DOI: 10.5272/jimab.2012182.168

Journal of IMAB - Annual Proceeding (Scientific Papers) 2012, vol. 18, book 2

BOND STRENGTH OF SELF-ETCH ADHESIVES WITH PRIMARY AND PERMANENT TEETH DENTIN – IN VITRO STUDY

Natalia Gateva[1], Valentin Dikov[2]

1) Department of Pediatric Dentistry, Faculty of Dental Medicine, Medical University, Sofia

2) Technical University, Sofia, Bulgaria

SUMMARY:

Objective: The aim of this study was to compare dentin bond strength of primary and permanent teeth with self-etching adhesive systems.

Methods: On 40 intact specimens of primary and permanent teeth was created flat dentin surfaces. The patterns were divided in 4 groups. Two different self-etching adhesive systems were used – one two steps (AdheSE, VivaDent) and one one step (AdheSE One, VivaDent). Resin composite build-ups were constructed by means of convetional copper ring after applying the adhesive. The specimens were stored in water for 72 h at room temperature. After that specimens were tested for macrotensile bond strength. Debonded surfaces were analyzed by SEM.

Conclusions: The measured values of dentin bond strength after applying self-etching adhesives are statistically significant in group of permanent teeth in comparison with group of primary teeth, and for both adhesive generations. Two steps self-etching adhesive provide significant stronger dentin bond strength with both dentitions in comparison with one step self-etching adhesive.

Key words: primary teeth, permanent teeth, self-etching adhesives, bond strength, SEM

INTRODUCTION

Current self-priming and latest all-in-one adhesives represent an attractive addition to the day-to-day dental practice. They are easy to use, because they have shortened application protocol, which is an important advantage in pediatric dentistry.

Purpose of the self-etching adhesives systems are:

- Simplifying the bonding procedures;
- Minimizing the technical sensitivity of the applications protocol through the elimination of the step of etching, rinsing and drying of tooth structures (35).

These goals are obtained through the included in the composition sour monomers, which:

- Simultaneous etch and prime dentin;
- Facilitate the dissolution of crystals around collagen fibrils and the resin infiltration beyond the covered with smear layer surface in the underlying dentin matrix (31, 35).

While the dentine bond strength of permanent teeth is examined quite often, significantly smaller number of researches are aimed at testing the dentine bond strength of primary teeth (10, 15, 26, 35). Studies, comparing similar adhesive systems show results, varying from the absence of any significant differences (7, 12, 14, 20, 29, 30) to higher (3, 15, 30) or lower (3, 15, 28, 29, 36, 43) values of the achieved strength by primary teeth measured up to permanent teeth. It is accepted, that chemical, physiological and micro morphological differences are responsible for the weaker dentine bond strength by primary teeth as a lower degree of mineralization, smaller size and amount of dentine tubules, and the connected dentine permeability, as well as bigger reactivity towards acid conditioners (2, 7, 10, 19, 21, 23, 29, 30).

The purpose of this study is to:

- compare the dentine bond strength after the application of self-etching adhesive systems by primary and permanent teeth;
- compare the failure type trough observation with scanning electron microscope after the macrotensile bond strength test.

METHOD AND MATERIALS

The examination consists of 40 intact teeth (20 primary molars and 20 permanent premolars and molars). The teeth are from healthy adult patients and children, after signed consent from them/their parents for the usage of these teeth in the experiment. Primary teeth are extracted because of physiological resorption. The teeth are divided on random principle (only primary and only permanent) in 4 groups. The division is shown in table 1.

Table 1. Grouping of experimental samples

Group	N	Adhesive system
Group 1 – primary teeth	10	AdheSE (Ivoclar Vivadent) – 2-steps – self-priming
Group 2 – permanent teeth	10	AdheSE (Ivoclar Vivadent) – 2-steps – self-priming
Group 3 – primary teeth	10	AdheSE One (Ivoclar Vivadent) – 1-step – all in one
Group 4 – permanent teeth	10	AdheSE One (Ivoclar Vivadent) – 1-step – all in one

Preparation of teeth surface. A section is made on the central occlusal fissure of every teeth, in medio-distal direction with turbine round borer (ISO 806 314 001534 012 for primary teeth and 806 314 001534 014 for permanent teeth), under water-air cooling. The depth of the section is dependant on the diameter of the borer. In order to remove the occlusal enamel and parts of dentine, another section is made, parallel to the occlusal surface, in the controlled depth, determined by the initial section of the borer. This manipulation is made with turbine diamond fissure borer (ISO 806 204 108 524 835 010) and water-air cooling. Afterwards the surface is leveled with abrasive disc, which is being replaced after every tooth. The models are observed with optical microscope OLYMPUS VANOX-T, under 25x-100x magnification, so that the complete removal of the enamel from the occlusal surface can be verified.

Perform of the restoration. A copper ring (!15) with height 5 mm and diameter 5mm is used for the manufacture of comparable and predictable surfaces of the restoration. Factory-made standard copper rings are cut with the help of two-side diamond disks, in order to achieve the desired height.

Adhesive systems were applied according to the manufactuteЧs instructions. By all patterns the application of the adhesive system is made directly on the occlusal dentine surface with a diameter, comparable to the one of the copper ring. On the arranged dentine surface is placed the beforehand prepared copper ring. Within this ring is placed one layer light cure composite (Tetric EvoCeram, Ivoclar Vivadent, A3 shade) with thickness 2mm, which is polymerized with UV light for 40 s and a lamp (Coltolux 75, Curing Light, Coltиne Whaledent). The next step consists of setting a metal loop of orthodontic wire (!0.8), perpendicular to the section of the occlusal surface with a length of about 10mm in the center of the ring, and a fresh amount of composit, which stretches the metal ring and clamps the metal loop. Up next comes light polymerization for 40 s. The two free ends of every metal loop, which is placed in the copper ring and is covered with composite, are finished with “rotational” loop.

From the side of the pulp camber, on the level of the cut roots, the preparations of the specimens consists of etching of the entire pulp camber for 15 s, washing – 15 s, air-drying and application of 3-steps adhesive system. A layer of composite is placed, along with light polymerization for 40 s. After that a second metal loop is being placed, alignment of the one, which is already on top of the occlusal surface in the metal ring. The final step is addition of composite untill the whole pulp camber is filled, along with light polymerization for 40s.

The prepared specimens are stored in water at room temperature for 72 hours, before the test conduct.

*Testing the bond strength.*The measurement of the achieved bond strength is conducted on stand for physical-mechanical examination type INSTRON – 1185. Metal loops similar to the ones built in the studied teeth are rigid standard in the grips of the machine and at the other end - hinged metal loops to the model. The loading bar is moving at a steady speed of 1 mm/min. Registered the maximum force of resistance, causing debonding (in MPa). The test is terminated after the final destruction of the test specimen.

Determining the failure type. After the macrotensile bond strength test specimens were dehydrated in ascending concentrations of ethanol - 75%, 95% and 100% for 1 h at each concentration. After dehydration the samples were placed on filter paper, covered with a glass lid for 24 h. Both halves of each specimen were observed in the SEM from 18x to 1500x magnification to determine the failure type. SEM observation allows more precise determination of the place of failure. The failure type for each sample is classified into one of the following types:

Type 1: Adhesive failure mode – the fracture line is located in the adhesive layer of the borderzone dentine – adhesive or composite – adhesive - this is a failure in the adhesion.

Type 2: Cohesive failure mode - fracture line passes only in the volume of the composite.

Type 3: Mixed failure mode - the specimens show both types of fracture - the adhesive and cohesive destruction - dentin-adhesive-composite.

The prepared samples are placed onto aluminum discs. Cover with gold dust vacuum in an environment of argon - cathode sputtering apparatus using a JEOL JFC - 1200 Fine coater. Studies were made with a SEM JEOL JSM -5510 SEM

RESULTS

Table 2 presents the values of minimum, maximum and average bond strength after a macrotensile bond strength test, measured in MPa.

Table 2. Values of the bond strength in MPa, as measured by macrotensile bond strength test.

Dentition	Adhesive system/group	N	Macrotensile bond strength (MPa)		
			mean±SD	Minimum	Maximum
Primary teeth	AdheSE – group 1	10	10.80±1.08	9.20	12.80
	AdheSE One – group 3	10	6.88±1.28	5.34	9.70
Permanent teeth	AdheSE – group 2	10	14.40±3.38	10.08	18.54
	AdheSE One – group 4	10	11.72±1.54	8.64	14.20

There was a statistically significant difference in the bond strength between the specimens from two dentitions ($p<0.000$). Greater bond strength is established between the groups with samples of permanent teeth (mean – 13.06 MPa) compared with speciemens of primary teeth (mean – 8.84 MPa) when tested by us self-etch adhesive systems (table 3). This indicates that the type of teeth (primary or permanent) effect the bond strength.

Tab. 3. Bond strength after macrotensile test in samples of both dentitions.

Dentition	N	Bond strengthmean±SE (MPa)	T	P
Permanent teeth	20	13.06±1.89	1.77	<0.000*
Primary teeth	20	8.84±2.77		

*The difference is statistically significant

In application of self-etch adhesive systems in both dentitions are registered higher average values of bond strength formations of permanent teeth (group 2 and 4) compared with those of primary dentition (group 1 and 3, table 2). Registered differences were statistically significant for both self-etch adhesive systems ($p<0.05$, table 4). This indicates that the type of adhesive system influence the results obtained for the bond strength.

Table 4. Bond strength in both dentitions with self-etch adhesive systems.

Group	N	Bond strengthmean±SE (MPa)	T	P
Group 1	10	10.80±1.08	3.20	<0.01*
Group 2	10	14.40±3.38		
Group 3	10	6.88±1.28	7.63	<0.0001*
Group 4	10	11.72±1.54		
Group 1	10	10.80±1.08	7.39	<0.0001*
Group 3	10	6.88±1.28		
Group 2	10	14.40±3.38	2.28	<0.05*
Group 4	10	11.72±1.54		

*The difference is statistically significant

The results show that application of two- and one-step self-etch adhesive systems led to reliably greater bond strength by permanent teeth compared with the primary teeth (group 2 permanent teeth - 14,40 MPa to a group 1, primary teeth - 10.88 MPa; group 4 permanent teeth - 11.72 MPa to group 3 primary teeth - 6.88 MPa, Table 3 and 4).

Registered average values of bond strength between group 1 and group 3 showed a statistically significant difference in favour of greater strength and applicated to the two-step self-etch adhesive system (Table 4) ($p<0.0001$). Statistically significant difference was found between samples from group 2 and group 4 (Table 4) ($p<0.05$). Greater average bond strength is taken into consideration when applicated to 2-steps self-etch adhesive (Table 4). Two-steps self-etch adhesive reliably create greater bond strength in both dentitions than all in one self-etch adhesive. All in one self-etch adhesive showed

lower average values of the bond strength in both samples dentitions (group 3 and group 4, Table 2 and 4).

Failure type

Figure1 presents photographs depicting various failure types in samples from both dentitions and used in our experimental setup self-etch adhesive systems.

Fig. 1. Cohesive failure mode in adhesive in group2 (permanent teeth). 1B.Adhesive failure mode in group 3 (primary teeth). 1C.Adhesive failure mode in group 4 (primary teeth). 1D.Mixed failure mode in group 1 (primary teeth).

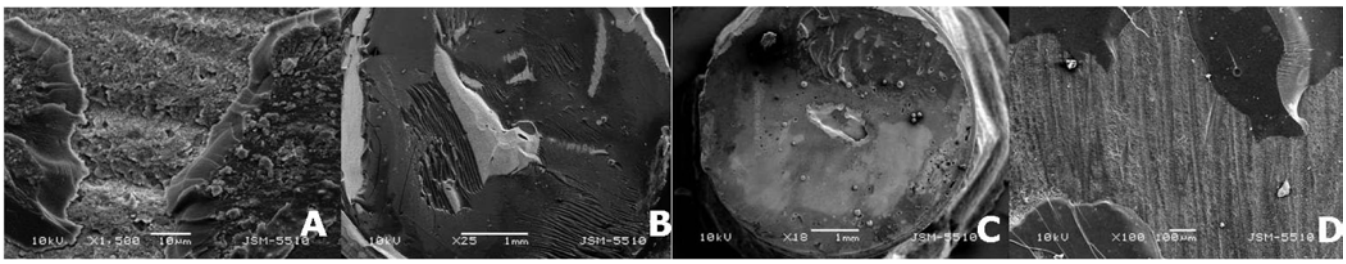

Table 5. Distribution by failure mode in patterns of primary and permanent teeth and self-etch adhesive systems

	Group	Adhesive failure mode		Cohesive failure mode		Mixed failure mode		Total	
		N	%	N	%	N	%	N	%
Self-etch adhesives	Group 1	9	90.0	0	0.0	1	10.0	10	100
	Group 3	10	100.0	0	0.0	0	0.0	10	100
	Primary teeth	19	95.0	0	0.0	1	5.0	20	100
	Group 2	6	60.0	0	0.0	4	40.0	10	100
	Group 4	8	80.0	0	0.0	2	20.0	10	100
	Permanent teeth	14	70.0	0	0.0	6	30.0	20	100

By application of self-etching adhesives the percentage of adhesive failure mode is highest - 95% for primary and 70% for permanent teeth (Table 5).

DISCUSION

The obtained results from the macrotensile bond strength test by primary and permanent teeth after application self-etch adhesive systems showed statistically significantly lower values of the bond strength to dentin of deciduous teeth compared to those in permanent (Table 3 and 4). Our results are consistent with results of other researchers who reported a weaker dentin bond strength of deciduous teeth due to micromorfological and chemical differences between the both dentitions (2, 8, 21, 29). On the other hand, the specific characteristics of different adhesive systems that determine the degree of smear layer removal, demineralization of the underlying dentin, ability of the adhesive wets and penetrates the dentine are also important to achieve sufficient bond strength (4, 11, 16, 17, 18, 21, 23, 29, 38). These results indicate that the type of tooth and type of used self-etch adhesive system affect the achieved dentin bond strength. They also show that there is no adhesive systems that are equally effective in achieved bond strength in the primary and permanent teeth.

Our SEM observation of the resin-dentin interdiffusion zone after application of various aggressive self-etch adhesives in both dentition also showed significant differences in morphological characteristics of this zone for the observed hybrid and adhesive layer thickness.These layers were thicker in primary teeth and indicate the presence of microcracks in them. Differences were observed in the characteristics of the formed resin tags and in the depth at which they penetrates into dentinal tubules (1). These descriptive characteristics probably have also relation to the explanation for the weaker results achieved in bond strength in primary teeth. In the literature results in terms of self-etch adhesives are contradictory. Some suggest that their application results in a not enough good and long-term

bond strength (8, 22, 24, 32, 33), other studies are in support of their use (5, 9, 19). The tendency of simplifying and shortening the adhesive application protocol is associated with loss of bonding efficiency to tooth structure, so that their benefits should be linked with their disadvantages (6, 11, 25, 37, 39). Our study found that more frequently observed failure type by self-etch adhesives is adhesive type for both dentitions (95% for primary and 70% for permanent teeth). At the higher dentin bond strength would be observed a higher frequency of mixed or cohesive type of failure. The study of the type of failure provides important information when analyzing the test results of bond strength and the classification of the type of failure is important observation (8). In vitro tests are useful and important for predicting the effect of new adhesive systems and their possible correlation with clinical practice, although in vitro studies are not able to fully predict clinical success. Must be taken into account the influence of other parameters of the study - the design of the experimental setup and experimental conditions, the operator skills, storage of samples until the experiment, the storage time of samples in water until testing. These are all factors which significantly influence the values obtained for the bond strength and type of failure (10, 13, 34, 40). Although not directly predict the clinical performance of adhesives the comparison between different generations of adhesives is valid and can be used in clinical decision making (41).

CONCLUSION:

1. In our study all in one adhesives showed lower values of achieved bond strength, compared with self-priming adhesives for the samples from both dentitions.

2. Lower values of the bond strength are registered in samples of deciduous teeth compared to permanent studied by us self-etching adhesives

3. None of the tested adhesive systems showed the same values of the dentin bond strength of the teeth from both dentitions.

REFERENCES:

1. Гатева Н, Кабакчиева Р. СЕМ характеристика на граничната зона адхезив-дентин при временни и постоянни зъби: *in vitro* изследване на четири самоецващи адхезивни системи. *Съвременна стоматология*, 2010; 41(1): 3-14. (in Bulgarian)

2. Agostini FG, Kaaden C, Powers JM. Bond strength of self-etching primers to enamel and dentin of primary teeth. *Pediatr Dent*. 2001 Nov-Dec;23(6):481-486. [PubMed]

3. Assakawa T. Manabe A, Itoh K, Inoue M, Hisamitu H, Sasa R. Efficacy of dentin adhesives in primary and permanent teeth. *J Clin Ped Dent*. 2001 Spring;25(3):231-236. [PubMed]

4. Atash R, Vanden Abbeele A. Sealing Ability of New Generation Adhesive Systems in Primary Teeth: An In Vitro Study. *Pediatr Dent*. 2004 Jul-Aug;26(4):322-328. [PubMed]

5. Bekes K, Boeckler L, Gernhardt CR, Schaller HG. Clinical performance of a self-etching and a total-etch adhesive system- 2-year results. *J Oral Rehabil*. 2007 Nov;34(11):855-861. [PubMed] [CrossRef]

6. Breschi L, Mazzoni A, Ruggeri A, Cadenaro M, Di Lenarda R, De Stefano Dorigo E. Dental adhesion review: Aging and stability of the bonded interface. *Dent Mater*. 2008 Jan;24(1):90–101. [PubMed] [CrossRef]

7. Burrow MF, Nopnakeepong U, Phrukkanon S. A Comparison of Microtensile Bond Strengths of Several Dentin Bonding Systems to Primary and Permanent Dentin. *Dent Mater*. 2002 May;18(3):239-245. [PubMed] [CrossRef]

8. Can-Karabulut D, Oz FT, Karabulut B, Batmaz I, Ilk O. Adhesion to primary and permanent dentin and simple model approach. *Eur J Dent*. 2009 Jan;3(1):32-41. [PubMed]

9. Christensen GJ. Self-etching primers are here. *J Am Dent Assoc*. 2001 Jul;132(7):1041–1043. [PubMed]

10. Courson F. Bouter D, Ruse ND, Degrange M. Bond strength of nine current dentine adhesive systems to primary and permanent teeth. *J Oral Rehabil*. 2005 Apr;32(4):296-303. [PubMed] [CrossRef]

11. Eliades G., Watts D.C., Eliades T. Dental hard tissues and bonding. Springer 2005; 109-122.

12. Fagan TR. Crall JJ, Jensen ME, Chalkley Y, Clarkson B. A comparison of two dentin bonding agents in primary and permanent teeth. *Pediatr Dent*. 1986 Jun;8(3):144-146. [PubMed]

13. Fowler CS. Swartz ML, Moore BK, Rhodes BF. Influence of selected variables on adhesion testing. *Dent Mater*. 1992 Jul;8(4):265-269. [PubMed] [CrossRef]

14. Hosoya Y, Kawashita Y, Yoshida M, Suefuji C, Marshall GW Jr. Fluoridated Light-Activated Bonding Resin Adhesion to Enamel and Dentin: Primary vs. Permanent. *Ped Dent*. 2000 Mar-Apr;22(2):101-106. [PubMed]

15. Hosoya Y, Nishiguchi M, Kashiwabara Y, Horiuchi A, Goto G. Comparison of two dentin adhesives to primary vs. permanent bovine dentin. *J Clin Pediatr Dent*. 1997 Fall;22(1):69-76. [PubMed]

16. Kaaden C, Powers JM, Friedl KH, Schmalz G. Bond strength of self-etching adhesives to dental hard tissues. *Clin Oral Invest*. 2002 Sep;6(3):155–60. [PubMed] [CrossRef]

17. Kenshima S, Francci C, Reis A, Loguercio AD, Filho LE. Conditioning effect on dentin, resin tags and hybrid layer of different acidity self-etch adhesives applied to thick and thin smear layer. *J Dent*. 2006 Nov;34(10): 775-783. [PubMed] [CrossRef]

18. Luz MA, Arana-Chaves VE, Netto VG. Scanning electron microscopy examination of 3 different adhesive systems. *Quintessence Int*. 2005 Oct;36(9):687-694. [PubMed]

19. Marquezan M, da Silveira BL, Burnett LH Jr, Rodrigues CR, Kramer PF. Microtensile Bond Strength of Contemporary Adhesives to Primary Enamel and Dentin. *J Clin Pediatr Dent*. 2007 Winter;32(2):127–132. [PubMed]

20. Mazzeo N, Ott NW, Hondrum SO. Resin bonding to primary teeth using three

adhesive systems. *Pediatr Dent.* 1995 Mar-Apr;17(2):112-115. [PubMed]

21. Nur JE, Feigal RJ, Dennison JB, Edwards CA. Dentin Bonding: SEM Comparison of the Dentin Surface in Primary and Permanent Teeth. *Pediatr Dent*. 1997 May-Jun;19(4):246-252. [PubMed]

22. Naughton WT, Latta MA. Bond strength of composite to dentin using self-etching adhesive systems. *Quintessence Int.* 2005 Apr;36(4):259–262. [PubMed]

23. Nur JE, Feigal RJ, Dennison JB, Edwards CA. Dentin bonding: SEM comparison of the resin dentin interface in primary and permanent teeth. *J Dent Res.* 1996 Jun;75(6):1396-1403. [PubMed] [CrossRef]

24. Oztas N, Olmez A. Effects of one versus two applications of a self-etching adhesive to dentin of primary teeth: a SEM study. *J Contemp Dent Prac.* 2005 Feb 15;6(1):18–25. [PubMed]

25. Peumans M, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, Van Meerbeek B. Clinical effectiveness of contemporary adhesives: a review of current clinical trials. *Dent Mater.* 2005 Sep;21(9):864-881. [PubMed] [CrossRef]

26. Rocha R , Soares FZ, Rodrigues CR, Rodrigues Filho LE. Influence of Aging Treatments on Microtensile Bond Strength of Adhesive Systems to Primary Dentin. *J Dent Child (Chic).* 2007 May-Aug;74(2):109-112. [PubMed]

27. Senawongse P, Harnirattisai C, Shimada Y, Tagami J. Effective bond strength of current adhesive systems on deciduous and permanent dentin. *Oper Dent*. 2004 Mar-Apr;29(2):196–202. [PubMed]

28. Shumikawa DA, Marshall GW, Gee L, Marshall SJ. Microstructure of primary tooth dentin. *Pediatr Dent.* 1999 Nov-Dec;21(7):439-444. [PubMed]

29. Soares FZ, Rocha Rde O, Raggio DP, Sadek FT, Cardoso PE. Microtensile bond strength of different adhesive systems to primary and permanent dentin. *Pediatr Dent.* 2005 Nov-Dec;27(6):457–462. [PubMed]

30. Stalin A, Varma BR, Jayanthi. Comparative Evaluation of Tensile-Bond Strength, Fracture Mode and Microleakage of Fifth, and Sixth Generation Adhesive Systems in Primary Dentition. *J Indian Soc Pedod Prev Dent.* 2005 June;23(2):83-88. [PubMed] [CrossRef]

31. Strydom C. Self-etching adhesives: review of adhesion to tooth structure part I. *SADJ.* 2004 Nov;59(10): 413, 415-417, 419. [PubMed]

32. Swift JE Jr. Dentin/Enamel Adhesives: Review of the Literature. *Pediatr Dent.* 2002 Sep-Oct;24(5): 456-460. [PubMed]

33. Technical specification ISO/TS 11405. Dental materials –testing of adhesion to tooth structure. Switzerland; 2003.

34. Torres CP, Corona SA, Ramos RP, Palma-Dibb RG, Borsatto MC. Bond Strength of Self-etching Primer and Total-etch Adhesive Systems to Primary Dentin. *J Dent Child (Chic).* 2004 May-Aug;71(2):131-134. [PubMed]

35. Uekusa S, Yamaguchi K, Miyazaki M, Tsubota K, Kurokawa H, Hosoya Y. Bonding efficacy of single-step self-etch systems to sound primary and permanent tooth dentin. *Oper Dent.* 2006 Sep-Oct;31(5):569–576. [PubMed] [CrossRef]

36. 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 May-Jun;28(3):215-235. [PubMed]

37. Van Meerbeek B. Inokoshi S, Braem M, Lambrechts P, Vanherle G. Morphological aspects of the resin-dentin interdiffusion zone with different dentin adhesive systems. *J Dent Res*. 1992 Aug;71(8):1530-1540. [PubMed] [CrossRef]

38. Van Meerbeek B. Van Landuyt K, De Munck J, Hashimoto M, Peumans M, Lambrechts P, et al. Technique-Sensitivity of Contemporary Adhesives. *Dent Mater J.* 2005 Mar;24(1):1-13. [PubMed]

39. Van Meerbeek B, Yoshida Y, Lambrechts P, Vanherle G, Duke ES, Eick JD, et al. A TEM Study of Two Water-Based Adhesive Systems Bonded to Dry and Wet Dentin. *J Dent Res*. 1998 Jan;77(1):50-59. [PubMed] [CrossRef]

40. Windley W 3rd, Ritter A, Trope M. The effect of short-term calcium hydroxide treatment on dentin bond strengths to composite resin. *Dental Traumatol.* 2003 Apr;19(2):79-84. [PubMed] [CrossRef]

41. Yaseen SM, Subba Reddy VV. Comparative evaluation of shear bond strength of two self-etching adhesives (sixth and seventh generation) on dentin of primary and permanent teeth: An *in vitro* study. *J Indian Soc Pedod Prevent Dent.* 2009 Jan-Mar;27(1): 33-38. [PubMed] [CrossRef]

Corresponding author:
Natalia Gateva
Department of Pediatric Dentistry, Faculty of Dentistry, Medical University, Sofia
1, St. Georgi Sofiiski str., 1431 Sofia, Bulgaria
e-mail: nataliagateva@yahoo.de