Differences in tensile adhesion strength between HEMA and nonHEMA-based dentin bonding applied on superficial and deep dentin surfaces

by Devi Eka Juniarti

Submission date: 02-Apr-2023 07:50PM (UTC+0800)
Submission ID: 2053385265
File name: nsile_adhesion_strength_between_HEMA_and_nonHEMA-based_2017.pdf (472.18K)
Word count: 3651
Character count: 19717

Dental Journal
Majalah Kedokteran Gigi

Dental Journal
(Majalah Kedokteran Gigi)
2017 March; 50(1): 14–18

Research Report

Differences in tensile adhesion strength between HEMA and non-HEMA-based dentin bonding applied on superficial and deep dentin surfaces

Eresha Melati Kusuma Wurdani, Adioro Soetojo, and **Devi Eka Juniarti**
Department of Conservative Dentistry
Faculty of Dental Medicine, Universitas Airlangga
Surabaya – Indonesia

ABSTRACT

Background: *Improvement in dentistry shows some progresses, due to patients awareness on the importance of dental care. Cervical lesion is the most common phenomenon which oftenly found 46.36% in man and 38.13% in woman. Cervical lesions need composite restoration for treatment to stop the process of tissue damage. The process of adhesion of composite restoration material to the structure of the tooth is not easily separated and it needs optimal function in the oral cavity. Application of dentin bonding agents to attach the composite is needed. Selection of HEMA-based bonding material and Hema free-based bonding material which have a different solvent in their composition, as applied to the dentin superficial and deep dentin, affect the results of debonding test. Debonding test is done to measure the adhesion strength of a bonding material.* ***Purpose:*** *The purpose of this study was to analyze differences in tensile bond strength of dentine bonding HEMA-based and HEMA-free based after application in superficial and deep dentine surfaces.* ***Method:*** *The tooth of the bovine was as samples. A superficial dentine sample was taken from 0.5-1 mm of dentino enamel junction and a deep dentine sample was taken from 0.5 mm culmination of pulp horn. Dentine surface area was equal to* $p \times r^2 = (3.14 \times 2^2) = 12.56$ *mm*^{2}*. Six samples of HEMA-based bonding was applied to the dentine superficial. Six samples of HEMA-free based bonding was applied to the superficial dentine. Six samples of HEMA-based bonding was applied to the deep dentine. Six samples of HEMA-free based bonding was applied to the deep dentine. Tensile strength was measured using an Autograph AG-10TE.* ***Result:*** *There were differences tensile bond strength of dentine bonding HEMA-based and HEMA-free based after the application on superficial (p=0.000) and deep dentine surfaces (p=0.000).* ***Conclusion:*** *There were differences tensile bond strength of dentine bonding HEMA-based and HEMA-free based after the application on superficial and deep dentine surfaces. The use of dentine bonding materials HEMA-free based were better than HEMA-based after application on different dentine depths.*

Keywords: *HEMA-based; HEMA-free based; superficial dentine; deep dentin*

Correspondence: Eresha Melati Kusuma Wurdani, Department of Conservative Dentistry, Faculty of Dental Medicine, Universitas Airlangga. Jl. Mayjend. Prof. Dr. Moestopo no. 47 Surabaya 60132, Indonesia. E-mail: eresha.melati@yahoo.com

INTRODUCTION

Development in the field of dentistry is growing in line with real demand of patients for dental care. Recently, cervical lesions with open cementum and dentin areas that can make teeth experience a sensitive to changes in temperature have commonly been found. The cervical lesions can be caused by toothbrush abrasion. Today, the number of erosion on dentin area increases. A previous research showed that the prevalence of cervical lesions in males was 46.36%, while in females it was 38.13%.[1] Dental fillings applied on the dentin area have been known to have an ability to stop the process of tissue damage, but the attachment process of filling materials to the tooth structure is complex, especially the attachment to the dentine.[2] This condition is caused by differences in the density of dentinal tubules and the level of water content in each dentin depth.[3]

Dental Journal (Majalah Kedokteran Gigi) p-ISSN: 1978-3728; e-ISSN: 2442-9740. Accredited No. 56/DIKTI/Kep./2012.

Available at http://e-journal.unair.ac.id/index.php/MKG
DOI: 10.20473/j.djmkg.v50.i1.p14-18

The lowest level of water is found in supeficial dentin, while the highest level is found in deep dentin. In the superficial dentin, there are fewer tubules. As a result, when dentin bonding penetrates into intertubular dentin, responsible for providing adhesion strength between dentin and dental restorative materials, the adhesion strength will become lower. In the deep dentin, there are numerous dentin tubules. Therefore, the permeability of intratubular resin will have higher adhesion strength.[4]

Dentin is a tissue that is always wet because of the presence of fluid in the dentin tubules. Thus, composite resins with hydrophobic properties cannot be attached to the dentin easily. Consequently, a bonding material for dentin and composites is required.[2] The application of adhesive resin material aims to form the bond between resin composites and tooth structure, derived from bonding system using adhesion technique.[5,6]

Dentin bonding is composed of 2-hydroxyethyl methacrylate (HEMA)-based material and non-HEMA-based material. However, the HEMA-based dentin bonding material is mostly often used because it has several advantages, namely relatively easy to manufacture, surviving long enough because of the addition of a preservative, and serving as hydrophobic and hydrophilic groups.[5,7] On the other hand, the non-HEMA-based dentin bonding generally has monomer, called as urethane dimethacrylate (UDMA). UDMA can form a congested cross-link polymer, resulting in increased mechanical strength. Each dentin bonding material also has different solvent composition. The composition greatly affects the adhesion strength of dentin bonding to the collagen fibrils.[8] Therefore, this research aimed to analyze whether there are differences in tensile adhesion strength between HEMA-based dentin bonding and non-HEMA-based dentin bonding applied on the surfaces of the superficial and deep dentin.

MATERIAL AND METHOD

This research was a laboratory experimental research with a One-way ANOVA design. Samples used in this research were teeth (bovine) obtained from a slaughterhouse in Pegirian, Surabaya. Those bovines selected were healthy and plump. After slaughtered, their good incisors were removed and cleaned with a brush and a sharp scalpel under running water. Soft tissue that still attached was disposed carefully. Those prepared teeth then were soaked in saline and stored in a refrigerator at a temperature 4° C.[5]

Afterwards, superficial dentin located 0.5-1 mm from dentino enamel junction was taken (Figure 1). Meanwhile, deep dentine located 0.5 mm from the top of pulp horn was taken. Dentin surface area used in this research was equal to p x r2 = (3.14 x 22) = 12.56 mm^2 (Figure 2).

Samples were divided into four groups. Group I was consisted of six samples using HEMA-based (Ivoclar vivadent, Inc., United States and Canada) dentin bonding applied on the surface of the superficial dentin. Group II was consisted of six samples using non-HEMA-based (G-ænial Bond ™ Inc., GC Europe) dentin bonding applied on the surface of the superficial dentin. Group III was consisted of six samples using HEMA-based dentin bonding applied on the surface of the deep dentin. Group IV was consisted of six samples using non-HEMA-based dentin bonding applied on the surface of the deep dentin.

All of the superficial and deep dentin taken was smeared with 37% phosphoric acid gel (Ivoclar vivadent, Inc., United States and Canada) for 10 seconds. The dentin was washed with water for ± 10 seconds, and then dried by cotton to remove excessive water. Two drops (0.02 grams) of the HEMA-based dentin bonding material were dropped on a disposable brush (according to the manufacturer's instructions), then smeared on the dentin (twice), and settled for 20 seconds. The dentin then was sprayed with an air spray of chip blower for 5 seconds to remove excessive solvent (solvent contained in the primer solution, namely water), and then curing was carried out for 10 seconds (according to the manufacturer's instructions). Cylinder cast was inserted into lower plunger and then fixed by installing a lock. Cylinder cast on the upper plunger then

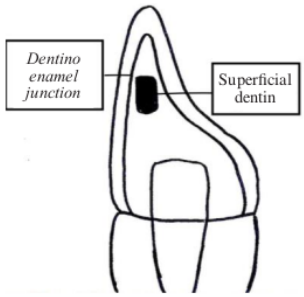

Figure 1. Illustration of the superficial dentin located 0.5-1 mm from dentino enamel junction (A sign black in the image refers to the superficial dentin).

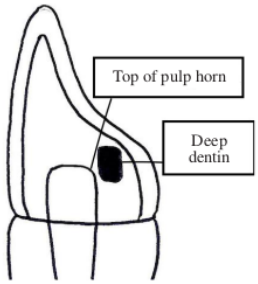

Figure 2. Illustration of the deep dentin located 0.5 mm from the top of pulp horn (A sign black in the image refers to the deep dentin).

Dental Journal (Majalah Kedokteran Gigi) p-ISSN: 1978-3728; e-ISSN: 2442-9740. Accredited No. 56/DIKTI/Kep./2012.
 Available at http://e-journal.unair.ac.id/index.php/MKG
DOI: 10.20473/j.djmkg.v50.i1.p14-18

was filled with composite, assembled with the lower plunger, and fixed by installing a lock. Irradiation was performed using a light cure for 20 seconds on both sides of the plunger, 10 seconds for each. It would harden within 2 minutes. Tensile strength test then was performed using a TE autograph (AG-10 Shimadzu, Japan). In all cases, the results were considered statistically significant with a p value <0.05

RESULTS

Visual illustration of the mean tensile adhesion strength of HEMA and non-HEMA-based dentin bonding applied on the surfaces of the superficial and deep dentin can be seen in Figure 3:

Results of the normality test using the Kolmogorov-Smirnov test showed a significance value (p) of >0.05. The data obtained were normally distributed. Moreover, results of the homogeneity test using the Levene test showed a significance value (p) of 0.343 (significance (p) value is (>0.05). Therefore, it was indicated that the data obtained were homogeneous. Furthermore, results of the difference test using the One-way ANOVA test showed a significance value (p) of 0.000, it means that there were significant differences in tensile adhesion strength between HEMA-based dentin bonding and non-HEMA-based dentin bonding applied on the surfaces of the superficial and deep dentin. Consequently, the use of non-HEMA-based dentin bonding was better than the use of HEMA-based dentin bonding applied on different dentin depths (Table 1).

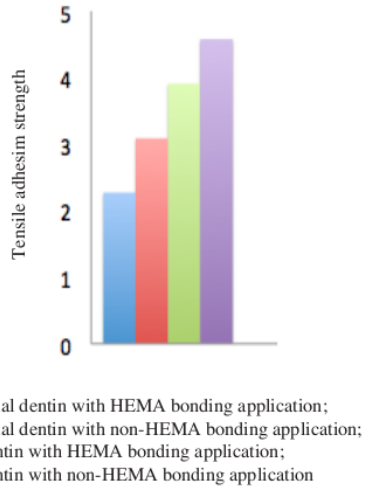

Figure 3. The mean tensile adhesion strength of HEMA and non-HEMA-based dentin bonding applied on the surfaces of the superficial and deep dentin (MPa).

Table 1. Results of the difference test on the tensile adhesion strength of HEMA and non-HEMA-based dentin bonding applied on the surfaces of the superficial and deep dentin (MPa)

Group	n	Mean	SD	p
I	6	2.2733	0.08506	0.000
II	6	3.0888	0.06769	
III	6	3.9110	0.08340	
IV	6	4.5788	0.09750	

DISCUSSION

The tensile strength obtained in this research was derived from the adhesion strength between HEMA based bonding resins and non-HEMA based bonding resins applied on the surfaces of the superficial and deep dentin. Based on Figure 1, it can be seen that the first tensile adhesion strength was found in non-HEMA-based dentin bonding applied on the surface of the deep dentin. The second adhesion strength was found in HEMA-based dentin bonding applied on the surface of the deep dentin. The third tensile adhesion strength was found in non-HEMA-based dentin bonding applied on the surface of the superficial dentin. And, the fourth tensile adhesion strength was found in HEMA-based dentin bonding applied on the surface of the superficial dentin. It can be said that the use of non-HEMA-based dentin bonding on different dentin depths was better than the use of HEMA-based dentin bonding.

Non-HEMA based bonding generally has monomers, called as urethane dimethacrylate (UDMA). UDMA can form a congested cross-link polymer, resulting in increased mechanical strength. When the polymer is stretched or tensed due to polymerization contraction, it can prevent individual chains form sliding over each other. When the polymerization is disappeared during stress condition, the cross-link polymer chains can move back to the starting position, so the object will be back to the previous form. UDMA also has a higher molecular weight, so UDMA can increase the degree of polymerization.[9,10]

In addition, each of dentin bonding materials has a different solvent composition. The composition greatly affects the tensile adhesion strength of dentin bonding to the collagen fibrils. Solvents commonly used are acetone and alcohol (ethanol).[9] Solvents are required to remove water from the surface of dentin to prepare collagen tissue for adhesive resin infiltration.[11] Priming materials can increase the diffusion of resin into the demineralized and humid dentin, leading to optimal micromechanical bond.[12] Therefore, in this research, HEMA-based bonding resin used contains alcohol solvent, while non-HEMA based bonding resin contains acetone.

The application of non-HEMA based bonding resin contains acetone on the superficial and deep dentin in this research could trigger higher tensile adhesion strength than

Dental Journal (Majalah Kedokteran Gigi) p-ISSN: 1978-3728; e-ISSN: 2442-9740. Accredited No. 56/DIKTI/Kep./2012.

Available at http://e-journal.unair.ac.id/index.php/MKG
DOI: 10.20473/j.djmkg.v50.i1.p14-18

the application of HEMA-based bonding resin containing alcohol solvent. That is because acetone contained in the non-HEMA based bonding resin can rapidly evaporate, causing optimal removal of water from the surface of the dentin, greater sensitivity to dentin humidity, and better dentin wetting than the alcohol solvent. Thus, infiltration of resin with collagen fibrils was getting higher. The attachment of non-HEMA based bonding resin to collagen fibrils then can form more hybrid layers, leading to stronger adhesion properties.[6,11]

On the other hand, the results of this research also showed that the use of HEMA-based bonding resin containing alcohol solvent could generate lower tensile strength of the attachment than the use of non-HEMA based bonding resin. That is because alcohol contained in the HEMA based bonding resin possess longer evaporate, causing the non-optimal removal of water from the surface of the dentin, lower sensitivity to dentin humidity, and worse dentin wetting than acetone contained in the non-HEMA based bonding resin. Consequently, infiltration of resin with collagen fibrils was getting lower. The attachment of HEMA based bonding resin to collagen fibrils then can form fewer hybrid layers, leading to weaker adhesion properties.[6,11]

The adhesion tensile strength of the non-HEMA-based dentin bonding on different dentin depths was better than the adhesion tensile strength of the HEMA-based dentin bonding. HEMA-based bonding, according to some previous researches, clinically has some weaknesses. One of them is that the material can be considered as the most common sensitizer to induce hypersensitivity in the teeth.[9] Several previous researches even have shown significant cytotoxic effects associated with methacrylate monomers contained in HEMA-based dentin bonding. Therefore, there is a dentin bonding material alternative in the form of non-HEMA-based dentin bonding that can be considered as a good choice.[3]

In this research, the adhesion strength value of HEMA-based bonding in the superficial dentin was 2.2733 Mpa. Meanwhile, the adhesion strength value of non-HEMA-based bonding in the superficial dentin was 3.0888 Mpa. The adhesion strength value of HEMA-based bonding in the deep dentin was 3.9110 Mpa. Meanwhile, the adhesion strength value of non-HEMA-based bonding in the deep dentin was 4.5788 MPa. Those values were quite small when compared with the adhesion strength values of the dentin bonding resin materials in other several previous researches.[5] In a previous research, the high tensile adhesion strength values were ranging from 10.02250 Mpa to 16.7375 Mpa.[5] Clinically, a good tensile adhesion strength value is about 5 MPa. These low tensile adhesion strength values actually could be caused due to some difficulties found in this research. One of them is because of not considering humidity dentin in detail. To generate the optimal humidity, drying should be performed using dry-bonding technique to prevent over-wet phenomenon. Unfortunately, this research did not measure humidity on the dentin scientifically. As a result, there were two possibilities occurred. The dentin was too dry as a result of the drying process. Thus, the collagen fibrils were collapse, and the water of the solvent was not enough to make the collagen do re-expansion. The dentin just did not completely dry in the drying process, and then added with water from the solvent. Therefore, the phenomenon of over-wet still occurred. Both possibilities then could lower the interaction between the bonding resin and the dentin collagen fibrils, resulting in lower adhesion strength as described previously.

Another difficulty in this research was a limitation on the tool (plunger set) used. This tool was not able to create the same filling procedure with clinical circumstances. In the clinical circumstances, composites were applied layer by layer, and then irradiation was carried out on the entire surface of the composites. Meanwhile, in this research, composites were applied only on the upper plunger set, providing a composite cast, and then assembled with the lower plunger set, containing specimens of teeth applied with dentin bonding before. After that, radiation was performed. Radiation, unfortunately, could not be performed in all parts of the surface of the composites. Radiation was only conducted on the exterior surfaces of the two sides that were visible through the gap of the plunger sets.

The results of tensile strength test showed that there were 70% of the dentin bonding resin materials released from the dentin in wet conditions, especially on the area of dentin hybrid layer. This is because the structure of collagen fibrils are very soft and easily cut when compared with the structures of dentin-bonding resin polymerization and composite-bonding resin polymerization. When observed with a microscope, it is known that dentin tubules are not aligned. Consequently, the anchoring of the collagen fibrils releasing the bonding resin is located in composite resin area, bonding resin layer, and demineralized dentin (30%).[12]

The release of the dentin bonding resin materials was expected to occur in the interface area of both the materials. After applying the bonding resin solution, the composite filling material then was applied on the top of it. During its polymerization, the bonding resin then would be covalently attached to the composite, considered as a primary chemical bond, strong enough for both resins as derivatives of methacrylate groups. Consequently, the risk of the release of the bonding resin materials in composite resin area, bonding resin layer, and demineralized dentin, not at the interface area of the dentin bonding resins, can be ignored.

The use of HEMA based bonding resin containing alcohol solvent can generate lower tensile adhesion strength than the the use of non-HEMA based bonding resin containing acetone. The density of dentin tubules and the level of water contained at each dentin depth is also known to have a great effect on the use of both bonding resin on the surfaces of the supeficial and deep dentin. The superficial dentin has lower water level and fewer tubules. The dentin

Dental Journal (Majalah Kedokteran Gigi) p-ISSN: 1978-3728; e-ISSN: 2442-9740. Accredited No. 56/DIKTI/Kep./2012.
 Available at http://e-journal.unair.ac.id/index.php/MKG
DOI: 10.20473/j.djmkg.v50.i1.p14-18

bonding penetrating into the intertubular dentin responsible for providing adhesion strength between dentin and dental restorative materials will have lower adhesion strength. On the other hand, the deep dentin has higher water level and more numerous tubules. Therefore, the permeability of the intratubular resin has higher adhesion strength.[3]

Finally, it can be concluded that there were differences in the tensile adhesion strength of HEMA and non-HEMA-based dentin bonding materials applied on the surfaces of the superficial and deep dentin. The use of non-HEMA-based dentin bonding material on different dentin depths was also known to be better than the use of non-HEMA-based dentin bonding material.

REFERENCES

1. Al Zahawi AR, Mahmood MA, Talabani RM, Mansoor RA. The prevelence and causes of dental non carious cervical lesion in the sulaimani population (cross-sectional study). IOSR Journal of Dental and Medical Sciences 2015; 14(8): 94-5.
2. Anusavice KJ. Philip's science of dental material. 11th ed. USA: WB Elsevier; 2003. p. 21, 24, 79, 251-9, 227-32.
3. Kumari RV, Siddaraju K, Nagaraj H, Poluri RK. Evaluation of shear bond strength of newer bonding systems on super cial and deep dentin. J Int Oral Health 2015; 7(9): 31–5.
4. Adioro S. Tensile bond strength of hydroxyethyl methacrylate (HEMA) bonding agent to bovine dentine surface at various humadity. Dental Journal (Majalah Kedokteran Gigi) 2006; 39(2): 59-62.
5. von Fraunhofer JA. Adhesion and cohesion. International Journal of Dentistry 2012; 2012: 1-9.
6. Craig RG. Restorative dental materials. 11th ed. London: Mosby; 2002. p. 57, 69-70, 232-40, 261, 269-70.
7. Bourbia M. Biodegradation of dental resin composite and adhesive by Streptococcus mutans: an in vitro study. Toronto: ProQuest; 2013. p. 6-13.
8. Papakonstantinou AE, Eliades T, Cellesi F, Watts DC, Silikas N. Evaluatin of UDMA's potential as a substitute for Bis-GMA in orthodontic adhesives. Dent Mater 2013; Dent Mater 2013; 29(8): 898-905.
9. van Dijken JWV. A randomized controlled 5-year prospective study of two HEMA-free adhesives, a 1-step self etching and a 3-step etch-and-rinse, in non-carious cervical lesions. Sweden: Dental materials; 2013. p. 271-80.
10. Felizardo KR, Lemos LVFM, de Carvalho RV, Junior AG, Lopes MB, Moura SK. Bond strength of HEMA-containing versus HEMA-free self-etch adhesive systems to dentin. Braz Dent 2011; 22(6): 468-72.
11. Cardoso MV, de Almeida Neves A, Mine A, Coutinho E, Van Landuyt K, De Munck J, Van Meerbeek B. Current aspects on bonding effectiveness and stability in adhesive dentistry. Aust Dent J. 2011; 56 (Suppl 1): 31-44.
12. Hashimoto M, Ohno H, Kaga M, Sano H, Endo K, Oguchi H. Fractured surface characterization: wet versus dry bonding. Dent Mater 2002; 18(2): 95-102.

Dental Journal (Majalah Kedokteran Gigi) p-ISSN: 1978-3728; e-ISSN: 2442-9740. Accredited No. 56/DIKTI/Kep./2012.

DOI: 10.20473/j.djmkg.v50.i1.p14-18

Differences in tensile adhesion strength between HEMA and nonHEMA-based dentin bonding applied on superficial and deep dentin surfaces

ORIGINALITY REPORT

9%	3%	7%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	"Abstracts of Papers", Journal of Dental Research, 2016 Publication	2%
2	journament.com Internet Source	1%
3	"Full Issue PDF", Operative Dentistry, 2017 Publication	1%
4	Rini Devijanti Ridwan, Yuliati, Sidarningsih, Fitri Mar'atush Sholihah, Mohammed Ahmed Qasim Aljunaid, Dur Mohammad Lashari. "A study of the mucoadhesive patches loaded with mangosteen peel extract in periodontitis", Journal of Taibah University Medical Sciences, 2021 Publication	1%
5	link.springer.com Internet Source	1%
6	"Full Issue PDF", Operative Dentistry, 2013 Publication	<1%

7	Sri Suparwitri, Niswati Fathmah Rosyida, Ananto Ali Alhasyimi. " Wheat seeds can delay orthodontic tooth movement by blocking osteoclastogenesis in rats ", Clinical, Cosmetic and Investigational Dentistry, 2019 Publication	<1 %
8	rigips.kiev.ua Internet Source	<1 %
9	www.scribd.com Internet Source	<1 %
10	Turki A Bakhsh, Bayan Al-Jeffery, Ghufran Zaatari, Hatoon Badr, Shada Ameen, Sarah Gashlan, Latifa Dughmash, Ahmed Jamleh. "Evaluation of the adaptation of dental polymers using cross-polarization optical coherence tomography", Biomedical Physics & Engineering Express, 2019 Publication	<1 %
11	www.e-journal.unair.ac.id Internet Source	<1 %
12	ojs.unud.ac.id Internet Source	<1 %
	eprints.ums.ac.id	

13 Internet Source <1%

Exclude quotes	Off	Exclude matches	< 10 words
Exclude bibliography	On		

Differences in tensile adhesion strength between HEMA and nonHEMA-based dentin bonding applied on superficial and deep dentin surfaces

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5