

Universal Adhesive Bond Performance in Randomized Clinical Trials: A Literature Review

Dr. Ali Rıza ÇETİN¹, Dr. Yasser Ismail Al Rawi¹

^{1, 2}Department of Restorative Dentistry, College of Dentistry, Selçuk University, Turkey

Abstract: ***Purpose of the review:** The purpose of this review was to summarize the existing clinical trials that evaluated the clinical performance of the universal adhesive bond when used with total-etch or self-etch mode by reviewing related literature. The review was done in Selçuk University, College of dentistry, by using the electronic library of the university. **Study selection:** An electronic search was conducted in EBSCOhost, PubMed, Wiley online library, Science direct databases. The following main keywords were used: "universal adhesive bond", "universal bond", "universal adhesive bond clinical trial" and "clinical trial of universal adhesive bond". We included the clinical trials that evaluated the clinical performance of universal adhesive bonds whether by using etch-and-rinse (wet or dry) or self-etch strategy (with or without selective enamel etching). We also included some clinical trials that evaluated the clinical performance of the traditional self-etch adhesive bond. **Result:** Only three clinical studies related to universal adhesive bond have been found and taken into consideration for the present review and some other clinical studies related to the traditional self-etch adhesive are also reviewed. **Conclusions:** On the basis of the limited reviewed studies, it can be concluded that currently there are no long-term clinical trials that evaluate the clinical performance of the universal adhesive, except for some clinical studies that evaluated its performance in noncarious cervical lesions. For this reason, it may be early to decide whether this adhesive (universal adhesive) is the ideal adhesive for all cases. For the reviewed studies, the universal adhesive showed acceptable clinical performance in NCCLs, especially when used in total or selective etch mode, and showed a decreased performance in marginal integrity when used in self-etch mode in the long-term evaluation.*

1. Introduction

The evolution of practical adhesive dentistry has started when Dr. Michael Buonocore found in 1955 that he could improve the retention of restorative materials by applying phosphoric acid to the enamel surface.¹ Since that time many studies and investigations have been made to develop and introduce an ideal adhesive. The early adhesive systems were generally ineffective, because they were unable to sufficiently penetrate the dentin smear layer due to their relatively hydrophobic nature and also because of the smear layer's low intrinsic cohesive strength.² The mechanism of adhesion has been described as a micromechanical bond which is achieved by penetration of resin into acid etched enamel.³ The differences between enamel and dentin in their histology, morphology and composition make the bonding to the phosphoric acid etched enamel more reliable than bonding to dentin which is considered to be more complicated.⁴ In order to achieve an adequate penetration of adhesive primer and resin into dentin, it was recognized that the smear layer should be completely removed and/or modified. With the use of total-etch (three-step or two-step) adhesive systems, the smear layer is completely dissolved with phosphoric acid and then removed during the rinsing step, thus resulting in exposing collagen fibers. In case of using self-etching systems (no phosphoric acid to be used), the smear layer will not be removed completely but will be modified and/or solubilized by the acidic primer.⁵ After removing and/or modifying the smear layer by these acids (total-etch) and/or acidic primers (self-etch) they create a thin zone of demineralization and exposing the collagen fibers that will be infiltrated later by primers and resins. Nakabayashi et al.⁶ described the formation of a hybrid layer which is a transitional layer consists of both resin and tooth substrate.

Within the last 25 years, many changes have been made to the dentin adhesives in order to produce an ideal adhesive system. For example, the number of application steps has been reduced from three or two-step adhesive to one-step adhesive (all in one 7th generation). Several clinical studies of self-etch adhesive systems showed that the performance of these adhesives can be improved when used with selective enamel etching technique.^{7,8} But for the dentin, the use of self-etch adhesives in a total-etch mode is not recommended in order to prevent the postoperative sensitivity from occurring.^{9,10} The postoperative sensitivity that happens with total-etch mode because of partial infiltration of resin monomer into the collagen fibers can be significantly reduced when self-etch adhesive is used, because of the integration of the smear layer, collagen, mineral, and resin into the hybrid layer.^{11,12} The introduction of universal adhesives has allowed dentists to use these new adhesive systems according to the clinical situation they have, they can be used as etch and rinse adhesives, self-etch adhesives or with a selective etch technique. Some clinical studies showed no significant difference in the retention of restorations of NCCLs when a universal adhesive was used in total-etch, self-etch, or selective etch modes after 6 and 18 months.^{13,14} On the other hand, the study showed signs of marginal defectiveness at 18 months in the restorations placed using self-etch mode.¹⁴ The reason behind enamel marginal discrepancies is that self-etch adhesives are not efficient (due to their lower pH) to etch enamel deeply as phosphoric acid does, causing weak enamel bond and subsequent occurrence of marginal defects.¹¹ To avoid this defect from occurring, it has been recommended to treat the enamel with phosphoric acid by what is called selective enamel etching before the application of self-etch adhesives.¹⁵

For the dentin, when phosphoric acid is applied prior to the self-etch adhesive, the bond strengths may be affected and

decrease.⁹In addition to that, the later formed hybrid layer may undergo degradation when acid-etched dentin is over dried, so the resin is not completely penetrating into the collagen fibers, resulting in low bonding quality.^{16,17}

For the universal adhesives, the manufacturers added the MDP (methacryloyloxydecyl dihydrogen phosphate) or 10 MDP to the universal adhesives as an acidic functional monomer. The addition of MDP to the universal adhesives makes it able to form a chemical bond between MDP components (polymerizable methacrylate group and a phosphate group) and the calcium in hydroxyapatite and forming a stable salt, which in result helps in creating a high bond strength and less degradation.¹⁸

In summary, the evolution of the dental adhesive systems which is represented by the introduction of the universal adhesives will ease the use of the adhesive materials and make the dentists choose their preferable way in using these adhesives in a manner compatible with the situation they have, especially that the universal adhesive can be used not only for bonding to enamel and dentin, but also as adhesive

on substrates such as zirconia, silica-based ceramics, composites, and noble and non-precious metals.

2. Materials and Methods

To identify trials to be included in this review, we searched the EBSCOhost, MEDLINE electronic databases via PubMed, Wiley online library, and Science direct by using the electronic library of the University of Selçuk, Konya, Turkey. No restrictions were placed on the publication date or languages.

We included randomized clinical trials (RCTs) that evaluated the clinical performance of universal adhesive in noncarious cervical lesions (NCCLs) and trials that compared the clinical performance of the universal adhesive used in self-etch and total-etch modes. We also included some clinical trials that evaluated the performance of the traditional self-etch adhesive. The included clinical trials are listed in Table 1.

Table 1: Studies included in this review

Study ID	Follow-ups	Number of subjects	Adhesive system	Number of restorations
1. Mena-Serrano et al. ¹³	6 months	39	Scotchbond Universal Adhesive (SU; 3M ESPE, St. Paul, MN, USA)	200
2. N.C. Lawson et al. ¹⁹	2 years	37	Scotchbond™ Universal Adhesive & Scotchbond™ Multi-purpose Adhesive	126
3. A.D. Loguercio et al. ²⁰	36 month	39	Scotchbond Universal Adhesive (SU; 3M ESPE, St. Paul, MN, USA)	200
4. Boeckler et al. ²¹	4 years	50	AdheSE (AS, Ivoclar Vivadent) & Excite (EX, Ivoclar Vivadent)	100
5. M. Peumans et al. ²²	13 years	29	Clearfil SE Bond (Kuraray Noritake)	100
6. EC Say et al. ²³	5 years	22	AdheSE (Ivoclar-Vivadent)	104

The USPHS and FDI evaluation criteria were used in all these studies.

3. Results

Only three clinical studies related to universal adhesive bond have been found and taken into consideration for the present review and some other clinical studies related to the traditional self-etch adhesive are also reviewed. One clinical study¹³ evaluated the 6-month clinical performance of Scotchbond Universal Adhesive (SU; 3M ESPE, St. Paul,

MN, USA) in noncarious cervical lesions (NCCLs). The results of the study showed no difference in the performance of the universal adhesive when used in any mode (selectiveetch, total-etch, and self-etch), but the marginal adaptation may be enhanced when the adhesive used with total-etch mode.¹³The other study¹⁹ compared the clinical performance of Scotchbond universal adhesive used in self- and total-etch modes and two-bottle Scotchbond Multi-purpose adhesive in total-etch mode in NCCLs. The results showed a reduced performance in the adhesive with time for enamel marginal adaptation and discoloration for both

adhesive materials even for the universal adhesive when used with self-etch or total-etch mode. Although there was no great difference in performance for the marginal adaptation between the two tested adhesives, the universal adhesive can perform better when used with total-etch technique.¹⁹The third study²⁰ which is a continuation of the first one evaluated the 36-month clinical performance of Scotchbond Universal Adhesive (SU, 3M ESPE) in (NCCLs). The results are almost the same for the 6-month study which showed no clinical problems related to retention or postoperative sensitivity. It showed the same result relating to bond degradation when the universal adhesive was used in self-etch mode.

The other included studies evaluated the performance of the self-etch adhesive with or without selective enamel etching. Boeckler et al.²¹ evaluated in their four-year study the clinical performance of two different adhesive systems. They compared two-step self-etch adhesive AdheSE (AS, Ivoclar Vivadent) to the etch and rinse adhesive system Excite (EX, Ivoclar Vivadent). The result of the study showed an acceptable clinical performance of both adhesive systems over time except for the marginal adaptation which showed deterioration after 4 years in self-etch adhesive. Peumans et al.²² evaluated the 13-year clinical performance of a mild two-step self-etch adhesive in NCCLs with and without prior enamel selective etching. The study showed great results for the two-step self-etch adhesive Clearfil SE Bond (Kuraray Noritake) in NCCLs after 13 years follow-up. Enamel marginal integrity was acceptable when enamel margins treated with phosphoric acid prior to applying the adhesive with no marginal discoloration.²² Say et al.²³ evaluated the five-year clinical performance of a two-step self-etch adhesive in non-carious cervical sclerotic lesions with or without enamel selective etching. Restorations placed with selective enamel etching showed better marginal integrity than restorations placed with the same adhesive but without selective enamel etching after five years follow-up. Most of the above-mentioned studies used the US Public Health Service criteria to clinically evaluate the restorations.

4. Discussion

The clinical performance of the universal adhesive is still vague to many clinicians since there are no many studies revealed its effectiveness in using in routine dental clinic work. Few numbers of studies have been made to evaluate the clinical performance of the universal adhesive in non-carious cervical lesions with a lack of studies that evaluate its performance in other tooth lesions. The universal adhesive contains the 10-MDP (10-methacryloyloxydecyl dihydrogen phosphate) as a functional acidic monomer which has the ability to bond chemically to enamel and dentin making the adhesive bond more strong and reliable. The monomer 10-MDP decalcifies hydroxyapatite²⁴ and combines with it to form a calcium stable salt.

Additionally, applying the universal adhesive with selective enamel etching may improve the bond strength and reduce enamel marginal defectiveness in long-term follow-up. The enamel acid etching may provide extra micromechanical enamel retention to the chemical bond provided by the 10-

MDP.¹³ On the other hand, when a 10-MDP-based adhesive applied in a self-etch mode, enamel marginal defects will be more common to see in clinical studies up to 8 years.^{11,25,26}

Reviewed clinical studies have shown no postoperative sensitivity in the follow-up recalls.^{54,55} When self-etch adhesive is applied, the smear layer becomes a part of the formed hybrid layer, which in result blocks the infiltration of fluid deep into the dentinal tubules and reduces post-operative sensitivity.

The presence of water as a content in the self-etch adhesives plays an important role in re-expanding the collapsed collagen fibers; and therefore, easing the penetration of the resin into the collagen network.^{27,28}

Some studies^{29,30} suggested that the adhesive should be applied by using rubbing movement which in result generates a mechanical pressure over the collapsed collagen fibers, allowing the adhesive to infiltrate into these collapsed collagen networks.³¹ In one study³², the authors suggested that the capability of water/HEMA to re-expand the collapsed collagen fibers depends on the percentage of water/HEMA exist in the adhesive material; with the increase of the water/HEMA percentage, the re-expansion increases.

On the other hand, the one-step self-etch adhesive contains both hydrophilic primers (HEMA), and the hydrophobic monomer, which allows water to infiltrate into the adhesive layer to form what is called water tree as a negative result, and finally causing hydrolytic degradation of the bond layer.

To overcome all these difficulties starting from choosing the appropriate adhesive to the way the adhesive should be applied, with less technique sensitivity, the universal adhesive may replace all early adhesive systems, due to its easy application and multimode using.

Unfortunately, few numbers of studies have evaluated the universal adhesive clinically for long-term, making our review difficult to some degree. In addition to the lack of studies that evaluate the performance of these adhesives in lesions other than non-carious cervical lesions.

5. Conclusions

On the basis of the limited reviewed studies, it can be concluded that currently there are no long-term clinical trials that evaluate the clinical performance of the universal adhesive, except for some clinical studies that evaluated its performance in non-carious cervical lesions. For this reason, it may be early to decide whether this adhesive (universal adhesive) is the ideal adhesive for all cases.

For the reviewed studies, the universal adhesive showed acceptable clinical performance in NCCLs, especially when used in total or selective etch mode, and showed a decreased performance in marginal integrity when used in self-etch mode in the long-term evaluation.

References

- [1] Buonocore M, Wileman W, Brudevold F. A report on a resin composition capable of bonding to human dentin surfaces. *Journal of Dental Research*. 1956;35(6):846-51.
- [2] Pashley D. Smear layer: Overview of structure and function. *Proceedings of the Finnish Dental Society SuomenHammaslaakariseuranToimituksia*. 1992;88:215-24.
- [3] Buonocore M, Matsui A, Gwinnett A. Penetration of resin dental materials into enamel surfaces with reference to bonding. *Archives of oral biology*. 1968;13(1):61IN1769IN19-67IN870IN20.
- [4] Alex G. FEATURES-COSMETIC DENTISTRY-Adhesive Dentistry in the New Millennium. *Oral Health*. 2000;90(4):59-66.
- [5] Alex G. Is total-etch dead? Evidence suggests otherwise. *CompendContinEduc Dent*. 2012;33(1):12-26.
- [6] Nakabayashi N, Kojima K, Masuhara E. The promotion of adhesion by the infiltration of monomers into tooth substrates. *Journal of Biomedical Materials Research Part A*. 1982;16(3):265-73.
- [7] Say EC, Özel E, Yurdagüven H, Soyman M. Three-year clinical evaluation of a two-step self-etch adhesive with or without selective enamel etching in non-carious cervical sclerotic lesions. *Clinical oral investigations*. 2014;18(5):1427-33.
- [8] Van Meerbeek B, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, Peumans M. A randomized controlled study evaluating the effectiveness of a two-step self-etch adhesive with and without selective phosphoric-acid etching of enamel. *Dental Materials*. 2005;21(4):375-83.
- [9] Torii Y, Itou K, Nishitani Y, Ishikawa K, Suzuki K. Effect of phosphoric acid etching prior to self-etching primer application on adhesion of resin composite to enamel and dentin. *American Journal of Dentistry*. 2002;15(5):305-8.
- [10] Van Landuyt K, Kanumilli P, De Munck J, Peumans M, Lambrechts P, Van Meerbeek B. Bond strength of a mild self-etch adhesive with and without prior acid-etching. *Journal of Dentistry*. 2006;34(1):77-85.
- [11] Peumans M, De Munck J, Van Landuyt K, Poitevin A, Lambrechts P, Van Meerbeek B. Eight-year clinical evaluation of a 2-step self-etch adhesive with and without selective enamel etching. *Dental Materials*. 2010;26(12):1176-84.
- [12] Carvalho RM, Chersoni S, Frankenberger R, Pashley DH, Prati C, Tay FR. A challenge to the conventional wisdom that simultaneous etching and resin infiltration always occurs in self-etch adhesives. *Biomaterials*. 2005;26(9):1035-42.
- [13] Mena-Serrano A, Kose C, De Paula EA, Tay LY, Reis A, Loguercio AD, et al. A new universal simplified adhesive: 6-month clinical evaluation. *Journal of Esthetic and Restorative Dentistry*. 2013;25(1):55-69.
- [14] Perdigão J, Kose C, Mena-Serrano A, De Paula E, Tay L, Reis A, et al. A new universal simplified adhesive: 18-month clinical evaluation. *Operative Dentistry*. 2014;39(2):113-27.
- [15] Frankenberger R, Lohbauer U, Roggendorf MJ, Naumann M, Taschner M. Selective enamel etching reconsidered: better than etch-and-rinse and self-etch? *Journal of Adhesive Dentistry*. 2008;10(5).
- [16] Hashimoto M, Ohno H, Kaga M, Endo K, Sano H, Oguchi H. In vivo degradation of resin-dentin bonds in humans over 1 to 3 years. *Journal of Dental Research*. 2000;79(6):1385-91.
- [17] Hashimoto M, Ohno H, Sano H, Tay FR, Kaga M, Kudou Y, et al. Micromorphological changes in resin-dentin bonds after 1 year of water storage. *Journal of Biomedical Materials Research Part A*. 2002;63(3):306-11.
- [18] Van Landuyt K, Yoshida Y, Hirata I, Snauwaert J, De Munck J, Okazaki M, et al. Influence of the chemical structure of functional monomers on their adhesive performance. *Journal of Dental Research*. 2008;87(8):757-61.
- [19] Lawson NC, Robles A, Fu C-C, Lin CP, Sawlani K, Burgess JO. Two-year clinical trial of a universal adhesive in total-etch and self-etch mode in non-carious cervical lesions. *Journal of Dentistry*. 2015;43(10):1229-34.
- [20] Loguercio AD, de Paula EA, Hass V, Luque-Martinez I, Reis A, Perdigão J. A new universal simplified adhesive: 36-Month randomized double-blind clinical trial. *Journal of dentistry*. 2015;43(9):1083-92.
- [21] Boeckler A, Boeckler L, Eppendorf K, Schaller H-G, Gernhardt CR. A prospective, randomized clinical trial of a two-step self-etching vs two-step etch-and-rinse adhesive and SEM margin analysis: four-year results. *Journal of Adhesive Dentistry*. 2012;14(6).
- [22] Peumans M, De Munck J, Van Landuyt K, Van Meerbeek B. Thirteen-year randomized controlled clinical trial of a two-step self-etch adhesive in non-carious cervical lesions. *Dental Materials*. 2015;31(3):308-14.
- [23] Say EC, Yurdagüven H, Özel E, Soyman M. A randomized five-year clinical study of a two-step self-etch adhesive with or without selective enamel etching. *Dental materials journal*. 2014;33(6):757-63.
- [24] Fukegawa D, Hayakawa S, Yoshida Y, Suzuki K, Osaka A, Van Meerbeek B. Chemical interaction of phosphoric acid ester with hydroxyapatite. *Journal of Dental Research*. 2006;85(10):941-4.
- [25] Perdigão J, Carmo AR, Anauate-Netto C, Amore R, Lewgoy HR, Cordeiro HJD, et al. Clinical performance of a self-etching adhesive at 18 months. *American journal of dentistry*. 2005;18(2):135-40.
- [26] Peumans M, De Munck J, Van Landuyt K, Lambrechts P, Van Meerbeek B. Five-year clinical effectiveness of a two-step self-etching adhesive. *Journal of Adhesive Dentistry*. 2007;9(1).
- [27] Gwinnett A. Moist versus dry dentin: its effect on shear bond strength. *American Journal of Dentistry*. 1992;5(3):127-9.
- [28] Reis A, Loguercio AD, Azevedo CLN, de Carvalho RM, Singer JDM, Grande RHM. Moisture spectrum of demineralized dentin for adhesive systems with different solvent bases. *Journal of Adhesive Dentistry*. 2003;5(3).
- [29] Dal-Bianco K, Pellizzaro A, Patzlaff R, de Oliveira Bauer JR, Loguercio AD, Reis A. Effects of moisture degree and rubbing action on the immediate resin-dentin bond strength. *Dental Materials*. 2006;22(12):1150-6.
- [30] Reis A, Pellizzaro A, Dal-Bianco K, Gomes O, Patzlaff R, Loguercio A. Impact of adhesive application to wet and dry dentin on long-term resin-dentin bond strengths. *Operative Dentistry*. 2007;32(4):380-7.
- [31] Zander-Grande C, Ferreira SQ, da Costa TRF, Loguercio AD, Reis A. Application of etch-and-rinse adhesives on dry and rewet dentin under rubbing action: a 24-month clinical evaluation. *The Journal of the American Dental Association*. 2011;142(7):828-35.
- [32] Pashley DH, Tay FR, Carvalho RM, Rueggeberg FA, Agee KA, Carrilho M, et al. From dry bonding to water-wet bonding to ethanol-wet bonding. A review of the interactions between dentin matrix and solvated resins using a macromodel of the hybrid layer. *American journal of dentistry*. 2007;20(1):7.