

Original Article

Effect of hemostatic agent on microshear bond strength of total-etch and self-etch adhesive systems

Maryam Hoorizad¹, Haleh Heshmat¹, Tara Ansar Hosseini², Seyedeh Sara Kazemi², Seyedeh Farnaz Tabatabaei³

¹Department of Restorative and Cosmetic Dentistry, Islamic Azad University, Tehran, ³Department of Restorative and Cosmetic Dentistry, Semnan University of Medical Science, Semnan, ²Dentist, Private Office, Tehran, Iran

ABSTRACT

Background: Application of hemostatic agents can negatively affect the bond strength of adhesive systems to dental substrate. This study aimed to assess the effect of ferric sulfate on microshear bond strength of four total- and self-etch adhesives to dentin after water storage.

Materials and Methods: In this *in vitro* study, 192 dentin slices with 2 mm thickness were made of 64 extracted sound human third molars. The samples were divided into 8 groups ($n = 24$) as follows: G1: Scotchbond Multi-Purpose, G2: hemostatic agent + Scotchbond, G3: Adper Single Bond, G4: hemostatic agent + Adper, G5: Clearfil SE Bond, G6: hemostatic agent + Clearfil, G7: Single Bond Universal, and G8: hemostatic agent + Single Bond Universal. Composite cylinders with 0.7 mm diameter and 1 mm height were bonded to the surfaces. Each group was then divided into two subgroups ($n = 12$) for water storage for 24 h and 3 months. The microshear bond strength was then measured. Data were analyzed using the Shapiro–Wilk test, three-way ANOVA, one-way ANOVA, and Tukey's test ($P < 0.05$).

Results: Application of ferric sulfate decreased the bond strength of all bonding agents after both 24 h and 3 months of storage; but, this reduction was not statistically significant ($P > 0.05$). Single Bond Universal at 24 h showed the highest and Adper Single Bond at 3 months showed the lowest bond strength ($P < 0.001$).

Conclusion: Dentin contamination with hemostatic agents negatively affects the bond strength of total- and self-etch adhesives.

Key Words: Adhesives, hemostatics, shear strength

Received: August 2018
Accepted: January 2019

Address for correspondence:
Dr. Seyedeh Farnaz
Tabatabaei,
Department of
Restorative and Cosmetic
Dentistry, Semnan
University of Medical
Science, Semnan, Iran.
E-mail: farnaztabatabaei96@gmail.com

INTRODUCTION

The demand for tooth-colored restorations is increasing worldwide.^[1] Appropriate isolation is among the most important factors determining the success and durability of composite restorations.^[2] Adequate isolation is particularly important at the gingival margins of restorations.^[2] In other words, to achieve maximum durability of

composite restorations, contamination of surfaces with blood or gingival crevicular fluid should be prevented^[2] because contamination of surfaces with blood or saliva decreases the resin bond strength to dentin in both total- and self-etch adhesive systems.^[3-6] Resin bonding to contaminated surfaces can cause microleakage at the restoration margins

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Hoorizad M, Heshmat H, Hosseini TA, Kazemi SS, Tabatabaei SF. Effect of hemostatic agent on microshear bond strength of total-etch and self-etch adhesive systems. *Dent Res J* 2019;16:361-5.

Access this article online	
	Website: www.drj.ir www.drjjournal.net www.ncbi.nlm.nih.gov/pmc/journals/1480

and subsequent development of secondary caries and restoration failure.^[7] Proteins, platelets, and macromolecules present in blood form a layer on dentin due to the affinity of dentin for proteins, which prevents resin penetration into dentin.^[8,9] This can decrease the bond strength to dentin by 30%–70%.^[10]

One commonly used technique to control bleeding during tooth restoration is the use of hemostatic agents. Hemostatic agents are hydrophilic and acidic.^[11] They remove the smear layer and demineralize dentin.^[12] Ferric sulfate is among the commonly used hemostatic agents. Application of ferric sulfate may cause changes in the morphology and properties of dentin and the smear layer.^[13] Controversy exists regarding the effects of hemostatic agents on the resin to dentin bond strength; however, the majority of studies on this topic have pointed to the negative effects of hemostatic agents on bond strength.^[14-16]

This study aimed to assess the effect of ferric sulfate hemostatic agent on bond strength of four total- and self-etch adhesive systems. The null hypothesis was that ferric sulfate would have no significant effect on the bond strength of the adhesive systems to dentin.

MATERIALS AND METHODS

This *in vitro*, cross-sectional study was performed on 64 selected sound human mandibular third molars with no cracks or caries extracted within the past 1 month. The study was approved by the Ethics Committee of Islamic Azad University, Dental Faculty, Tehran (No# 179). The teeth were rinsed and immersed in 0.5% chloramine T solution (Fisher Chemical, Fair Lawn, NJ, USA) for 24 h. The teeth were longitudinally sectioned into dentin slices with 2 mm thickness. The bonding surface of each slice was polished using 600-grit silicon carbide paper for 1 min under water coolant to obtain a

standard smear layer. After rinsing, the samples were randomly divided into 8 groups ($n = 24$) according to the type of bonding agent and use of hemostatic agent (Astringedent; Ultradent Product Inc., Utah, USA) as follows. Table 1 shows the composition of bonding agents used.

- Group 1: The surface was etched with 37% phosphoric acid for 15 s and rinsed for 30 s. Excess water was removed using a cotton pellet such that the surface remained moist. Scotchbond multipurpose primer was then applied on the surface and dried with gentle air spray. Bonding agent was then applied on the surface
- Group 2: Astringedent hemostatic agent was applied on the surface for 60 s followed by 60 s of rinsing. The remaining steps were performed as in Group 1
- Group 3: The surface was etched with 37% phosphoric acid for 15 s followed by 30 s of rinsing. Excess water was dried by a cotton pellet such that the surface remained moist. Adper Single Bond was then applied over the surface for 15 s and dried with gentle air spray for 5 s
- Group 4: Astringedent hemostatic agent was applied on the surface for 60 s followed by 60 s of rinsing. The remaining steps were performed as in Group 3
- Group 5: Clearfil SE Bond primer was applied on the surface, allowed 20 s, and dried with gentle air spray. The bonding agent was then applied on the surface, and a thin uniform layer was formed using gentle air spray
- Group 6: Astringedent hemostatic agent was applied on the surface for 60 s followed by 60 s of rinsing. The remaining steps were performed as in Group 5
- Group 7: Single Bond Universal was applied on the surface for 35 s and thinned with gentle air spray for 10 s
- Group 8: Astringedent hemostatic agent was applied on the surface for 60 s followed by 60 s of

Table 1: Materials used in this study

Adhesive systems	Composition	Manufacturer
Adper Scotchbond multi-purpose	Primer: HEMA, polyalkenoic acid polymer, water Bonding: Bis-GMA, HEMA, tertiary amines, photoinitiator	3M, ESPE, St Paul, MN, USA
Adper single bond	Bis-GMA, HEMA, dimethacrylates, polyalkenoic acid copolymer, initiators, water and ethanol	3M, ESPE, St Paul, MN, USA
Clearfil SE bond	Primer: MDP, HEMA, dimethacrylate Monomer, water, catalyst Bond: MDP, HEMA, dimethacrylate Monomer, microfiller, catalyst	Kuraray, Okayama, Japan
Single Bond Universal	MDP, Bis-GMA, HEMA, decamethylene DMA, ethanol, water, silane treated silica, 2-propenoic acid, -methyl-, reaction products with 1,10-decanediol and phosphorous oxide, copolymer of acrylic and itaconic acid, dimethylaminobenzoate(-4), camphorquinone, (dimethylamino) ethyl methacrylate, methyl ethyl ketone	3M, ESPE, St Paul, MN, USA

SE: Standard error

rinsing. The remaining steps were performed as in Group 7.

In all groups, adhesive was light cured using a light-emitting diode light-curing unit (Demetron LC; Kerr, Orange, CA, USA) with an intensity of 600 mW/cm². Cylindrical plastic molds with an internal diameter of 0.7 mm and 1 mm height were then mounted on the surface and filled with A2 shade of Z250 composite (3M ESPE, St. Paul, MN, USA). Composite resin was light cured for 40 s. Samples in each group were then randomly divided into two subgroups ($n = 12$) for measurement of microshear bond strength after 24 h and 3 months of storage in distilled water at 37°C. The microshear bond strength was measured in a universal testing machine (M350-10CT Testometric, Lancashire, United Kingdom) at a crosshead speed of 0.5 mm/min until debonding. The bond strength was recorded in megapascals (MPa). Data were analyzed using the Shapiro–Wilk test, three-way ANOVA, one-way ANOVA, and Tukey's test via SPSS version 22.0 (SPSS Inc., IL, USA) at 0.05 level of significance.

RESULTS

Table 2 shows the mean and standard deviation of microshear bond strength in different groups. Type of bonding agent had a significant effect on bond strength ($P = 0.045$) such that the bond strength of Single Bond Universal was averagely 3.40 MPa higher

than that of Scotchbond ($P = 0.019$) and 3.69 MPa higher than that of Adper Single Bond ($P = 0.011$).

Application of Astringedent hemostatic agent decreased the bond strength at both 24 h and 3 months. However, the effect of use/no use of Astringedent hemostatic agent and duration of water storage were not significant on bond strength ($P > 0.05$). The interaction effect of type of bonding agent and storage time on bond strength was statistically significant ($P < 0.001$) such that Single Bond Universal after 24 h of water storage (24.01 ± 1.58 MPa) and Clearfil SE Bond after 24 h of water storage (23.36 ± 1.66) yielded the highest and Adper Single Bond after 3 months of water storage (15.12 ± 1.24 MPa) and Clearfil SE Bond after 3 months of water storage (16.93 ± 0.87 MPa) yielded the lowest bond strength.

DISCUSSION

Most hemostatic agents are hydrophilic and acidic and can cause contamination of bonding surfaces.^[12] They can also demineralize dentin and affect the hybrid layer formed by different adhesive systems and as a result affect the bond strength of adhesive systems to tooth structure.^[16] The current results confirmed the null hypothesis regarding no significant effect of Astringedent hemostatic agent on bond strength since the reduction in bond strength was not significant in any of the total- or self-etch adhesive systems at any time point. In contrast to our findings, Arslan *et al.* reported a significant reduction in bond strength of total- and self-etch adhesive systems following the use of hemostatic agent.^[14]

Astringedent is a hemostatic agent containing 15.5% ferric sulfate ($\text{Fe}_2[\text{SO}_4]$). It is a hydrophilic solution with acidic properties ($\text{pH} = 1$), which can modify the dentin surface, hybrid layer, and smear layer in the etching and bonding process.^[17] Ferric sulfate can also cause coagulation of the organic collagen matrix or plasma matrix proteins in dentinal tubules,^[13] which can explain the reduction in bond strength to dentin following the use of this hemostatic agent. Kuphasuk *et al.*^[18] showed that the reduction in bond strength of the total-etch adhesive to dental substrate following the application of hemostatic agent was not significant, which was in agreement with our results. Many studies have reported significant reduction of bond strength of self-etch adhesives as the result of application of hemostatic agents.^[15,19] In the present

Table 2: Mean and standard error values of bond strength (MPa) in the different groups under study

Bonding	Astringedent	Time of evaluation	Mean±SE
Adper Scotchbond multi-purpose	Yes	24 h	18.77±2.56
		3 months	18.58±1.88
	No	24 h	19.42±2.42
		3 months	18.90±1.81
Adper single bond	Yes	24 h	21.58±2.42
		3 months	13.41±1.53
	No	24 h	22.69±2.11
		3 months	16.83±1.89
Clearfil SE bond	Yes	24 h	18.41±1.21
		3 months	15.45±1.16
	No	24 h	26.31±2.80
		3 months	20.41±1.43
Single Bond Universal	Yes	24 h	22.54±2.49
		3 months	16.02±1.39
	No	24 h	25.47±1.96
		3 months	25.23±2.37

SE: Standard error

Archive of SID

study, the bond strength of self-etch adhesives decreased following the application of ferric sulfate; however, this reduction was not significant. Such a controversy in the results may be attributed to different methodologies, sample preparation, and assessment of bond strength.

According to Ayo-Yusuf *et al.*,^[20] contamination of dentin surfaces with hemostatic agents changes the properties and morphology of dentin. They also demonstrated that dissolution of dentin smear layer following the application of hemostatic agents results in occlusion of dentinal tubules and formation of granular deposits, which remain even after acid etching^[20] and can decrease the bond strength of total-etch adhesives. However, this reduction in bond strength was not significant in our study because phosphoric acid can demineralize dentin due to its high acidity (pH = 0.5).^[12] Phosphoric acid also might degrade ferric sulfate.^[13] On the other hand, self-etch adhesives cannot cause adequate demineralization of dentin following the application of hemostatic agents due to their low acidity, which can decrease the bond strength.^[15] Insignificant reduction in bond strength of self-etch adhesives in this study following the application of ferric sulfate can be attributed to the presence of 10-Methacryloyloxydecyl dihydrogen phosphate (MDP) in the composition of these adhesives and formation of chemical bonds by the MDP.^[21]

In our study, the mean bond strength of Single Bond Universal was significantly higher than that of Scotchbond and Adper Single Bond. Anil *et al.*^[22] demonstrated that total-etch adhesives have higher technical sensitivity due to their higher clinical procedural steps and there is a risk of inadequate dentin surface moisture following rinsing and drying or contamination of bonding surfaces and consequent reduction in bond strength. On the other hand, Yoshida *et al.*^[21] indicated that the chemical bonds between MDP present in the composition of Single Bond Universal and tooth hydroxyapatite increase the bond strength.

Since the present study aimed to assess the effect of contamination of dentin surface with ferric sulfate on bond strength without stress application, the samples were not subjected to thermocycling.^[23] If thermocycling is performed, it increases the generalizability of results to the oral condition.

The current findings enhance the knowledge of clinicians regarding the effects of hemostatic agents on the quality of bonding of adhesives to dentin. Further studies are required to assess the efficacy of certain materials to decontaminate the surface from hemostatic agents.

CONCLUSION

Within the limitations of this *in vitro* study, the results showed that contamination of dentin surface with hemostatic agents could negatively affect the bond strength of total- and self-etch adhesives.

Acknowledgments

This study was resulted from two student thesis which supported by Islamic Azad University of Medical Sciences. The authors thank Islamic Azad University of Medical Sciences and Dental Research Center of Tehran University of Medical Sciences and Dr. Ghorbani for statistical analysis.

Financial support and sponsorship

Nil.

Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

REFERENCES

1. Beck F, Lettner S, Graf A, Bitriol B, Dumitrescu N, Bauer P, *et al.* Survival of direct resin restorations in posterior teeth within a 19-year period (1996-2015): A meta-analysis of prospective studies. *Dent Mater* 2015;31:958-85.
2. Carvalho RM, Manso AP, Geraldini S, Tay FR, Pashley DH. Durability of bonds and clinical success of adhesive restorations. *Dent Mater* 2012;28:72-86.
3. Nair P, Hickel R, Ilie N. Adverse effects of salivary contamination for adhesives in restorative dentistry. A literature review. *Am J Dent* 2017;30:156-64.
4. Kucukyilmaz E, Celik EU, Akcay M, Yasa B. Influence of blood contamination during multimode adhesive application on the microtensile bond strength to dentin. *Niger J Clin Pract* 2017;20:1644-50.
5. Taneja S, Kumari M, Bansal S. Effect of saliva and blood contamination on the shear bond strength of fifth-, seventh-, and eighth-generation bonding agents: An *in vitro* study. *J Conserv Dent* 2017;20:157-60.
6. Prasad M, Mohamed S, Nayak K, Shetty SK, Talapaneni AK. Effect of moisture, saliva, and blood contamination on the shear bond strength of brackets bonded with a conventional bonding system and self-etched bonding system. *J Nat Sci Biol Med* 2014;5:123-9.

7. Munaga S, Chitumalla R, Kubigiri SK, Rawtiya M, Khan S, Sajjan P, *et al.* Effect of saliva contamination on the shear bond strength of a new self-etch adhesive system to dentin. *J Conserv Dent* 2014;17:31-4.
8. Tachibana A, Castanho GM, Vieira SN, Matos AB. Influence of blood contamination on bond strength of a self-etching adhesive to dental tissues. *J Adhes Dent* 2011;13:349-58.
9. Neelagiri K, Kundabala M, Shashi RA, Thomas MS, Parolia A. Effects of saliva contamination and decontamination procedures on shear bond strength of self-etch dentine bonding systems: An *in vitro* study. *J Conserv Dent* 2010;13:71-5.
10. Ebrahimi SF, Shadman N, Abrishami A. Effect of ferric sulfate contamination on the bonding effectiveness of etch-and-rinse and self-etch adhesives to superficial dentin. *J Conserv Dent* 2013;16:126-30.
11. Tarighi P, Khoroushi M. A review on common chemical hemostatic agents in restorative dentistry. *Dent Res J (Isfahan)* 2014;11:423-8.
12. Pucci CR, Araújo RM, Lacerda AJ, Souza MA, Huhtala MF, Feitosa FA, *et al.* Effects of contamination by hemostatic agents and use of cleaning agent on etch-and-rinse dentin bond strength. *Braz Dent J* 2016;27:688-92.
13. Rodríguez-Priego ME, Bolaños-Carmona MV, González-López S, Rodríguez-Navarro A, Sánchez-Sánchez MP. Ferric sulphate alterations on primary dentin and the adhesive interface. *J Adhes Dent* 2014;16:347-56.
14. Arslan S, Ertaş H, Zorba YO. Influence of ankaferd blood stopper on shear bond strength of bonding systems. *Dent Mater J* 2012;31:226-31.
15. Ajami AA, Kahnamoii MA, Kimyai S, Oskoe SS, Pournaghi-Azar F, Bahari M, *et al.* Effect of three different contamination removal methods on bond strength of a self-etching adhesive to dentin contaminated with an aluminum chloride hemostatic agent. *J Contemp Dent Pract* 2013;14:26-33.
16. Xu X, Chen Q, Lederer A, Bernau C, Lai G, Kaisarly D, *et al.* Shear bond strength of two adhesives to bovine dentin contaminated with various astringents. *Am J Dent* 2015;28:229-34.
17. Bandi M, Mallineni SK, Nuvvula S. Clinical applications of ferric sulfate in dentistry: A narrative review. *J Conserv Dent* 2017;20:278-81.
18. Kuphasuk W, Harnirattisai C, Senawongse P, Tagami J. Bond strengths of two adhesive systems to dentin contaminated with a hemostatic agent. *Oper Dent* 2007;32:399-405.
19. Chaiyabutr Y, Kois JC. The effect of tooth-preparation cleansing protocol on the bond strength of self-adhesive resin cement to dentin contaminated with a hemostatic agent. *Oper Dent* 2011;36:18-26.
20. Ayo-Yusuf OA, Driessen CH, Botha AJ. SEM-EDX study of prepared human dentine surfaces exposed to gingival retraction fluids. *J Dent* 2005;33:731-9.
21. Yoshida Y, Yoshihara K, Nagaoka N, Hayakawa S, Torii Y, Ogawa T, *et al.* Self-assembled Nano-layering at the adhesive interface. *J Dent Res* 2012;91:376-81.
22. Anil A, Sekhar A, Thomas MS, Ginjupalli K. Haemostatic agents on the shear bond strength of self-adhesive resin. *J Clin Exp Dent* 2015;7:e356-60.
23. Tonial D, Ghiggi PC, Lise AA, Burnett LH Jr., Oshima HM, Spohr AM, *et al.* Effect of conditioner on microtensile bond strength of self-adhesive resin cements to dentin. *Stomatologija* 2010;12:73-9.