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Effects of Rinsing Water Temperature and Preheated Composites on Microleakage of Composite Restorations with Two Bonding Agents

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ABSTRACT

Objectives: The aim of this study was to evaluate the effects of rinsing water temperature and preheated composites on microleakage of class V restorations with two different bonding agents.

Materials and Methods: Eighty class V cavities were prepared in the buccal and lingual surfaces of 40 molars. Single Bond and Prime and Bond NT bonding agents were used. The teeth were divided into four groups of 10. G_1: After acid etching, cavities were rinsed with 23°C water and filled with 23°C composite resin. G_2: Rinsing water and composite resin had 55°C temperature. G_3: Rinsing water had 55°C and composite resin had 23°C temperature. G_4: Rinsing water had 23°C and composite resin had 55°C temperature. The specimens were immersed in 0.5% basic fuchsine dye. Microleakage scores were analysed with the Kruskal-Wallis, Mann-Whitney U, and Wilcoxon tests.

Results: There were significant differences in microleakage of specimens prepared with Single Bond and Prime and Bond NT only in group 1 ($P<0.05$). There were no significant differences between the microleakage of groups rinsed with different water temperatures ($P>0.05$). There were significant differences between the unheated and preheated composite groups ($P<0.05$).

Conclusion: Preheating of composite is a valuable method to increase its adaptability and decrease microleakage of composite restorations.

Keywords: Dental Leakage, Adhesives; Temperature; Composite Resins

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INTRODUCTION

Viscosity and stickiness are among the problems of high-filled composites, which can lead to poor adaptation, and subsequent marginal gap formation, which further causes microleakage and failure of restorations [1]. Preheating of composite resins is a method of composite application, which decreases its viscosity and increases its flowability, and therefore leads to easier application and enhanced sealing properties [2,3]. Other benefits of preheating of composites include improvement of physical and mechanical properties due to higher degree of conversion, superior surface hardness, and greater curing depth [4,5]. Infiltration of resin into demineralized dentin or "hybridization" is a fundamental mechanism in achieving a durable bond to dentin [6].

Table 1: Adhesive systems, composition and mode of application according to the manufacturers' instructions

Adhesive Systems		Application Mode
Adper Single Bond (3M, ESPE, St. Paul, MN, USA)	35% phosphoric acid Bis-GMA, HEMA, dimethacrylates, polyalkenoic acid, camphorquinone, stabilizers, water and ethanol	Acid etching (15 seconds) Rinse (15 seconds) and air-dry Apply two coats of adhesive. Air-dry (2-5 seconds) Light-cure (20 seconds)
Prime & Bond NT (Caulk, Dentsply, USA)	35% phosphoric acid PENTA, UDMA, resin5-62-1, resin-T, resin-D, bisphenol A dimethacrylate, acetone, nanoscale filler cetylaminehydrofluoride	Acid etching (15 seconds) Rinse (15 seconds) and air-dry Apply two coats of adhesive. Air-dry (2-5 seconds) Light-cure (20 seconds)

Different clinical approaches have been proposed to improve cross-linking of polymer in a collagen mesh. These approaches include increasing the application time, multiple adhesive coatings, increasing the temperature of the adhesive or rinsing-water, and use of warm air stream for solvent evaporation. Most of these methods favor resin infiltration and solvent evaporation for formation of a strong polymer [7,8]. Increasing the temperature of dentin substrate using warm rinsing water following acid etching in use of etch and rinse bonding agents could affect collagen fibrils, infiltration of resin monomers into demineralized dentin, and solvent evaporation. In addition, by increasing the temperature of the substrate, we could simulate clinical situations and evaluate the rapid drop of temperature in preheated composite and the effects of warm substrate on this temperature drop. Therefore, the aim of this study was to evaluate the effect of warm rinsing water and preheated composite on micro-leakage of class V composite restorations. We also compared an ethanol/water based two-step etch and rinse adhesive system (Adper Single bond, 3M, ESPE, MN, USA) with an acetone-based (Prime and Bond NT, (Dentsply Caulk, Milford, DE, USA) adhesive.

MATERIALS AND METHODS

The protocol of this in vitro, experimental study was approved by the ethics committee of Islamic Azad University, School of Dentistry, Khorasgan Branch (23810201901007). Forty extracted caries-free human molars were selected for preparation of 80 class V cavities in their buccal and lingual surfaces. They were stored in distilled water and were used within 1 month of their extraction. The teeth were randomly assigned to four groups of 10 teeth each. Two class V cavities were prepared in each tooth (buccal and lingual) with a high speed handpiece using water spray and a straight cylindrical diamond bur (008; D & Z, Germany). The cavity dimensions were 4mm wide, 3mm high, and 2mm deep with the occlusal and gingival margins located in enamel and dentin, respectively. The four groups included negative control, positive control, warm rinsing water and warm composite. Each treatment group had 10 teeth, each with two restorations (20 restorations in each group). Buccal cavities were treated with Adper Single Bond (3M, ESPE, St. Paul, MN, USA) and lingual cavities were treated with Prime and Bond NT (Dentsply Caulk, Milford, DE, USA) adhesive.

In group 1, cavities were acid-etched with 35% phosphoric acid and rinsed with distilled water at room temperature (23°C) for 20 seconds. Then, the adhesives were applied according to the manufacturer's instructions as described in Table 1 and then light polymerized for 20 seconds using a LED light-curing unit (Litex 695c; Dentamerica Inc., CA, USA) with a light intensity of 600 mW/cm^2.

The cavities were filled with room temperature composite resin (Gradia Direct; GC America, IL, USA) in three increments; each increment was cured for 40 seconds.

Group 2: After acid etching, rinsing was done with distilled water at 55°C for 20 seconds. A compound heater was used to warm the water.

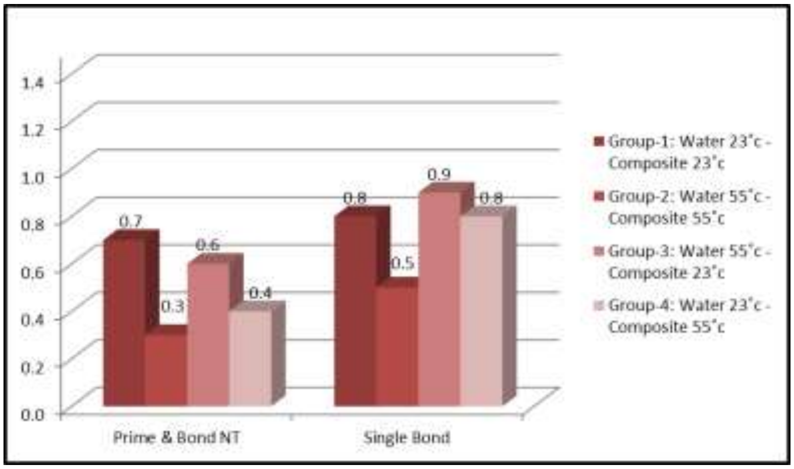

Fig. 1. Average amount of microleakage at enamel margin in the groups with different bonding agents at different rinsing water and composite temperature

Then, the bonding agents were applied as in group 1. In this group, an assembly of a composite compule held by a dispenser gun was placed in the compound heater and held in place for 10 minutes in order to reach 55°C temperature.

Then, the bonding agents were applied as in group 1. In this group, an assembly of a composite compule held by a dispenser gun was placed in the compound heater and held in place for 10 minutes in order to reach 55°C temperature. The composite was then immediately applied into the tooth cavity in three increments. To prevent heat loss, all composite increments were preheated. The mean time between removing the composite from the device and light polymerization was approximately 20 seconds for all tests.

Group 3: After acid etching, rinsing was done with distilled water at 55°C for 20 seconds and the same bonding agent was used as in group 2. Then, filling was done with room temperature composite as in group 1.

Group 4: Rinsing was done with distilled water at 23°C for 20 seconds and the cavities were filled with preheated composite (55°C; Table 2)

Table 2 summarizes the procedures used for restoration of specimens. All the specimens were placed in a 37˚C water bath for 24 hours. They were then thermocycled for 1500 cycles between 5˚±2˚C to 55˚C.

Sticky wax was applied over the root apices and bifurcations, and the entire tooth was covered with 2 layers of nail polish, leaving a 1mm window around the cavity margin.

The teeth were then immersed in 0.5% basic fuchsine (Merck, Darmstadt, Germany) dye solution for 24 hours. After removal from the dye, the teeth were cleaned and rinsed thoroughly.

Table 2: Summary of the procedures used for restoration of specimens

Group*	Procedure
1	Room temperature (23°C) rinsing water - Room temperature composite
2	Warm rinsing water (55°C)- Preheated composite (55°C)
3	Warm rinsing water (55°C) - Room temperature composite (23°C)
4	Room temperature rinsing water (23°C) – Preheated composite (55°C)

* Groups 1: negative control; Group2: positive control

A precision diamond saw (Bego, Bremen, Germany), cooled with water, sectioned each tooth longitudinally through the center of the restoration from the buccal to the lingual surface. The section with greater leakage was examined visually for dye penetration along the restoration margins, at x32 magnification using a stereomicroscope (MBC-10; Lomo, Saint Petersburg, Russia). Two blind examiners scored the extent of dye penetration.

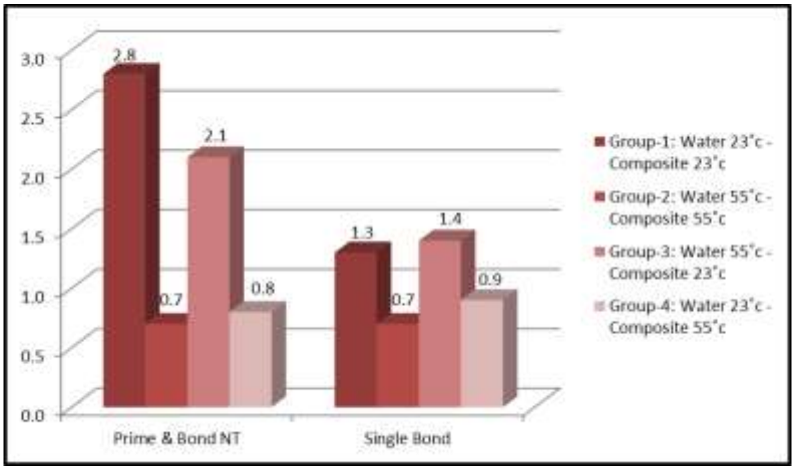

Fig. 2. Mean score of microleakage at the dentin margin in the groups with different bonding agents at different rinsing water and composite temperatures

Scoring was done according to the following criteria at occlusal and gingival margins [1](Fig. 1):
Score 0: No dye penetration
Score 1: Dye penetration up to half of the cavity wall
Score 2: Dye penetration up to the entire cavity wall
Score 3: Dye penetration up to half of the axial wall
Score 4: Dye penetration to more than half of the axial wall

Statistical analyses:

Multiple comparisons were carried out using the Kruskal-Wallis test after Bonferroni adjustment. The Wilcoxon test was used for non-parametric paired comparisons.

RESULTS

The frequency distribution of different degrees of dye penetration in the groups with different bonding agents is shown in Table 3. Figure 2 shows the mean scores of microleakage at the dentin margin in the groups with different bonding agents at different rinsing water and composite temperatures. Using the Kruskal Wallis and Bonferroni tests, no significant differences were found between the microleakage scores of the four subgroups of the Single Bond groups with different rinsing water and composite temperatures (P>0.05).

Table 3. Frequency distribution of different degrees of dye penetration in the groups with different bonding agents at different rinsing water and composite temperatures

	Groups	**Occlusal**					**Cervical**				
		0	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**
Prime & Bond NT	**G1: Water 23°C -Composite 23°C**	4	5	1	0	0	1	1	1	3	4
	G2: Water 55°C -Composite 55°C	7	3	0	0	0	4	5	1	0	0
	G3: Water 55°C -Composite 23°C	5	4	0	0	1	0	4	3	1	2
	G4: Water 23°C -Composite 55°C	6	4	0	0	0	5	3	2	0	0
	Total	22	16	1	0	1	10	13	7	4	6
Single Bond	**G1: Water 23°C -Composite 23°C**	2	8	0	0	0	0	8	1	1	0
	G2: Water 55°C -Composite 55°C	5	5	0	0	0	4	5	1	0	0
	G3: Water 55°C -Composite 23°C	4	5	0	0	1	2	5	1	1	1
	G4: Water 23°C -Composite 55°C	2	8	0	0	0	5	3	1	1	0
	Total	13	26	0	0	1	11	21	4	3	1

Table 4. Comparison of the degree of microleakage in different groups of bonding agents at different rinsing water and composite temperatures using the Kruskal Wallis and Bonferroni tests

	Groups	1	2	3	4
Occlusal	1	-	0.018	0.315	0.393
	2	-	-	0.215	0.739
	3	-	-	-	0.243
	Groups	**1**	**2**	**3**	**4**
Cervical	1	-	0.003	0.247	0.003
	2	-	-	0.007	0.912
	3	-	-	-	0.011

But in Prime and Bond groups, there were significant differences between subgroup 1 (negative control) and subgroup 2 (positive control) at the dentin margins (P<0.05). Also, there were significant differences between the microleakage scores of the following subgroups at the dentin margins: Subgroups 1 and 4, and subgroups 2 and 3 (P<0.05). Significant differences (Table 4) were found between the microleakage scores at the enamel and dentin margins (P=0.00). Between the two bonding agents, no significant differences were found in the microleakage scores at the enamel margin (P>0.05). However, at dentin margins of subgroup 1, the amount of microleakage was significantly higher in Prime and Bond NT (P<0.05).

DISCUSSION

Single-component adhesives include solvents that act as a transport medium and allow greater penetration of resins into prepared substrate. Also, these solvents facilitate displacing surface moisture without collapsing the collagen network [7].

In the present study, the adhesive systems had similar microleakage scores at the enamel margins. However, at dentin margins, the acetone-based system (Prime and Bond NT) showed significantly higher degree of microleakage than ethanol/water based system in group 1 (rinsing water and composite at room temperature).

One possible reason for the observed difference between the adhesive systems in group 1 may be that it was the last group that was restored and that acetone-based adhesive systems are more sensitive to repeated use than ethanol/water based systems. Similarly, Lima et al, [9] and Reis et al. [10] reported that high frequency of use might hasten solvent evaporation especially in acetone-based adhesive systems, which could lead to poor hybridization and impair bonding ability. Due to the fact that in other groups, both adhesive systems exhibited similar sealing ability, we can conclude that by using a single-dose system in acetone-based adhesive systems, the clinical performance of ethanol/water-based and acetone-based adhesive systems becomes similar, which is in line with several studies [9,11-13]. However, Manso et al, [14] Lopes et al, [15] and Reis and Loguercio [16] reported higher bond strength values for ethanol/water-based adhesives, while Mohan and Kandaswamy [17] and Karadag et al. [18] revealed better adaptation and maximum resin tag formation in acetone-based adhesives.

Interestingly, the previous expectation [8] that the application of warm rinsing water could promote resin infiltration into interfibrillar collagen spaces and therefore reduce the microleakage was not confirmed in the present study. Probably, the result of drying method with air syringe, as specified by the manufacturer, would have been different if we had used a dry cotton pellet instead for preservation of temperature. As a result, our hypothesis which stated that warm rinsing water can influence properties of the bonding agent was rejected.

The use of a warm rinsing water is based on the fact that when heat is delivered to a substrate, it can alter the way in which molecules bond to one another, which could increase the evaporation rate of solvents at the bonding interface and therefore provide higher resin-dentin bond strength [7,8].

There are several controversial studies about the effects of temperature on properties of bonding agents. In agreement with our results, de Alexandre et al. [19] showed no difference in microtensile bond strength of Prime and Bond NT at three different temperatures. Some authors reported high bond strength or sealing ability of Prime and Bond when subject to heat [7], while Reis and Loguercio [16] and Leguerciu et al. [20] showed low bond strength for this adhesive system with increased temperature. They confirmed that by increasing the temperature, evaporation of solvent is accelerated and the adhesive layer becomes very thick.

Regarding Single Bond adhesive, Loguercio et al. [20] reported similar microtensile bond strength at four different temperatures. In contrast, Reis and Loguercio [16] and Pazinatto et al. [21] found higher bond strength values by heating the Single Bond bonding agent.

This can be explained by the fact that by warming the substrate in vitro, the rapid drop in temperature, followed by application of room temperature adhesive systems could not influence solvent evaporation or properties of bonding agents. Another explanation for this observation is that acetone and ethanol have a high vapour velocity; they can therefore evaporate normally at room temperature. Thus, the effect of heat on their vapour velocity or bonding properties is insignificant, and heating cannot influence the bond strength or sealing ability of bonding agents.

According to the results of this study, the degree of microleakage was significantly lower in groups 2 and 4 where preheated composite was used. This indicates low viscosity and more adaptability of warm composite to cavity margins; preheating of composite is therefore a valuable method for reducing microleakage. This result was in accordance with that of Wagner et al, [22] and Froes Salgado et al. [23] who reported that preheated composites increased the marginal adaptation and decreased microleakage. Despite these results, Karaarslan et al, [1] Sabatini et al, [24] and Deb et al. [25] found that there were no significant differences in microleakage of preheated and room temperature composites. They expressed that the rapid drop in composite temperature could justify the similar results by the preheated and room temperature composites. Several authors revealed that by preheating of composites, the degree of conversion increases, leading to greater polymerization shrinkage.

Polymerization shrinkage along with thermal contraction might increase interfacial stresses and affect marginal adaptation and sealing [25,26]. Contrary to this finding, our results showed that this shrinkage did not cause any adverse effects on marginal sealing, that may be due to lower viscosity and enhanced flow of the warm composite, which better adapts to cavity walls.

Other advantages of preheating of composite resins include improvement of physical and mechanical properties due to higher degree of conversion, improvement of handling properties, and reduction of curing time, even though the degree of polymerization increases [25-27].

Finally, the intrapulpal temperature increase generated by the preheated composites is not a concern. Daronch et al. [28] found no significant difference between preheated and room temperature composites in intrapulpal temperature. When warming the composite to 60°C or 54°C, only a 0.8°C temperature increase was found in the pulp while during light curing this increase may reach 5°C, which is near the critical temperature [28].

CONCLUSION

Acetone based and ethanol/water based adhesive systems have similar sealing abilities. Use of warm rinsing water in order to warm substrates had no significant effect on microleakage of composite restorations. Preheating of composite is a valuable method for increasing its adaptability and reducing microleakage of composite resin restorations.

CONFLICT OF INTEREST STATEMENT

None declared.

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