Original Article

# Comparison of Shear Bond Strength of Composite to Primary and Permanent Enamel Using Dentin bonding and Enamel Bonding Agents

**Mehdi Shahrabi [1], Ali Reza Heidari [2], Parvin Musavi Sahlan [3].**

[1]Associate Professor, Pediatric Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[2]Assistant Professor, Pediatric Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran
[3]Dentist

**Abstract**

***Background and Aim:*** Dentin bonding agents are gradually replacing enamel bonding agents in the clinical setting. Considering the different properties of these two materials, their bonding strength to enamel may be different.

The aim of this study was to compare the shear bond strength of composite restorations to enamel using dentin bonding and enamel bonding agents.

***Materials and Methods:*** In this experimental study, buccal surfaces of 24 freshly extracted primary and permanent teeth were polished by the polishing papers in order to obtain a piece of flat enamel 3 mm in diameter. After etching, rinsing and drying the surfaces, the specimens were divided into 4 groups. Enamel bonding (Margin Bond) was applied to the surfaces of 6 primary and 6 permanent teeth and Single Bond was applied to the surfaces of the remaining teeth. All teeth were cured. Composite resin (3mm in diameter and 4 mm in height) was applied to the prepared surfaces. Then, the specimens were thermocycled for 2000 cycles and the shear bond strength was determined using an Instron universal testing machine. The findings were analyzed by SPSS and two-way ANOVA.

***Results:*** There was no significant difference in the mean shear bond strength of the two groups of primary and permanent teeth ($p=0.518$). Also, no significant difference was found between enamel and dentin bonding agents in primary and permanent teeth ($p=0.17$).

***Conclusion:*** The shear bond strength of composite to enamel was not significantly different between the primary and permanent teeth following the use of enamel or dentin bonding agents.

***Key Words:*** Enamel bonding agent, Dentin bonding agent, Shear bond strength, Enamel, Primary teeth, Permanent teeth

Corresponding author:
Ali Reza Heidari, Assistant Professor, Pediatric Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran.
*ar-heidari@tums.ac.ir*

Received: 25 Aug 2013
Accepted: 26 Feb 2014

**Journal of Islamic Dental Association of IRAN (JIDAI) Summer 2014 ;26, (3)**

## Introduction

A major goal in restorative dentistry is to create an optimal bond between the tooth-colored restorations and the tooth structure. Different generations of bonding agents have been introduced and the science of chemical bonding to tooth structure has evolved. The first bonding agent used was enamel bond; which was hydrophobic and considering the enamel structure and its dehydration following the process of etching, this bonding agent seemed to be efficient [1, 2]. Since dentin dehydration leads to collagen collapse and subsequently decreased bonding ability, another product was introduced for bonding of tooth-colored restorations to dentin. This product had both hydrophobic and a hydrophilic ends. In a relatively moist environment, this product would bond to dentin at one end and to composite (which is hydrophobic) at the other end. Dentin bonding agents underwent numerous alterations over years; however, the general underlying structure is presence of both hydrophobic and hydrophilic ends [3, 4].

At first, separate application of enamel bond to enamel and dentin bond to dentin was recommended; which was extremely difficult in the clinical setting. However, over time, by the advances in bonding agents, the manufacturers claimed that dentin bonding agents could also be applied to enamel without any reduction in their efficacy.

The enamel bond strength varies from 18-22 MPa; affected by the thickness of the bonding agent, and shear resistance and type of enamel crystals. Usually, 20 MPa resistance is sufficient to tolerate loads applied to the teeth [1, 2, 5, 6]. Following the clinical success of enamel bonding agents, different bonding systems were introduced for optimal bond to dentin. Although dentin bonding is still not as favorable as the bond to enamel, dentin bonding agents currently show acceptable results [5, 7].

Enamel bonding systems often include a saturated acrylic monomer that is applied to the acid etched enamel. The monomer penetrates into the porosities in between and within the enamel crystals. Resins that penetrate into the etched enamel often include Bis-GMA (bisphenol glycidyl methacrylate) or UDMA (urethane dimethacrylate). Both monomers are viscous and hydrophobic and are often diluted with lower viscosity monomers like TEG-DMA (Triethylene glycol dimethacrylate) or HEMA (Hydroxyethyl methacrylate) [2, 5, 8, 9, 10, 11].

Primary dentin bonding agents were hydrophobic and directly bonded to the dentin smear layer. Thus, their shear bond strength was less than 6 MPa. Due to different structure and high water content of dentin compared to enamel, the clinical longevity of materials bonded to dentin may not be as high as that of materials bonded to enamel. Resins used for enamel bonding cannot wet a hydrophilic surface like that of dentin and thus, require a surface activating monomer to enhance their bond to dentin [1,6,7].

Primers of the dentin bonding agents are designed in such way that they can penetrate into the smear layer residues and into the tubular dentin. Thus, a network is formed around dentin collagen. This layer is called the hybrid zone (penetration or diffusion zone) [3,4,6].

On the surface of primary enamel and cervical area of the molar teeth (75% of the cases), a prism-free layer with a uniform structure is found known as the prismless enamel. With approximately 200µ thickness, this layer covers the enamel crystals. Presence of this layer significantly decreases the etchability and bond strength of resin to primary enamel. Thus, before etching, a thin layer of the primary enamel surface had better be eliminated by bur. By doing so, the prismless layer is removed and enamel crystals are exposed [12].

Considering the gradual replacement of enamel bonding agents with dentin bonding systems and the manufacturers' claim that these systems can very well bond to both enamel and dentin as well as the structural differences between enamel and dentin and their water, mineral and organic contents (affecting the bond to enamel and dentin), this study aimed to compare the shear bond strength of composite restorations following the application of dentin bonding and enamel bonding agents to primary and permanent enamel.

## Materials and Methods

In this experimental study, 12 primary and 12 permanent recently extracted teeth were selected. According to the results of a study by Krifka and considering $\alpha=0.05$ and $\beta=0.2$, difference of 10 MPa and standard deviation of 8.2, number of specimens in each group was calculated to be 12. The selected teeth had intact buccal surfaces with no caries or anomaly. After prophylaxis and cleaning the crowns and the roots, the teeth were mounted in resin blocks measuring 2.5cm in length, 1.8cm in width and 1.2cm in depth. The buccal surfaces of the teeth were then polished with 400 grit abrasive papers to achieve a smooth enamel surface 3mm in diameter. Then, 37% phosphoric acid (Ultra-Etch, Ultradent Product Inc., USA) was applied to the surfaces for 20s and rinsed for 15 seconds. Air spray was checked on a dental mirror to ensure that it is free from water and oil. Dental surfaces were dried for 5 seconds to obtain a chalky appearance on the etched surface.

Enamel bonding agent (MarginBond) was applied to the prepared surfaces of 6 primary and 6 permanent teeth. Dentin bonding agent (SingleBond, 3M ESPE, USA) was then applied to the surfaces of the remaining 6 primary and 6 permanent teeth and light cured for 20 seconds by Coltolux 75 light curing unit (Coltene/Whaledent, Switzerland). A composite cylinder measuring 3mm in diameter and 4mm in height (Z250, 3M ESPE, USA) was placed on the prepared surface and light cured twice each time for 20 seconds. Specimens, separately wrapped in a thin cloth were thermocycled (Dorsa, Malek Teb, Iran) at 2000 rpm between 5-55°C with an exposure time of 20 seconds in each bath and 10 seconds of dwell time. Next, specimens were stored in distilled water at room temperature for 24 hours and were then subjected to shear bond strength testing (FTM-B, Santam, England). Load (50 N) was applied by a blade with a diameter of 1mm at a crosshead speed of 0.5 mm/min at composite-enamel interface until bond failure. The load at failure indicated maximum shear tolerance of the bond prior to failure in MPa.

Data regarding shear bond strength of composite to enamel were recorded in data bank of SPSS. The mean and standard deviation (SD) of the shear bond strength in each group were calculated. Data were compared using two-way ANOVA.

To calculate the shear bond strength, load (N) was divided by the composite restoration surface area ($mm^2$) and the results were recorded in MPa.

## Results

The mean shear bond strength of enamel bond was 8.35 MPa to primary enamel and 9.62 MPa to permanent enamel. Also, the mean shear bond strength of Single Bond was 10.45 to primary enamel and 10.62 MPa to permanent enamel (Table 1).

Two-way ANOVA showed no significant interaction among the study groups (p=0.62). Also, type of bonding agent (p=0.17) and type of tooth (p=0.518) had no significant effect on shear bond strength.

## Discussion

Clinical The current study results showed no significant difference in shear bond strength of enamel bond and dentin bond to primary or permanent enamel and even the shear bond strength of Single Bond, although insignificant, was greater than that of enamel bond. This finding can be explained by the fact that although dentin bond has hydrophobic and hydrophilic ends, its efficacy does not necessarily depend on the presence of moisture in the environment. In a completely dry, moisture-free environment, like dried enamel after etching, dentin bond can adequately penetrate into the porosities caused by enamel etching. Such penetration creates adequate shear bond strength. However, the question is, why it is often said that the tooth must not be completely dry before the application of dentin bonding agents? This is especially true for the bond to dentin rather than enamel because in case of dentin over-drying, its collagen fibers collapse and thus, the bonding agent cannot penetrate into them and subsequently, adequate bond cannot be achieved. Therefore, it is stated that dentin must remain slightly wet in order for the collagen fibers not to collapse. On the other hand, the hydrophilic end of the agent bonds to moist dentin while the other end bonds to composite and an adequate bond is achieved as such. However, enamel structure is totally different. It is crystalline with no collagen fibers. Thus, enamel does not need to be wet and by complete drying, enamel structure does not collapse and the bonding agent easily penetrates into the etched enamel with no problem. However, the question is, why the shear bond strength of Single Bond was found to be slightly, but not significantly, higher than that of enamel bond?

This issue may be attributed to the advances made in polymer science because enamel bonds, after introduction, did not undergo much modification or advancement and they are being wiped out of the market; whereas, great advances have been made in dentin bonding systems and their characteristics are constantly improving. Therefore, the slightly higher bond strength of dentin bond may be due to these advances in polymer science.

Another important finding of the current study was insignificantly higher bond strength to permanent enamel than primary enamel; which was observed for both enamel bond and dentin bond. This result may be due to the orientation of enamel crystals in primary and permanent teeth. The orientation of enamel crystals in permanent teeth is more orderly. Thus, the bonding agent can better penetrate into them and yield a stronger shear bond.

Da Costa et al, in their in-vitro study in 2008 evaluated the enamel surface texture and shear bond strength to direct restorations in both primary and permanent teeth. They found no significant difference in shear bond strength between primary or

**Table 1.** Descriptive statistics of Single Bond and enamel bond shear bond strength to primary and permanent teeth

| Teeth | Bonding agent | Minimum | Maximum | Mean | SD |
|---|---|---|---|---|---|
| Permanent | **Enamel bond** | 5/43 | 13/09 | 8/35 | 2/95 |
| | **Single Bond** | 7/83 | 15/68 | 10/45 | 3/16 |
| Primary | **Enamel bond** | 7/70 | 11/38 | 9/62 | 1/38 |
| | **Single Bond** | 5/86 | 15/23 | 10/62 | 3/91 |

permanent enamel or different adhesive systems [13].

Our results were in line with those of Andrad et al, [14], Mcleod et al, [15] and da Costa et al, [13]. In the mentioned studies, no significant difference was reported in shear bond strength of composite with different bonding agents. However, using self-etch bonding agent decreased the shear bond strength. In the current study, self-etch bonding agent was not used and our results were in accord with the rest of their findings.

Kanaca et al. [16] believe that the shear bond strength of dentin bonding agent to dry and moist enamel is equal. Our results also showed that the shear bond strength of dentin bonding agent to dry enamel does not decrease compared to wet enamel. Also, the results of Wakafielo [17], Woronko [18] and Torii [19] revealed that moist enamel had no effect on shear bond strength of dentin bonding agents but Swift [20], Triclo [21] and Yassini [22] stated that moist enamel increases the shear bond strength when using dentin bonding agents. Such different results may be attributed to the different types of dentin bonding agents used in these studies.

## Conclusion

It can be concluded that dentin bonding agents are suitable for use even on dried enamel and yield bond strength as high as that of enamel bonding agents.

## Acknowledgement

This study was part of a thesis by Parvin Mousavi Sahlan (4864) for doctor of dental surgery (DDS) degree.

## References

1. Roberson MT, Heymann OH, Swift JR. Art and science of operative dentistry. 5th ed. USA: Mosby; 2006: Chap 5.
2. Soetopo N, Beech O, Hardwick J. Mechanism of adhesion of polymers to acid-etched enamel. J Oral Rehabil. 1978 Jan; 5(1):69-80.
3. Kanca J. Resin bonding to wet substrate. 1. Bonding to dentin. Quintessence Int. 1992 Jan; 23 (1):39-41.
4. Swift EJ Jr. Bonding systems for restorative materials. A comprehensive review. Pediatr Dent. 1998 Mar-Apr; 20(2):80-84.
5. Pinkham JR. Pediatric Dentistry: Infancy through Adolescence. 4th ed. China: Elsevier Saunders; 2005.
6. Graig RG, Orbien WJ, Powers JM. Dental materials, Properties and manipulation. 11th ed.USA: The Mosby; 2002.
7. Walls AW, Leey MC, Cabe JF. The bonding of composite resin to moist enamel. Br Dent J. 2001 Aug; 191(3):148-50.
8. Hormati A, Fuller J, Denehy G. Effect of contamination and mechanical disturbance on the quality of acid-etched enamel. J Am Dent Assoc. 1980 Jan; 100(1):34-38.
9. Barghi N, Knight G, BerryT. Comparing two methods of moisture control in bonding to enamel. Oper Dent. 1991 Jul-Aug; 16(4):130-35.
10. Powers JM, Finer WJ, Xif J. Bonding of composite resin to contaminated human enamel and dentin. J Prosthet Dent. 1995 Mar; 4(1):28-32.
11. Jain P, Stewart GP. Effect of dentin primer on shear bond strength of composite resin to moist and dry enamel. Oper Dent. 2000 Jan-Feb; 25(1): 51-8.
12. Jain P, Stewart GP. Effect of dentin primer on shear bond strength of composite resin to moist

and dry enamel. Oper Dent. 2000 Jan-Feb; 25(1): 51-8.
13. Da Costa CC, Oshima HM, Costa Filho LC. Evaluation of shear bond strength and interfacial micromorphology of direct restorations in primary and permanent teeth. Gen Dent. 2008 Jan-Feb; 56 (1):85-93.
14. Andrade AM, Moura SK, Reis A, Loguercio AD, Garcia EJ, Grande RH. Evaluating resin-enamel bonds by microshear and microtensile bond strength tests: effects of composite resin. J Appl Oral Sci. 2010 Dec;18(6):591-8.
15. Mc leod ME, Price RB, Felix CM. Effect of configuration factor on shear bond strengths of self etch adhesive systems to ground enamel and dentin. Oper Dent. 2010, Jan-Feb; 35(1):84-93.
16. Kanca J. Resin bonding to wet substrate. II. Bonding to enamel. Quintessence Int. 1992 Sept; 23(9):625-7.
17. Wakefielo CW, Sneed WD, Draughn RA, Davis TN. Composite bonding to dentin and enamel of humidity. Gen Dent. 1996 Nov-Dec; 44(6):508-12.
18. Woronko G, Germain H, Meiers J. Effect of dentin primer on the shear bond strength between composite resin and enamel. Oper Dent. 1996 May -Jun; 21(3):116-21.
19. Torii Y, Itou K, Hikasa R, Iwat A, Nishitani Y. Enamel tensile bond strength and morphology of resin enamel interface crated by acid etching system with or without moisture and self-etching priming system. J Oral Rehabil. 2002 Jun; 29(6): 525-33.
20. Swift E, Triolo P. Bond strength of scotch bond multi-purpose to moist dentin and enamel. Am J Dent. 1992 Dec; 5(6):318-20.
21. Yasini E, Malekan E. Comparison of shear bond strength between unfilled resin to dry enamel and dentin bonding to moist and dry enamel. J of Dentistry TUMS 2005 Spring; 18(1):15-20.