Original Article

Comparative Evaluation of Shear Bond Strength of Seventh- and Eighth-generation Dentin Bonding Agent between Lithium Disilicate Veneer and Natural Tooth: An *In Vitro* Study

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Abstract

Background: Improvements in the chemical formulation of dentin bonding agents from no etch to total etch (fourth- and fifth-generation) to more recent self-etch systems (sixth-, seventh-, and eighth-generation) have led to a revolution in dentistry, placing these adhesives on the front page. This study, compares the shear bond strength of seventh- and eighth- generation bonding agents between lithium disilicate veneers and natural teeth. **Materials and Methods:** Twenty extracted premolars were prepared to be restored with lithium disilicate veneers. The specimens were randomly divided into two groups: Group A (seventh- generation) and Group B (eighth-generation) where seventh- and eighth-generation bonding agents were, respectively, applied on the prepared teeth surfaces in each group on which lithium disilicate veneers were luted with resin cement. All the specimens were subjected to ageing for 500 cycles replicating 45 days of intraoral use. Ageing was done at 5°C and 500°C temperatures. Shear load was applied at 0.5 mm/min until bonding failure occurred following which bond strength was calculated using a universal testing machine. The result was tabulated and statistically analyzed. **Results:** The result revealed that there was a statistically significant difference in the value of shear bond strength in two groups. **Conclusion:** The eighth-generation bonding agent showed higher shear bond strength when compared to seventh-generation bonding agent.

Keywords: Bonding agent, Laminate veneers, Thermocycling, Shear bond strength.

Introduction

Over the last couple of decades, increased focus on esthetics has led to a greater use of bonded restorations in dentistry. Direct composite veneers used to cover-up the unaesthetic form and color of the teeth are susceptible to discoloration, marginal fractures, and low wear resistance thereby questioning the longevity of the direct technique. On the other hand, porcelain veneers result in superior aesthetic quality, longevity, and require minimal tooth preparation. The success of this type of restoration is greatly determined by the strength and durability of the bond formed amongst three different components of bonded veneer complex, which includes enamel surface, luting resin, and the porcelain veneer.[1]

In tune with the growing demands of adhesive restorations, dentin bonding systems have also evolved in terms of improved bond strength and reduced technique sensitivity. Dentin bonding agents have advanced from the old standard-etch and rinse fifth-generation adhesives to the present single bond universal adhesives. Seventh-generation self-etch system offers an etchant, primer and adhesive all in one bottle, which reduces the technique sensitivity associated with the procedure, thereby decreasing the time required for the same. It is hydroxyethyl methacrylate (HEMA) free while eighth-generation bonding agent contains the HEMA. Pashley *et al.* stated that HEMA makes an excellent adhesion promoting monomer by enhancing wetting of dentin that significantly improves the bond strength thereby reducing microleakage.[2]

The adhesives with nano particles prevent agglomeration of the particles and produce high dentin bond strength, high stress absorption, longer shelf life, durable marginal seal, and release of fluorides. The nano filled dentin adhesives

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are available as eighth-generation dentin bonding agents. Furthermore, some eighth-generation bonding agents have fluoride releasing property as well.[3] In the light of these developments, the present *in vitro* study was undertaken to investigate and compare the bonding efficacy of seventh- and eighth- generation bonding agents between lithium disilicate veneers and natural teeth.

Materials and Methods

Twenty sound maxillary and mandibular premolars extracted for orthodontic purpose were collected. Non-carious and unrestored teeth, without any dental anomalies, were included in this study, while teeth with dental anomalies, caries or any restorations were excluded from the study. The extracted teeth were cleaned and stored in distilled water. The teeth were embedded vertically into self-cure acrylic (Ashvin) resin block up to the cemento-enamel junction [Figure 1]. The teeth were randomly divided into Group A and Group B with 10 teeth in each group.

The amount and configuration of tooth preparation for all the specimens were standardized using a putty index. The index was prepared by kneading, half a scoop of base of elastomeric putty impression material (Aquasil) with its catalyst paste, and was adapted over the tooth to be prepared. Once set, index was removed and cut into a labial and lingual half with a bard parker blade.

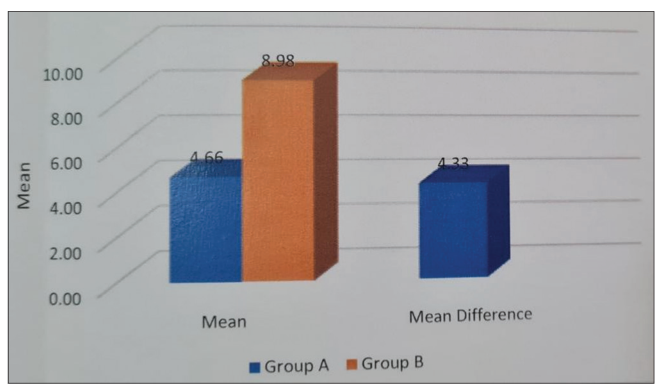
The buccal surface of each tooth was prepared by placing depth orientation grooves using a depth marker diamond bur in two planes: One, parallel to the gingival half of the tooth and another following the incisal contour. The surface to be prepared was marked with an indelible pencil. The specimen was prepared without exceeding the depth orientation grooves to provide a flat enamel surface area of approximately 0.5 mm after finishing and polishing. For standardization, all specimens were evaluated using the putty index.

For the fabrication of lithium disilicate veneer, a wax pattern was prepared using direct technique and invested in Starvest soft-3 investment (Dentsply Sirona Pvt Ltd, North Carolina, USA). The investment and an ingot of IPS E-MAX press (Celtra press, Dentsply Sirona Pvt Ltd, North Carolina, USA) were then transferred to the furnace and automatically pressed. A 0.5 mm thick lithium disilicate veneer was obtained which was subjected to finishing and polishing procedures.

The lithium disilicate veneer was etched with 10% hydrofluoric acid (Angelus, The Angelus corporation, Waukesha County, USA) for 20 s, washed, dried, and silanized (Angelus, The Angelus corporation, Waukesha County, USA) for 1 min. The seventh- (GC SOLARE U, GC Corporation, Tokyo, Japan) and eighth- (GC G- Premio bond, GC Corporation, Tokyo, Japan) generation bonding agent was applied on the prepared teeth surface in Group A and B, respectively, according to the manufacturer's instructions. Each specimen was cured with high intensity curing light (Woodpecker India Pvt. Ltd, Delhi, India) for 20 s. The luting agent (Variolink light cure cement,lvoclar Vivadent Ltd Co, Schaan, Germany) was applied on the internal treated surface of the veneer which was placed on the prepared tooth followed by tac curing for 2 s. Excess cement was removed from the margins. High intensity light was used to cure the luting agent for 40 s.

Figure 1: Prepared specimens embedded in resin block

Figure 2: Testing of specimen using universal testing machine



Graph 1: Graphical representation of comparison of mean shear bond strength in two groups

All the prepared specimens were stored in 37°C distilled water for 24 h. The specimens were then subjected to ageing in

Table 1: The intergroup comparison of mean shear bond strength

Group	N	Mean	Standard deviation	Standard error mean	Mean difference	*P* value
A	10	4.66	0.75	0.23663	4.328	<0.001**
B	10	8.98	1.61	0.50919		

**Highly significant

artificial saliva (100 mL of 0.34 g monopotassium phosphate, 0.44 g of disodium phosphate, 0.5 g of potassium bicarbonate, 0.58 g of sodium chloride, 0.5 g of citric acid, and 0.22 g of calcium chloride)[4] for 5000 cycles replicating 45 days of intraoral use at 5°C and 500°C temperatures. Shear bond strength test was then performed using a universal testing machine [Figure 2]. Shear load was applied at 0.5 mm/min until bonding failure occurred following which bond strength was calculated in megapascals (Mpa), where the applied force was divided by the bonding area (mm^2). The results were statistically analyzed using Kolmongrow–Smirnow test.

Results

In this study, the shear bond strength of seventh- and eighth- generation bonding agent was determined. The shear bond strength for both the groups [Table 1]was measured using computerized universal testing system in megapascals and the data were analyzed using SPSS version 23. To assess the normality of distribution of data, Kolmongrow–Smirnow test was done.

For intergroup comparison of data, descriptive and independent t-test were done. The *P* value was kept at <0.05 [Graph 1].

Discussion

Restorative dentistry has often demanded removal of sound tooth structure to provide large undercuts to get retention and stabilization of restoration, thereby compromising the life of tooth.[2] The objectives of restorative dentistry have constantly evolved with time due to the development of dentin bonding agents with the property of adherence to tooth structure by both micro-mechanical and chemical means.

Self-etching adhesives gained popularity as sixth- generation dentin bonding agents. Noteworthy feature of this material was the acidic primer that eliminated the acid etching step. Apart from simplification of three-step to two-step, the rationale behind this system was to superficially demineralize dentine and simultaneously penetrate it with monomers that could be polymerized. The seventh- generation self-etch system combines an etchant, primer, and adhesive in one bottle which eliminates separate etching, rinsing, and mixing thereby reducing technique sensitivity and thus are time saving. One of the most recent novelties is the introduction of dual cured (light- and self-cured) eighth- generation dentin bonding agent. It is a new single bottle delivery system which prevents solvent evaporation, a common problem in a variety of other bonding systems. This material contains polyfunctional adhesive monomers as phosphoric acid modified methacrylate esters. These acid esters, when mixed with water, produce a favorable low pH value of 1.4 when compared to unfavorable higher pH values of 1.8 and 2.4 of seventh- and sixth-generation dentin bonding agents, respectively. The lower pH favors complete removal of smear layer and the hydroxyapatite is dissolved (demineralized), creating a deeper retentive pattern on the tooth surface. Moreover, the eighth-generation dentin bonding agent is a nano filled adhesive which forms a thicker adhesive layer and a more flexible interface that helps to counteract stress resulting from polymerization shrinkage of the resin composite.

The present study contributes to a better understanding of these adhesive systems, thus empowering dental professionals with the ability to make more efficient material and treatment choices by understanding the physical, mechanical, and biological properties of these materials. In this study, commercially available seventh- and eighth-generation bonding agents were used to bond lithium disilicate veneers to tooth surface and shear bond strength of both the adhesives was tested. Results of this study revealed that eighth-generation adhesive shows better bond strength than seventh-generation, which may be attributed to the component methacryloyloxydecyl dihydrogen phosphate (10-MDP) which has a potential to bond chemically with hydroxyapatite crystals. This result was in tune with the study carried out by Yoshida *et al.* (2004) where 10-MDP readily adhered to hydroxyapatite.[5] This bond appeared very stable. Both seventh- and eighth- generation dentin bonding agents contain functional monomers, cross-linking monomers, solvent, inhibitors, and activators, all in different proportions. Cross-linking monomers provide most of the mechanical strength and eighth- generation bonding agent contains micro sized cross-linking functional monomers therefore, there is a potential for higher bond strength than seventh- generation. Joseph *et al.*[6] and Kambale *et al.*[7] concluded that 8^{th} generation bonding agent appeared to be more advantageous than sixth- and seventh-generation bonding agent. Somani *et al.*[8] stated that the microleakage value was the highest in seventh-generation bonding agent followed by sixth-generation and least in eighth-generation.

The objective of bond strength test is to numerically evaluate the value for how strong the bonding of an adhesive system is to the dentin. Shear bond strength is commonly used laboratory parameter in measurement and evaluation of the efficacy of dentin adhesive system. In the present study, universal testing machine was used, for evaluating the adhesive ability of dentin bonding agent. Joseph *et al.*[6] compared the bond strength of sixth-, seventh-, and eighth- generation dentin bonding agents and stated that the highest bond strength was seen in eighth-generation dentin bonding agent as observed in the present study. These findings were in accordance with the findings by Kambale *et al*.[7] who compared in vitro tensile bond strength of sixth-, seventh-, and eighth-generation dentin adhesives and concluded that tensile bond strength of eighth-generation dentin bonding agent was highest followed by sixth- and seventh-generation, respectively.

Contrary to the result of the present study, El Sayed *et al*.[9] investigated the effect of thermocycling on the microshear bond strength of solvent-free self-etch adhesive system (sixth-generation) and solvent containing self-etch adhesives (eighth- and seventh-generation) and concluded that thermocycling had a negative effect on the bond strength of self-etching adhesive systems. Ghaffari *et al*.[10] stated that thermocycling and masticatory cycles failed to reduce the shear bond strength. Bailey and Bennet[11] and Chen *et al*.[12] concluded that good surface treatment of porcelain laminate veneers and nature of adhesive system and luting agent, also their chemical composition play an important role in making a durable bond between the tooth surface and the indirect restoration. In the present *in vitro* study, all manufacturer's instructions have been strictly followed to ensure a successful adhesive bonding of the laminate veneers fabricated from E-Max Press to tooth structure. Enas *et al*.[13] concluded that storage media and storage conditions had no significant effect on the shear bond strength of dentin of extracted teeth to esthetic restoration; hence, the storage media in this study used was distilled water.

There are several other factors which influence the bond strength to dentin such as degree of dentin mineralization, dentin surface being bonded, type of bond strength test (shear/tensile), storage media, manipulation procedure, and complex nature of testing procedure. These factors compromise the clinical success of the restoration; hence, more investigations simulating the clinical scenario should be made through *in vivo* studies.

Conclusion

Within the limitations of this research work, it can be concluded that the eighth-generation bonding agent produced higher bond strength values compared to seventh-generation bonding agent. Reduction in the number of application steps reduces manipulation time, and technique sensitivity, thus improving bond effectiveness and are the most user-friendly adhesive systems available in the market.

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