Comparison of Microleakage beneath Orthodontic Brackets Using Two Different Methods of Enamel Preparation

Pakshir HR. [a], **Ajami Sh.** [a*]

[a] Orthodontic Research Center, Shiraz University of Medical Sciences, Shiraz, Iran.

KEY WORDS

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ABSTRACT

Statement of Problem: Decalcification of the enamel in orthodontic patients mainly follows plaque accumulation, but it is promoted by appliance components and the materials used for bonding.

Purpose: This study was designed to compare the microleakage beneath metallic orthodontics brackets, using two different methods of enamel preparation.

Materials and Method: Sixty bovine deciduous lower incisors were collected, and divided into two equal groups. For bonding the stainless steel brackets using Transbond XT as light cured composite, the surface enamel preparation of each group was as follows: Group I: Acid etch+Transbond XT primer and Group II: self-etching primer. After immersion in fuchsin basic 0.5% for 24 hours, each group was randomly divided into two subgroups of 15 samples and placed in acrylic block, in order to have mesiodistal and buccolingual sectioning. The sectioned teeth were evaluated under stereomicroscope and both enamel-adhesive and adhesive-bracket interfaces were scored for the microleakage. Kruskal-Wallis and Mann-Whitney U tests were used for statistical analysis to compare the groups. The level of significance was set at $p < 0.05$.

Results: No significant differences in the microleakage scores on the gingival and incisal sides were observed in the interfaces between the groups ($p > 0.05$). Mesiodistal margins of the self-etching group showed significantly lower scores for microleakage in the enamel-adhesive interface in comparison with acid etch group ($p < 0.05$).

Conclusion: With the limitation of this study using the self-etch primers in enamel preparation for bonding of the orthodontic brackets seems acceptable if all the margins of the brackets are cured directly.

[*] **Corresponding author.** Ajami Sh., Address: Dept. of Orthodontics, Faculty of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran.; **Tel:** 0711-6307245; **Fax:** 0711-6270325;
E-mail: shabnamaj@hotmail.com

Introduction

One of the challenges that every orthodontist has to encounter in his practice is the iatrogenic demineralization of the enamel during orthodontic treatment [1]. These lesions can happen in about 45 percent of orthodontic patients [2] and according to Mizrahi et al. [3] with higher rates in male patients. They are unsightly and detected as some form of enamel opacity, covering at least one third of the labial surface [4]. These enamel demineralizations may lead to early discontinuation of treatment without achieving the treatment objectives. Decalcification of the enamel in orthodontic patients mainly follows plaque accumulation, but it is promoted by appliance components and the materials used for bonding [5].

According to some studies even using phosphoric acid as a conditioning agent on the enamel surface can increase the risk of initial caries [6-7]. If the enamel is not sealed, the etch pattern is still detectable a few months after application of the echant [8]. The susceptibility of this surface and the necessity of applying sealants are the subjects of some arguments.

Recently, another conflicting issue is the introduction of new materials as the primers in orthodontic bonding, such as self-etching primers. Self-etching primers eliminate one step of the enamel preparation and combines conditioning and priming into one step. The priming liquid itself has a component that conditions the enamel surface. It is composed of methacrylated phosphoric acid esters that remove calcium from hydroxyapetite, and the dissolved calcium builds a complex network when the primer polymerizes [9]. Many investigations have been performed on their bond strength comparing with conventional systems [10-11]. In some studies, promising adhesive bonding results were revealed [12-13], but few studies are available on their seal ability [14-15].

Microleakage has been considered as an important issue in the field of operative dentistry, but it is not a long time that it has drawn a lot of attention in orthodontics. From the orthodontic point of view, microleakage can be defined as a factor explaining the formation of white spot lesions at the adhesive and enamel interface.

For the first time in 2003, James et al. [16] emphasized the importance of microleakage under the orthodontic brackets. Then, Arhun et al. [14] investingated the amount of microleakage with application of two different adhesive systems (a conventional and an antibacterial) for bonding the ceramic and metal brackets. The amount of microleakage was higher beneath the metal brackets in both interfaces regardless of the adhesive system, but the difference was statistically significant between groups bonded with the antibacterial system at the gingival side. They concluded that the higher amount of microleakage in the adhesive-bracket interface in groups which received metal brackets might have led to the lower clinical shear bond strength; however, they did not find any significant differences between the antibacterial and the conventional system on the amount of microleakage.

For determining the microleakage beneath the orthodontic brackets, another study was conducted by Uysal et al. [15]. They evaluated the microleakage score under metallic and ceramic bracket, using self-etching adhesive systems. The differences in the microleakage score under the occlusal sides in both adhesive systems were not statistically significant. The higher microleakage scores belonged to the gingival margins for both adhesive systems in comparison to the occlusal margins; however, they only cured the adhesives from the occlusal margins in their study.

To the best of our knowledge, this is the first study evaluating the microleakage under the orthodontic brackets using a self-etching primer on the enamel surface of the bovine incisors and comparing it with the conventional method of the enamel preparation.

The null hypothesis of this study assumed that there is no significant difference in the microleakage scores of the adhesive beneath the orthodontic brackets using different methods of the enamel preparation and light curing.

Materials and Method

In this study, 60 freshly extracted mandibular bovine incisors were collected. They were examined to be free of surface developmental defects and cracks, using a direct light of dental unit. The samples were stored in distilled water immediately after extraction for a maximum period of one month. The teeth were prepared by removing the soft tissue remnants and cleaned off the debris and further polished with pumice and rubber caps for 10 seconds each. Because bovine incisors have very long roots, for a more precise placement in the acrylic block, their roots were cut off from 3mm below their cementoenamel junction with a high speed bur. Before bonding, all the specimens were disinfected in 1% thymol solution for one week, and then stored in the distilled water for the rest of the experiment.

Transbond XT (3M unitek, Monrovia, Calif), as the most commonly used light-cured composites for orthodontic bracket bonding was selected for this study. The samples were randomly divided into two groups of 30 teeth each. The specimens were prepared for bracket bonding according to one of the following procedures:

Group I: The middle third of the enamel surfaces were etched with acid phosphoric 37% (Elching Gel, 3M unitek, Movovia, Calif) for 30 seconds, and then rinsed with water for 10 seconds and dried with an oil-free air source for 20 seconds till the surface showed a frosty appearance. The etched enamel was coated with a thin uniform primer (Transbond XT primer), using a disposable brush. A small amount of Transbond XT (3M Unitek) adhesive paste was applied onto the bracket base. After placement of the brackets on the prepared surfaces, a gentle pressure was applied on each bracket to ensure about of the complete contact between the brackets and the teeth and the excess resin was removed with an explorer before polymerization.

Group II: In this group, the enamel conditioning was different from the previous group. A self-etching primer (Transbond Plus, 3M, unitek, Monrovia, Calif), based on the manufacturer's instruction, was used. The applicator was applied to the tooth in the middle third of the buccal surface, with some pressure for 3-5 seconds. Then, with an oil and moisture free air source, a gentle air burst was delivered for 1-2 seconds to dry the self-etching primer into a thin layer. These steps were done for each sample in this group separately. The adhesive application and placement of the brackets were performed as the previous group. For curing, a quartztungestan halogen light unit (Coltolux 75, coltene) with a 10-mm diameter light tip was used according to the manufacture's guidelines. The samples were cured for 10 seconds from the mesial and 10 seconds from the distal side while keeping the distance of 5mm from the tip of the light curing unit.

After finishing the procedure of bonding, the samples of each group were kept in a separate container. They were stored in the room temperature for 3 months and kept in a dark environment for avoiding any direct light. In the next step, the first thermal cycling in deionized water was performed at 5±2 °C to 55±2 °C for 500 cycles with a dwell time of 30 seconds and a transfer time of 5 seconds.

For preparing the teeth for sectioning, the 30 samples in each group were randomly divided into two groups of 15 teeth to have two different directions of sectioning. In one of the subgroups, the samples were sectioned in a buccolingual direction and in the other they were sectioned in a mesiodistal direction from the middle part of the brackets. As a result, 4 groups were obtained and numbered, as shown in Table 1.

Table 1 Groups according to the method of enamel conditioning and direction of sections

Groups (numbering)	Type of enamel condition	Direction of section
1	Acid etch + primer	Buccolingual
2	Self etch primer	Buccolingual
3	Acid etch + primer	Mesiodistal
4	Self etch primer	Mesiodistal

Microleakage Evaluation

For microleakage measurement, the nail varnish was applied to the whole surface of the teeth except 1 mm from the margins which were supposed to be examined. The apexes of all the samples were sealed with sticky wax; then, the specimens were coated with two consecutive layers of nail varnish.

They were kept in distilled water as soon as the

Table 2 Comparison of the microleakage scores (mm) between incisal and gingival sides for enamel-adhesive and adhesive-bracket interface[a]

Interface	Groups [b]	N	Incisal		Gingival		P value	
			Mean	SD	Mean	SD		
Enamel-Adhesive	1	15	0.18	0.10	0.21	0.18	.706	NS
	2	15	0.18	0.10	0.21	0.09	.449	NS
Adhesive- Bracket	1	15	0.13	0.19	0.18	0.22	.505	NS
	2	15	0.14	0.12	0.21	0.13	.271	NS

[a] N indicates sample size; SD, standard deviation; S, significant; NS, not significant [b] Group 1: Acid etch; Group 2: Self etch

nail polish was dried to prevent dehydration of the samples before dye penetration. When all the teeth were ready, they were immersed in 0.5% solution of basic fuchsine for 24 hours at room temperature. After being removed from the solution, the teeth were rinsed with distilled water and the superficial dye was removed with a brush and left to dry. Then, they were embedded in epoxy resin (Heraeus kulzer, Germany) blocks; the impression for the blocks was prepared, using a polyvinyl siloxane impression material (Speedex Putty/ Coltene) with an index to place the samples properly in the acryle.

The samples were set in the acrylic blocks according to the proposed direction of the sections. Each acrylic block had the index to determine the position of the disc for sectioning. The cutting was carried out with a low-speed diamond saw (Auccutom-50, Struers, Denmark). All the samples were numbered before sectioning according to their groups and randomly examined by one investigator under a stereo-icroscope (Miotic, China) at standard magnification (X 40) in a blinded fashion (Figures 1 and 2).

Microleakage scores were directly recorded, using an electronic digital caliper (Guang Lu,China) twice by one observer and the data were recorded. For each section, there were two sides to be evaluated (incisal-gingival or mesial-distal) and each side had two interfaces to the score (enamel-adhesive and adhesive-bracket).

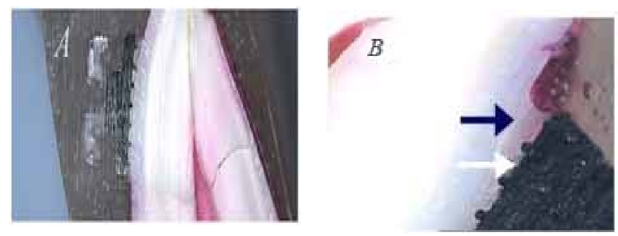

Figure 1 A and B (close up view), Stereomicroscopic views of a sectioned sample in buccolingual direction (blue arrow: adhesive-bracket interface, red arrow: enamel-adhesive interface)

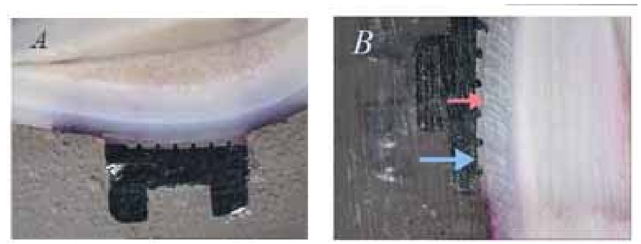

Figure 2 A and B (close up view), Stereomicroscopic views of a sample sectioned in Mesiodistal direction (Dark blue arrow: enamel-adhesive interface, white arrow: adhesive-bracket interface)

Statistical Analysis

After gathering all the data for each group, the means and the standard deviations were obtained (SPSS, version 15.0, Chicago). To compare the sides and interfaces with each other within every group (dependent samples), the non-parametric test of Wilcoxon Singed Ranks Test was performed. Mann-Whitney U test was used as the statistical analysis to compare the groups. Intra-examiner error was evaluated by Kappa test. The level of statistical significance was set at $p<0.05$.

Results

The overall intra-observer agreement Kappa score for assessing the microleakage was high (Kappa value of 0.792). Comparison of the microleakage scores

Table 3 Comparison of the microleakage scores (mm) between mesial and distal sides for enamel-adhesive and adhesive-bracket interface[a]

Interface	Groups[b]	N	Mesial		Distal		P value	
			Mean	SD	Mean	SD		
Enamel-adhesive	3	15	0.19	0.18	0.22	0.21	.441	NS
	4	15	0.03	0.04	0.02	0.04	.317	NS
Adhesive- bracket	3	15	0.18	0.15	0.26	0.22	.081	NS
	4	15	0.16	0.16	0.17	0.15	1.000	NS

[a] N indicates sample size; SD, standard deviation; S, significant; NS, not significant [b] Group 3: Acid etch; Group 4: Self etch

between the incisal and gingival sides for both adhesive interfaces are shown in Table 2. Microleakage was observed in all the groups. For both adhesive interfaces, differences between the amount of microleakage scored in the gingival and occlusal sides were not statistically significant (p >0.05).

Comparison of the amount of microleakage on the mesial and distal sides for both adhesive interfaces is shown in Table 3. All the groups showed some degree of microleakage, but the differences were not statistically significant (p >0.05).

Comparing the groups based on the method of enamel conditioning revealed that there were no significant differences in the microleakage scores on the gingival and incisal sides in neither of the interfaces (p >0.05) (Table 4). When the mesial and distal margins were compared, the score in the enamel adhesive interface was significantly lower for group 4 (self-etch) than group 3 (acid etch) (p <0.05), and there were no significant differences between the other groups (Table 5).

Discussion

The aim of the present study was to compare the microleakage scores of the orthodontic adhesive for two different methods of enamel conditioning. In this study, there was no significant difference between acid etch and self-etching enamel preparation in their microleakage scores, except in mesiodistal margins of the self-etch group.

In contrast to the phosphoric acid which can create an etched surface with deep and uniform demineralization areas, self-etching primers produce a uniform and more conservative etch pattern with regular adhesive penetration and a less aggressive enamel demineralization [17]. A deeper penetrance of the acid etch and longer resin tags in comparison to the self-etch primer cannot guarantee an inter-face free of microleakage [18]. This is supported by an in-vivo study where no differences were found between the sealants applied over a self-etching primer or acid-etched enamel surface after 24 months [19]. In the present study, no differences were found in the amount of microleakage between self-etching and acid-etched groups on the incisal and gingival sides of the brackets. Moreover, significantly less microleakage on the mesial and distal margins of the self-etching group was observed. It seems that factors other

Table 4 Comparison of the microleakage scores (mm) between self etch primer and acid-etch + primer groups on the incisal and gingival sides for enamel-adhesive and adhesive- bracket interface[a]

Interface	Side	N	Groups[b] Mean (SD)	Groups[b] Mean (SD)	Significance (P)	
			Group 1	Group 2		
Enamel-adhesive	Incisal	15	0.18 (0.10)	0.18 (0.10)	.653	NS
	Gingival	15	0.21 (0.18)	0.21 (0.09)	.624	NS
Adhesive- bracket	Incisal	15	0.13 (0.10)	0.14 (0.13)	.935	NS
	Gingival	15	0.18 (0.22)	0.21 (0.13)	.250	NS

[a] N indicates sample size; SD, standard deviation; S, significant; NS, not significant; [b] Group 1: Acid etch; Group 2: Self etch

than the depth of the resin tags are more important in causing microleakage. One reason for even less microleakage of self-etching adhesive systems especially at the margins which were cured directly could be the simultaneous penetration of etching and monomer and the identical depth of the primer tags to the etched area.

Less penetration of the resin tags in self-etching primer systems may not resist the contracting forces of resin shrinkage and the competition between this contracting force and the bond of the adhesive resin to the wall of restoration can lead to marginal failure and microleakage [20]. In an in-vitro study by Sener et al. [21], the lowest amount of shrinkage was reported for Transbond XT in comparison to the other composites in that experiment. However, the shrinkage of a resin is more acceptable in restorative dentistry when a bulk of composite is placed in the cavity preparation [16]. In contrast, orthodontic adhesive layers are very thin and the free floating bracket is pulled closer to the enamel surface by the composite shrinkage [22]. Therefore, the less penetration of the resin tags in self-etching adhesive systems is not required to resist the polymerization shrinkage in orthodontic bonding as in restorative fillings. Uysal et al. [15] reported that both metallic and ceramic brackets bonded with a self-etching primer showed significantly higher microleakage scores on the gingival side than the conventional acid etch method. However, in their study, the light tip was used for 40 seconds from the occlusal margin only. This result is comparable to that of the present study in which the margins were directly cured (mesial and distal), showing no significant differences in the amount of microleakage between acid-etched and self-etching groups. It could be concluded that sufficient polymerization with light is more important than the method used for enamel preparation on the amount of microleakage. Arhun et al. [14] did not report any significant difference in the amount of microleakage between self-etch adhesive and conventional system on the gingival and occlusal sides. This is similar to the results of the present study.

Both of the above studies [14-15] showed a significant difference between the microleakage score of the gingival and occlusal sides regardless of the method of enamel preparation. Arhun et al. [14] related these differences to the surface curvature anatomy of the used teeth (human premolar) which caused a relatively thicker adhesive at the gingival margins. Ramuglu et al. [23] also attributed the lower amount of microleakage on the occlusal side in their study to a relatively thinner adhesive on this side. The most ideal tooth for testing of the bonding properties is the human maxillary central incisors; however, because of the improvements in the oral health, access to non-carious, sound human incisors became difficult. In the present study, we used bovine incisors, as advocated by some researches to be used in orthodontic bonding experiments [24-25].

Most of the studies in evaluating the microleakage in the orthodontic bonding have used human premolars as their samples. In the present study, we used the bovine central incisors to reduce the anatomic variations that can affect the thickness of the

Table 5 Comparison of the microleakage scores between self etch primer and acid-etch + primer groups on the mesial and distal sides for enamel-adhesive and adhesive- bracket interfaces[a]

Interface	Side	N	Groups [b] Mean (SD) Group 3	Mean (SD) Group 4	Significance (P)	
Enamel-adhesive	Mesial	15	0.19 (0.18)	0.03 (0.04)	.007	S
	Distal	15	0.22 (0.21)	0.02 (0.04)	.001	S
Adhesive- bracket	Mesial	15	0.18 (0.15)	0.16 (0.16)	.683	NS
	Distal	15	0.26 (0.22)	0.17 (0.15)	.233	NS

[a] N indicates sample size; SD, standard deviation; S, significant; NS, not significant, [b] Group 3: Acid etch; Group 4: Self etch

adhesive under the bracket. Bovine central incisors have flat enamel surfaces and as such there will be a more proper fitness between the base of the brackets and the enamel surfaces, causing a relatively more uniform and thinner adhesive beneath the brackets in all sides. This may explain the fact that no significant differences were found between the incisal and the gingival sides of the group with direct illumination.

Another factor which should be concerned in microleakage is a phenomenon called percolation. If the coefficient of thermal expansion for a restorative material does not match that of the teeth, they expand and contract at different rates during hot and cold food intakes. In this study, thermocycling was used to mimic temperature changes in the mouth and generate thermal stresses at the enamel-adhesive and adhesive-bracket interfaces, as it was also performed in some studies [14, 26].

In some recent studies which evaluated the microleakage beneath the orthodontic brackets, thermocycling of the samples has not been performed. It was assumed that thermocycling did not affect the amount of microleakage [15, 23]. However, in the most recent studies conducted by Vicente et al. on the effect of thermocycling on the microleakage beneath the brackets bonded on bovine incisors, they found that microleakage increased significantly at the enamel-adhesive interface when using Transbond XT as the bonding material [27]. This may explain the increased amount of microleakage on all sides in the present study comparing to some other recent studies on this subject [15, 23]. It seems that polymerization starts at the adhesive material close to the light source. Even in metal brackets, the best result will be obtained if the light source is applied from all the four sides of the bracket. As Yoon et al. [28] explained, the incomeplete polymerization increases from the top surface inward.

Although James et al. [16] could not find any correlation between the amount of microleakage and the bond strength of the brackets, several studies related the bond strength to the microleakage of adhesive-bracket interface [14, 26]. However, it is impossible to extrapolate the result of an in-vitro study to the actual oral environment, so further studies are necessary to evaluate the correlations among microleakage and shear bond strength, different bonding materials and curing techniques.

Conclusion

In the present study, self-etch primers would show even less microleakge if the margins of the metallic brackets were cured directly. Using self-etch primer in bonding of the orthodontic brackets is acceptable if all the margins of the bracket are cured directly.

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