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Original Research

Evaluation of Shear Bond Strength of Newer Bonding Systems on Superficial and Deep Dentin

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Abstract:

Background: The purpose of this study was to compare the shear bond strength of nanocomposite resin to superficial dentin and deep dentin using two different dentin bonding systems.

Materials and Methods: All teeth were sectioned at various levels (superficial dentin: Dentin within 0.5-1 mm of dentinoenamel junction; deep dentin: Dentin within 0.5 mm of the highest pulp horn) using a Carborundum Disc and embedded in acrylic block of specific size. Selected specimens (60 premolar teeth) were grouped randomly into three groups, the groups were differentiated into superficial dentin, deep dentin, and control group which were further divided into sub Group A and Subgroup B containing 10 teeth each, depending on the bonding agents used. In Subgroup A, Tetric N Bond, and in Subgroup B Single Bond Universal were used. In the control group no bonding agent was used. The specimens were thermocycled for 500 cycles between 5°C and 55°C water bath for 40 s. Finally, the specimens were subjected to shear bond strength study under INSTRON machine (Universal Testing Machine). The maximum shear bond strengths were noted at the time of fracture (de-bonding) of the restorative material. Results were analyzed using ANOVA test, Bonferroni test, and paired *t*-test.

Results: Bond strength values of fifth generation bonding system (Tetric N Bond) showed higher mean shear bond strength compared to seventh generation bonding system (Single Bond Universal). There was a significant fall in bond strength values as one reaches deeper levels of dentin from superficial to deep dentin.

Conclusion: There was a significant difference between the bond strength of fifth generation bonding system (Tetric N Bond) and seventh generation bonding system (Single Bond Universal). Decrease in the bond strength values is seen for the deeper level of dentin as compared to superficial dentin.

Key Words: Bonding, deep dentin, self-etch, superficial dentin, total-etch

Introduction

The success of any dental restoration is based on the high adhesive property of the material. Various materials are available which utilizes this adhesive property such as, glass ionomer cement restoration, composite restorations, and pit and fissure sealants. Among these composite resins have been developed since few years in order to provide the best esthetics to the anterior restorations as well as for posterior restorations.

Dental adhesive systems are agents used to promote adhesion in between dental structure and composite resin, and should give a similar performance on enamel and dentine. Bonding to enamel and dentin is clinically dependable with acid etching technique. It differs from enamel, as it has smear layer, organic contents, and presence of fluid inside the dentinal tubules.[1]

Dentin is a biologic composite of a collagen matrix filled with sub-micron to nanometer-sized carbonate-rich apatite crystallites dispersed between hyper mineralized collagen poor hollow cylinders. 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. In superficial dentin, which contains fewer tubules and the permeation of resin into intertubular dentin will be responsible for most of the bond strength. In dentin, dentinal tubules are more in number and hence, the intratubular permeability of resins will be responsible for higher bond strength.

Two bonding techniques have been refined namely.

Total-etch technique involves the simultaneously removal of the smear layer from both enamel and dentin surface followed by the utilization of single bottle agent that incorporates the primer and adhesive in one solution.

Self-etching technique - their bonding mechanism is based on the simultaneous etching, priming and adhesive of the dentin surface in a single bottle.[2]

Bonding to enamel was achieved earlier and easier (Buonocore, 1955) because enamel is mostly composed of hydroxyapatite crystals. Although it is possible to obtain predictable and reliable

adhesion to enamel, adhesion to dentin, which is the largest part of the tooth, has proved to be more challenging because of its heterogeneous nature. The mechanism of dentin adhesion, enhanced by hybrid layer formation between the resin and dentin, was proposed by Nakabayashi (1982). The adequate hybrid layer formation is believed to be essential to create a strong and durable bond between resin and dentin. 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. During the last two decades, a variety of adhesive systems has been continuously developed in order to produce good adhesion to dental substrates. These great advances in the adhesive dentistry have changed the concepts of cavity preparation based on the principals proposed by Black (1955) into more conservative and minimally invasive ones. The current self-etching adhesives provide monomer formulation for synchronic conditioning and priming of enamel and dentin. As of today, less research is available to indicate the effectiveness of new generation self-etching primers against superficial and deep dentin. Shear bond strength measurements are used evaluate the efficiency of dentin bonding systems.

The aim of this study was to evaluate the Shear Bond Strength of the newer bonding systems on superficial dentine and deep dentin.

Materials and Methods

The present *in vitro* study was conducted in the department of conservative dentistry and endodontic, MR Ambedkar Dental College and Hospital, Bengaluru. Sixty intact human maxillary premolar teeth extracted for orthodontic reasons were collected from Oral and Maxillo-Facial Department at MR Ambedkar Dental College and Hospital. The teeth were stored, disinfected and handled as per rules given by OSHA and CDC. Teeth selected were randomly divided into three groups of 20 teeth each. Group A, Group B, and Control group. Group A and B were further subdivided into Subgroup A and Subgroup B, of ten each. All teeth were sectioned at various levels using a Carborundum Disc under copious water and embedded in an acrylic block of a specific size.

Group I: Superficial dentin – 20 specimens
- Subgroup A: Superficial dentin (Tetric N Bond) 10 specimens
- Subgroup B: Superficial dentin (Single Bond Universal) 10 specimens

Group II: Deep dentin – 20 specimens
- Subgroup A: Deep dentin (Tetric N Bond) 10 specimens
- Subgroup B: Deep dentin (Single Bond Universal) 10 specimens

Group III: Control Group – 20 specimens
- Subgroup A: Superficial dentin 10 specimens
- Subgroup B: Deep dentin 10 specimens

The occlusal surfaces of teeth were ground on a water-cooled trimming wheel to produce flat dentin surfaces.

Group 1 (Superficial dentin)

Subgroup A

All the specimens were etched the prepared dentinal flat surface with (N Etch) and washed. The surface was smudged with gauze to yield a visible damp dentin surface. The total-etching adhesive (Tetric N Bond) was applied on the prepared dentinal flat surface left undisturbed for 20 s and the excess solvent was with a gentle stream of air. Light curing was done for 40 s with a visible light curing unit. After curing the bonding agent, resin (Tetric N Ceram) was placed on the prepared dentinal surface using Teflon mold and cured according to manufacturer's instructions. The same procedure was carried out on the 10 specimens in this group.

Subgroup B

The self-etching adhesive (Single Bond Universal) was applied on the prepared dentinal flat surface left undisturbed for 20 s and the excess solvent was removed with a gentle stream of air. Light curing was for 40 s with a visible light curing unit. After curing the bonding agent, nanocomposite resin was placed on the prepared dentin using Teflon mold and cured according to manufacturer's instructions. The same procedure was carried out on the 10 specimens in this group.

Group II (Deep dentin)

Subgroup A

The same procedure as carried out in the Group I, Subgroup A is carried out on all specimens in this group.

Subgroup B

The same procedure as carried out in the group A, Subgroup B is carried out on all specimens in this group.

Group III (Control Group)

No bonding agent was applied. Nanocomposite resin was placed and cured according to manufacturer's instructions. Specimens were then stored at room temperature for 48 h.

The specimens were then thermocycled for 500 cycles between 50°C and 55°C water bath. A dwell time of 40 s was used for each bath. All the 60 specimens were transferred to the Instron testing machine and subjected to shear bond strength test.

Statistical analysis

The statistical data derived from the four subgroups were analyzed using ANOVA test, Bonferroni test, and paired *t*-test.

Results

For superficial dentin - Higher mean shear bond strength was recorded in fifth generation bonding system followed by seventh generation bonding system and control respectively as seen in Graph 1.

The difference in mean shear bond strength between the groups was not statistically significant ($P > 0.05$).

Deep dentin: Higher mean shear bond strength was recorded in fifth generation bonding agent followed by seventh generation bonding agent and control respectively as seen in Graph 2. The difference in mean shear bond strength between the groups was found to be statistically significant ($P < 0.001$).

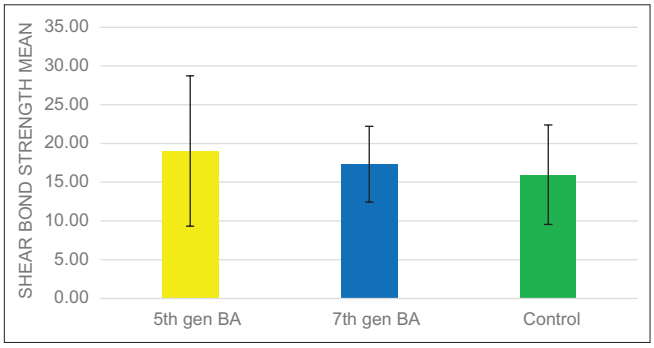
The difference in bond strength using fifth generation bonding agent in superficial dentin and deep dentin was not statically significant ($P > 0.05$) as seen in Graph 3.

The difference in bond strength using seventh generation bonding agent in superficial and deep dentin was statically significant ($P < 0.001$) as seen in Graph 4.

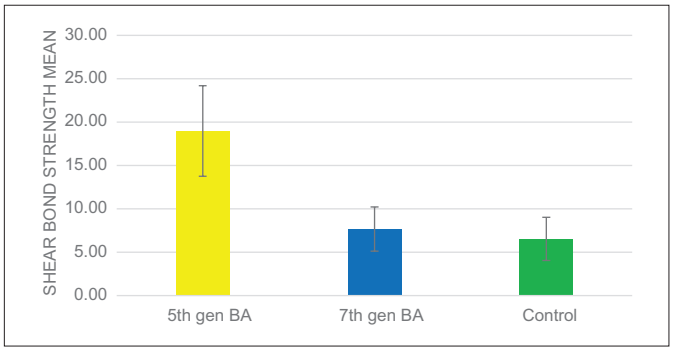
Discussion

Adhesion to acid-etched enamel was proposed by Buonocore in 1955. Bond strength to enamel or dentin is of an adhesive system's effectiveness. The bonding layer must not only support composite shrinkage stress, but also occlusal loads in stress bearing areas to avoid post-operative sensitivity, secondary caries and gap formation leading to micro leakage.[3] Bond strength testing and measurement of marginal - sealing effectiveness are the two most frequently selected methodologies to figure bonding efficiency in the laboratory in predicting clinical performance. Dentin is a dynamic tissue. It represents a challenge to resin based adhesives while the bond strength of enamel has studied extensively, bonding to dentin with the generation of bonding systems has remained unsolved. The dentin is characterized as a biologic composite of collagen matrix filled with apatite crystals dispersed between parallel micrometer-sized hypermineralized collagen poor dentinal tubules containing peritubular dentin. The composition of dentin substrate is made up of 50 % minerals, 20% of water, and 30% of the organic matrix. As the dentin deepens, this composition may change accordingly. This is due to the fact that the superficial dentin has few tubules and is composed predominantly of intertubular dentin. Deep dentin is composed mainly of larger funnel-shaped dentinal tubules with much less intertubular dentin.[4] The intertubular dentin plays an important role during hybrid layer formation in superficial dentin.[5]

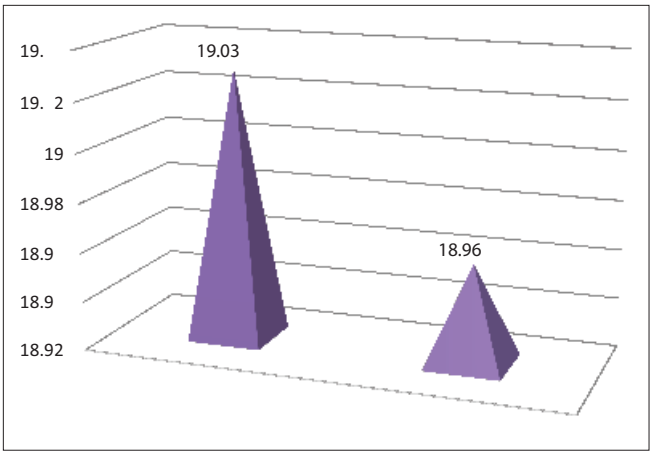
Adhesive dentistry is based on the development of materials, which establish an effective bond with the tooth tissues.



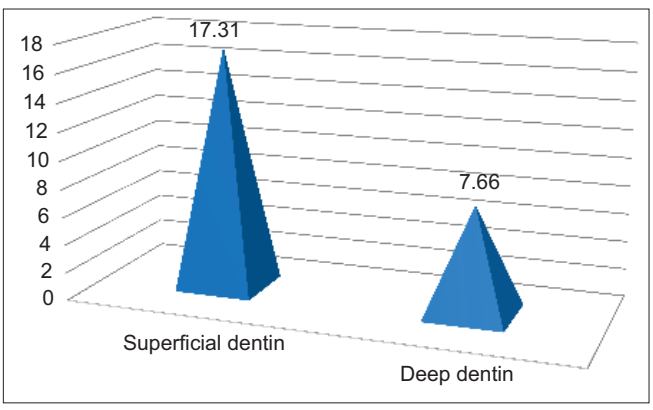
Graph 1: Mean shear bond strength recorded at superficial dentin.



Graph 2: Mean bond strength recorded at deep dentin.



Graph 3: Mean shear bond strength using fifth generation bonding agent at superficial dentin and deep dentin.



Graph 4: Mean shear bond strength using seventh generation bonding agent at superficial dentin and deep dentin.

Successful adhesive bonding depends on the chemistry of adhesive and morphological changes caused on the dental tissue by different bonding procedures.[6] The rationale behind the bond strength testing is that higher the actual bonding capacity of an adhesive, the better it will withstand such stresses and longer the restorations will survive *in vivo*. Bond strength testing is relatively easy and fast and remains most popular methodology for measuring the bonding effectiveness of adhesive systems.[7]

The results of this study revealed that superficial dentin presented bond strength values that were statistically higher and different from values obtained in dentin at a deep level, Tagami *et al.* (1990) 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. Several earlier reports indicate that the bond strength of resin is highest on superficial dentin and lowest in deep dentin.[8]

Suzuki and Finger (1988) studied the efficacy of dentin bonding systems based on the site of dentin with reference to the observation of Causton *et al.* that bond strengths to deep dentin were considerably lower than those to superficial dentin. The present study has confirmed the observation of Causton *et al.* that the efficacy of dentin adhesives depends upon the dentin surface from superficial to deep dentin in the tooth tested.[8]

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. Self-etch adhesives are user-friendly because of shorter application time and less steps and less technique sensitive because of 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.[9]

The mechanism of bonding to dentin for most adhesive systems depend on hybridization.[10]

This study is in consensus with Suzuki and Finger, with regard to, higher bond strength at all levels of dentin with Tetric N Bond which belongs to the-etch and rinse approach.

Huaxi-BAG-ceramic material can be an effective material for reducing dentinal hypersensitivity.[11]

Pegado *et al.* (2010) [4] 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.

In the present study, comparison (paired *t*-test) among the Tetric N Bond group, higher mean bond strength was recorded at the superficial dentin level than deep dentin. Moreover, comparison (paired *t*-test) among the Single Bond Universal group higher bond strength was recorded at the superficial dentin level than deep dentin.

Van Meerbeek *et al.* (2011)[9] 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

At superficial dentin level higher mean shear bond strength was recorded in fifth generation bonding system followed by seventh generation bonding system and control group, respectively. The difference in mean shear bond strength between the groups was not statistically significant ($P > 0.05$).

At deep dentin level, higher mean shear bond strength was recorded in fifth generation bonding system followed by seventh generation bonding system and control group, respectively. The difference in mean shear bond strength between the groups was found to be statistically significant ($P < 0.001$).

At deep dentin level, statistically significant results were obtained with the fifth generation (Tetric N Bond) bonding system which had higher mean shear bond strength values compared to the Seventh generation self-etch bonding system (Single Bond Universal).

There was a statistically significant difference in shear bond strength values with fifth generation bonding system and control group (without bonding system) at deep dentin.

There was a significant fall in bond strength values as one reaches deeper levels from the superficial dentin to deep dentin.

References

1. Susin AH, Vasconcellos WA, Saad JR, Oliveira Junior OB. Tensile bond strength of self-etching versus total-etching adhesive systems under different dentinal substrate conditions. Braz Oral Res 2007;21(1):81-6.
2. Ceballos L, Camejo DG, Victoria Fuentes M, Osorio R, Toledano M, Carvalho RM, *et al*. Microtensile bond strength of total-etch and self-etching adhesives to caries-affected dentine. J Dent 2003;31(7):469-77.
3. Neelima L, Sathish ES, Kandaswamy D. Comparative evaluation of micro tensile bond strength of different solvent based one - step and two - step adhesive systems to dentin: An *in vitro* study. J Conserv Dent 2013;16(4):317-74.
4. Pegado RE, do Amaral FL, Flório FM, Basting RT. Effect of different bonding strategies on adhesion to deep and superficial permanent dentin. Eur J Dent 2010;4(2):110-7.
5. Yousry MM, ElNaga AA, Hafez RM, El-Badrawy W. Microshear bond strength and interfacial morphology of etch-and-rinse and self-etch adhesive systems to superficial and deep dentin. Quintessence Int 2011;42(9):e96-106.
6. De Munck J, Vargas M, Van Landuyt K, Hikita K, Lambrechts P, Van Meerbeek B. Bonding of an auto-adhesive luting material to enamel and dentin. Dent Mater 2004;20(10):963-71.
7. Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M, Vijay P, *et al*. Buonocore memorial lecture. Adhesion to enamel and dentin: Current status and future challenges. Oper Dent 2003;28:215-35.
8. Suzuki T, Finger WJ. Dentin adhesives: Site of dentin vs. bonding of composite resins. Dent Mater 1988;4(6):379-83.
9. Van Meerbeek B, Yoshihara K, Yoshida Y, Mine A, De Munck J, Van Landuyt KL. State of the art of self-etch adhesives. Dent Mater 2011;27(1):17-28.
10. Mohanbabu V, Mala K, Priyadharshini IK. The importance of dentin collagen fibrils on the marginal sealing of adhesive restorations: An *in vitro* study. Int Dent Med J Adv Res 2015;1:1-5.
11. Sonarkar S, Purba R. Bioactive materials in conservative dentistry. Int J Contemp Dent Med Rev 2015;2015:Article ID: 340115. doi: 10.15713/ins.ijcdmr.47.