/tensile), storage medium, relative humidity of the substrate environment, complexity of testing procedures, sensitivity of manipulating these systems, and composite restorative material.[14]

CONCLUSIONS

Within the limitations of this study, it can be concluded that sixth generation showed significantly higher mean shear BS to dentin than eighth-generation adhesives followed by seventh-generation adhesives.

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Conflicts of interest

There are no conflicts of interest.

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