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Influence of operator experience on bond strength of different adhesives to dentin

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Abstract

Aim: Application of adhesive systems on dentin is a multistep, technique-sensitive procedure. Thus, the aim was to assess the effect of operator experience on the shear bond strength of an etch-and-rinse adhesive system and a self-etch adhesive system on dentin.

Materials and Methods: Forty-eight extracted human molar teeth were used in the study. They were embedded in an acrylic resin after cutting off the roots. The mesial and distal enamels of the teeth were removed to expose dentin surfaces. The samples were allocated to four groups ($n = 12$): Group 1: restorative dentistry specialist with 13 years of experience, Group 2: with 6 years of experience, Group 3: postgraduate operator with 2 years of experience, and Group 4: undergraduate student with 1 year of experience and familiar with adhesive with systems. Each operator applied an etch-and-rinse adhesive system (Adper Single Bond 2) to mesial surface and a self-etch adhesive system (Clearfil SE Bond) to distal surface ($n = 12$). Then, a composite resin (Filtek Z250) was inserted with the aid of a plastic ring (2 mm × 2 mm) and light polymerized. The specimens were stored in distilled water before shear bond strength test. A two-way ANOVA test was used for statistical analysis.

Results: No statistically significant difference was found between each operator type with respect to etch-and-rinse adhesive system ($P > 0.05$); however, the undergraduate student performed better than 2-year experienced operator with respect to self-etch system application ($P < 0.05$).

Conclusion: The shear bond strength of a self-etch system might vary according to the operator's experience.

Keywords: Adhesive system; dentin; operator experience; shear bond strength

INTRODUCTION

Cycling between observing and practicing that are frequently enrolled in dental education improves the learning of treatment procedures in depth. Undergraduate students observe or assist more experienced tutors in the collaborative treatment approach. This apprentice style of clinical education of restorative dentistry with a sound theoretical background ensures to convey required

information for common clinical materials and procedures. These education procedures in presenting acquiring clinical skills in real life provide the income of clinical mastery for future dentists. Likewise, instructional practices such as adhesive and restorative application are still trained by conventional operative dentistry by tutors.

The clinical success of adhesive restorations is related to the developments in wide range of materials, development of clinical techniques and skills, and advances in adhesion technology.^[1-4] Today, advances in adhesion technology have mainly focused on simplifying adhesive systems by reducing the duration of clinical application and technical sensibility.^[5,6]

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There are two main approaches for the bonding of resin-based materials to dentin: “etch-and-rinse” or “self-etch.”^[7] Etch-and-rinse systems include an acid etching and rinsing step. In three-step systems, after etching, primer and adhesive resin are applied, respectively. In two-step etch-and-rinse adhesives, the primer and adhesive are integrated into a single bottle and the number of steps in clinical practice is reduced.^[8] In these systems, since the demineralized collagen network joins the connection, the wet-bonding technique must be accomplished to ensure full collagen network expansion.^[9] Therefore, the operator has to control the level of moisture on dentin to achieve adequate bonding. Self-etch adhesive systems have been developed to overcome the problems in etch-and-rinse adhesive systems such as difficulties in clinical practice such as excessive application time and postoperative sensitivity.^[10] Self-etch adhesive systems are generally water based and thus simplify dentin moisture control. The air-drying step that can influence their bond strength is very important during application procedure. The duration and the pressure of air-drying protocols are different for each manufacturer and may influence the bond strength values.^[11]

The success of these dentin-bonding procedures is directly related to the operator's experience and working routines, especially in dentin. Unlu *et al.*^[12] reported that operator experience influences bond strength values of adhesives to dentin. Similar results were shown in another *in vitro* study in which the operator experience appears to play a critical role at microleakage when using an adhesive.^[13] However, Ueda *et al.* showed that experience seems not to be necessary to achieve good bonding effectiveness to dentin using self-etch adhesives.^[14]

The aim of this study was to examine the effect of operator experience on the shear bond strength of an etch-and-rinse adhesive system and a self-etch adhesive system on dentin. The null hypothesis was that the experience level of the operators with the adhesive system procedures does not affect the shear bond strength of the etch-and-rinse and self-etch adhesive systems.

MATERIALS AND METHODS

Specimen preparation

The University Institutional Review Board (Project No: D-DA 17/10) approved the study. Forty-eight extracted anonymous human molar teeth without decay, and previous restorations were used. These teeth had been extracted due to orthodontic treatment. The teeth were stored for 1 month in distilled water at 37°C in glass containers and then scaled and washed out before preparations.

The teeth were embedded in acrylic resin (Meliodent, Heraeus Kulzer, Germany) after cutting off the roots with

a diamond bur under running water. The mesial and distal enamel surfaces of the teeth were removed with a low-speed diamond disc in a hard tissue-sectioning machine (Labcut Extec Corp., Enfield, CT, USA) under water cooling to expose a flat dentin surfaces. To create proper smear layer, the dentin surfaces were abraded with 600-grit silicon carbide abrasive paper for 20 s.^[15] The surfaces were then rinsed with distilled water and air-dried before adhesive applications.

The teeth were randomly allocated into four groups ($n = 12$) with respect to operators with different experience levels: Group 1: restorative dentistry specialist with 13 years' experience, Group 2: restorative dentistry specialist with 6 years' experience, Group 3: postgraduate operator with 2 years' experience, and Group 4: undergraduate student with 1-year experience and familiar with the adhesive systems.

Adhesive system application

The used materials were shown in Table 1. Mesial surface of each tooth was bonded with etch-and-rinse adhesive system (Adper Single Bond 2, 3M ESPE, USA; ASB), and the distal surface was bonded using the self-etch adhesive system (Clearfil SE Bond, Kuraray, Japan; CSE) ($n = 12$) according to the respective manufacturers' instructions. Each operator applied the adhesive systems with the same instruments and under standardized conditions.

Mesial dentin surfaces were etched with 37.5% phosphoric acid (Scotchbond Etchant, 3M Dental Products, St. Paul, MN, USA) for 15 s, rinsed for 30 s and gently dried with compressed air taking care not to desiccate the dentine. Immediately after, two coats of ASB were applied to the etched dentin for 15 s with using a microbrush and gently air thinned for 5 s to evaporate the solvents. The surfaces were light cured with a light-emitting diode (LED) LED-curing device (light density: 1000 mW/cm²; LedMax, Benlioglu Dental Inc., Ankara, Turkey) for 10 s. The conditioning of distal surfaces incorporated application of a generous amount of primer under rubbing with moderate finger pressure for 20 s. The surfaces were blotted with airstream to evaporate the volatile ingredients. Subsequently, CSE was applied to the surface. The bond was gently air thinned and light cured for 10 s with the LED light-curing device. A microhybrid resin composite (Filtek Z250, 3M ESPE, USA) was inserted with the aid of a plastic ring (2 mm diameter × 2 mm height) to mesial and distal dentin surfaces and polymerized with the light-curing unit for 20 s. The specimens were kept in distilled water at 37°C for 24 h before shear bond strength test.

Shear bond strength test

Shear load was applied to the specimens using a universal testing machine (LRX, Lloyd Instruments, Fareham, England) until failure. The crosshead speed was 0.5 mm/min.

Maximum loads at bond failure were recorded in Newtons (N), and bond strengths were measured in megapascals. The maximum loads were divided at failure by the surface area of the resin composite.

Statistical analyses

A two-way ANOVA test was used to analyze the data of shear bond strength test. A Bonferroni test was used to make multiple comparisons. The significance level was 0.05.

RESULTS

Table 2 presents the shear bond strength values between all groups. For the etch-and-rinse adhesive system, no statistically significant difference was found between each operator type ($P > 0.05$). The differences between the undergraduate student and 2-year experienced operator in the self-etch adhesive system group were statistically significant ($P = 0.021 < 0.05$). The undergraduate student performed better than 2-year experienced operator with respect to self-etch adhesive application. However, there were no statistically significant differences between specialists and both postgraduate operator and undergraduate operator ($P > 0.05$).

DISCUSSION

This study confirmed that the experience of the operator influenced the shear bond strength of CSE to dentin. Likewise, regarding the outcomes of shear bond strength of CSE and ASB, the hypothesis was partially rejected because significant differences were observed between the

undergraduate student and 2-year experienced operator in the self-etch adhesive system group.

Dentin bond strength can be affected by some factors such as surface characteristics of dentin, type of the adhesive system, and application mode. The success of adhesive procedures also depends on the operator's experiences.^[16,17] New adhesive systems have been developed to make the application procedures simpler than the multiple-step systems. This new approach promotes less technically sensitive steps, which provide the success of bond strength at the same time. However, regardless of the type of the adhesive, each adhesive requires a learning cycle to achieve effective outcomes for adhesion of resin materials to dentin. Sano *et al.*^[4] reported that to reach successful adhesion, the operator should know the dentin adhesive system and be careful about technique sensitivity of the system, especially when choosing the new system for clinical practice.

Today, preclinical education of undergraduate students is generally text-guided and repetitive self-practice to reach proficiency standards of clinical education. Even though the demonstration of the treatment is substantial, observing the clinical mentor while performing the procedure would provide the student to complete learning. Although Adebayo *et al.*^[18] confirmed that acceptable outcomes can only be achieved with experience and being familiar with the adhesive systems, some studies showed different results. For example, an *in vitro* study showed that while microleakage of enamel margin within the expert group was lower than the student group, for self-etch system, enamel margin microleakage within the student group was lower than the expert group.^[16] Unlu *et al.* showed that an operative dentistry specialist and postgraduate student

Table 1: Materials used in the study

Product	Type	Manufacturer	Batch number	Chemical composition	Application procedure
Adper Single Bond 2	Two-step etch-and-rinse system	3M ESPE, USA	N908557	1. Etchant: 35% phosphoric acid (Scotchbond Etchant) 2. Adhesive: bis-GMA, HEMA, dimethacrylates, ethanol, water, photoinitiator, methacrylate functional copolymer of polyacrylic and poly (itaconic) acids, 10% by weight of 5-nm diameter spherical silica particles	Apply etchant to tooth surface for 15 s. Rinse thoroughly for 10 s. Blot excess water using a cotton pellet. Apply 2-3 consecutive coats of adhesive for 15 s with gentle agitation. Gently air-dry for 5 s. Light cure for 10 s
Clearfil SE Bond	Two-step self-etching system	Kuraray Medical Inc., Japan	370291(P) 360466(B)	1. Primer: water, MDP, HEMA, camphorquinone, hydrophilic dimethacrylate 2. Bonding: MDP, bis-GMA, HEMA, camphorquinone, hydrophobic dimethacrylate, N, N-diethanol p-toluidine bond, colloidal silica Bis-GMA, UDMA, and bis-EMA, 66% of filler zirconium/silica	Apply primer to the tooth surface and leave in place for 20 s. Dry with a mild air stream. Apply adhesive to the tooth surface. Light cure for 10 s
Filtek Z250 Universal	Microhybrid composite resin	3M ESPE, USA	N902105		Apply 2-mm height to dentin surfaces and light cure for 20 s

Table 2: Mean±standard deviation) shear bond strength values in measured in megapascals

	Specialist (13 years' experience)	Specialist (6 years' experience)	Postgraduate operator	Undergraduate student	P
Self-etch	28.3±11 ^{a,b}	25.1±8.4 ^{a,b}	24.5±8.4 ^a	35.2±12.9 ^b	< 0.05
Etch-and-rinse	10±11 ^c	10.5±6.3 ^c	11.7±6.9 ^c	10±5.4 ^c	> 0.05

Means with the same superscript letter are not statistically significantly different from each other in the same row ($P > 0.05$)

had better results than general practitioner who graduated 10 years ago at etch-and-rinse and self-etch adhesive systems.^[12]

When steps of the traditional etch-and-rinse systems were taken into consideration, it was expected that the undergraduate student would have difficulty to reach the required wet dentin condition before the bonding step, but there was no significant difference between the operators in etch-and-rinse system in our study. Similarly, Karaman *et al.*^[13] showed that the tested etch-and-rinse adhesives revealed similar results both with the expert operators and the undergraduate student, showing little sensitivity to operator skill. According to a clinical study performed by Scotti *et al.*^[19] that the students showed better results etch-and-rinse adhesive than self-etch adhesive, all techniques require a learning curve for optimal bonding conditions and the number of steps is not always related to reduced technique sensitivity of adhesive.

In this study, the undergraduate student reached better results than 2-year experienced operator with the self-etch adhesive system. Spreafico *et al.*^[11] reported that the duration of air blowing and the pressure may show alterations according to manufacturer, and this may influence the efficiency of adhesion. However, interestingly, Miyazaki *et al.*^[20] reported that when undergraduate students start using adhesives, they tended to read the manufacturer's instructions carefully and strictly apply the adhesives following the manufacturers' instructions. CSE was used as a self-etch system in the present study. Some studies concluded that self-etching adhesives applied with rubbing motion increased bond strength to dentin, but normally, manufacturer introductions do not recommend it.^[21] However, Peutzfeldt and Asmussen^[22] suggested that to reach reliable results, especially bonding to dentin, the procedures recommended by the manufacturer should be followed carefully. This may explain why the undergraduate student who carefully applied the self-etch adhesive after reading the manufacturers' instructions showed acceptable results like experienced operator.

This study had a limitation. There was only one operator in each group and that operator might not have been the representative of the experienced and inexperienced clinicians.

CONCLUSION

Within the limitations of this *in vitro* study, it may be concluded that the shear bond strength of adhesive systems might be influenced by the operator's experience.

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Conflicts of interest

There are no conflicts of interest.

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