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Original Article

Microleakage under orthodontic brackets bonded with different adhesive systems

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ABSTRACT

Objective: This *in vitro* study aimed to compare the microleakage of orthodontic brackets between enamel-adhesive and adhesive-bracket interfaces at the occlusal and gingival margins bonded with different adhesive systems. **Materials and Methods:** A total of 144 human maxillary premolar teeth extracted for orthodontic reasons was randomly divided into four groups. Each group was then further divided into three sub-groups. Three total-etching bonding systems (Transbond XT, Greengloo and Kurasper F), three one-step self-etching bonding systems (Transbond Plus SEP, Bond Force and Clearfil S3), three two-step self-etching bonding systems (Clearfil SE Bond, Clearfil Protectbond and Clearfil Liner Bond), and three self-adhesive resin cements (Maxcem Elite, Relyx U 100 and Clearfil SA Cement) were used to bond the brackets to the teeth. After bonding, all teeth were sealed with nail varnish and stained with 0.5% basic fuchsine for 24 h. All samples were sectioned and examined under a stereomicroscope to score for microleakage at the adhesive–enamel and adhesive–bracket interfaces from both occlusal and gingival margins. **Statistical Analysis Used:** Statistical analyses were performed with Kruskal–Wallis and Wilcoxon signed-rank tests. **Results:** The results indicate no statistically significant differences between the microleakage scores of the adhesives; microleakage was detected in all groups. Comparison of the average values of the microleakage scores in the enamel–adhesive and adhesive–bracket interfaces indicated statistically significant differences ($P < 0.05$). The amount of the microleakage was higher at the enamel–adhesive interface than at the bracket-adhesive interface. **Conclusions:** All of the brackets exhibited some amount of microleakage. This result means that microleakage does not depend on the type of adhesive used.

Key words: Microleakage, orthodontics, self-adhesive resin cements, self-etching primers

INTRODUCTION

In orthodontics, the failure of bracket bonding due to the lack of connection between the enamel and the bracket compromises treatment success and prolongs treatment time. A reliable bonding between an orthodontic attachment and the tooth enamel is necessary to achieve effective orthodontic treatment.[1] In this regard, studies on the development of adhesive systems have increased. Different bonding systems, like self-etching primers, have been developed and manufactured to simplify the orthodontic bonding procedure.[2]

The effects of self-etching primers on shear bond strength and the microleakage of orthodontic brackets are well-documented.[3-5] Low bond strengths with SEP have also been reported.[4,5] Several authors reported that self-etching and the standard etching protocol do not vary in terms of bond strength.[6,7] Arhun *et al*.[8] reported that self-etching primers and conventional systems are not significantly different in terms of the amount of microleakage produced. Uysal *et al*.[3] also found high microleakage scores of self-etching primers.

Information on the adhesion properties of self-adhesive resin cements remains limited. The bonding of orthodontic brackets is not an indication of self-adhesive resin cements. However, in some studies, orthodontic brackets bonded with self-adhesive resin cements on the etched surface of the enamel and their

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bond strengths were compared with conventional systems. The shear bond strengths of self-adhesive resin cements were found to be lower than those of conventional systems.[9,10] To the best of our knowledge, no study has evaluated the efficiency of self-adhesive resin cements on microleakage under orthodontic brackets.

On the other hand, increasing the adhesive systems may increase the amount of microleakage. In restorative dentistry, the clinical symptoms associated with the occurrence of microleakage are breakdown and discoloration of margins, secondary caries, increase in post-operative sensitivity, and the pulp pathology.[11]

In orthodontics, penetratıon faılure of orthodontic adhesives can cause microleakage under brackets. Microleakage under orthodontic brackets may cause problems, such as enamel decalcification, enamel discoloration, corrosion, and decreased bond strength. The development of white spot lesions is a major complication for patients undergoing fixed orthodontic treatment.[12] To the best of our knowledge, no study has simultaneously compared the microleakage of all adhesive systems.

The aim of this study was to evaluate the effect of different adhesive systems used for bonding brackets on microleakage formed under the bracket-adhesive-enamel complex. The null hypothesis of this study is as follows: The adhesive type does not affect the amount of microleakage under orthodontic brackets.

MATERIALS AND METHODS

A total of 144 extracted human premolar teeth was used in this study. The teeth were stored in a distilled water solution. They were separated into four groups of 36 teeth each. Then, these groups were further divided into three sub-groups each. Before bonding, the buccal surfaces were cleaned with a mixture of water and pumice. The teeth were thoroughly rinsed with water and dried with oil and moisture-free compressed air. Ormco Mini 2000 (Ormco Corp, Glendora, CA, USA) bicuspid metal brackets were used. In group 1, Transbond XT, GreenGloo and Kurasper F, in group 2 Transbond Plus SEP, Bond Force and Clearfil S3 with Transbond XT composite resin, in group 3, three two-step self-etching bonding systems (Clearfil SE Bond, Clearfil Protectbond and Clearfil Liner Bond with Transbond XT composite resin), and in group 4, three self-adhesive resin cements (Maxcem Elite, Relyx U 100 and Clearfil SA Cement) were directly bonded according to the manufacturer's recommendations. To etch the enamel surface in the total etch groups and self-adhesive resin cement groups, 37% etching gel was used. Table 1 shows the adhesive systems used in this study and Table 2 shows the steps of bonding systems.

The apical portion of the teeth was clogged with wax. Then, all of the teeth, including the roots, were covered with nail varnish up to 1 mm away from the bracket margins. The samples were incubated for 24 h in 0.5% basic fuchsine solution. The teen was then removed from the solution, washed with distilled water, and dried with air. The roots of the teeth were embedded in acrylic resin. Four parallel longitudinal sections were made in the direction of buccolingual with a low-speed diamond saw (Isomet, Buehler, Illinois, USA). All samples were examined under stereomicroscope with×16 magnification. Each section was scored from

Table 1: Materials used in this study

Adhesive	Corporation
Transbond XT	3M Unitek, California, USA
Greengloo	Ormco, California, USA
Kurasper F	Kuraray Medical Inc. Tokyo, JAPAN
Transbond plus SEP	3M Unitek, California, USA
Bond force	Tokuyama Dental Inc., Tokuyama, USA
Clearfil S^3 bond	Kuraray Medical Inc., Tokyo, Japan
Clearfil SE bond	Kuraray Medical Inc., Tokyo, Japan
Clearfil protect bond	Kuraray Medical Inc., Tokyo Japan
Clearfil liner bond 2V	Kuraray Medical Inc., Tokyo, Japan
Maxcem elite	Kerr Products, USA
RelyX U 100	3M ESPE Dental Products, USA
Clearfil SA cement	Kuraray Medical Inc., Tokyo, Japan

SE: Self etch, SA: Self-adhesive, SEP: Self etching primer

Table 2: Application procedures of the materials investigated in this study

Groups	Etch (s)	Water (s)	Rinse	Primer (P)/ bond (B) (s)	Curing (s)
Transbond XT	15	30	30	3 (B)	20
Greengloo	15	30	30	3 (B)	20
Kurasper F	15	30	30	3 (B)	20
Transbond plus				3 (P)	20
Bond force				3 (P)	20
Clearfil S^3 bond				3 (P)	20
Clearfil SE bond				3 (P)+3 (B)	20
Clearfil protect bond				3 (P)+3 (B)	20
Clearfil liner bond 2V				3 (P)+3 (B)	20
Maxcem elite					20
RelyX U100					20
Clearfil SA cement					20

SE: Self etching, SA: Self-adhesive

both incisal and gingival margins to the brackets between both the bracket-adhesive and adhesive-enamel interfaces. Scoring was performed as described in Table 3.

Statistical analysis

Statistical analysis was performed using SPSS Version 16.00 (SPSS Inc, Chicago, Illinois, USA). The microleakage scores of the groups were statistically evaluated with the use of the Kruskal–Wallis test and Wilcoxon signed-rank test, with the level of significance set at $P < 0.05$.

RESULTS

The microleakage scores of the conventional system are shown in Table 4. No statistically significant difference was found between the groups. The microleakage scores of the one-step self-etching primers are shown in Table 5. No statistically significant difference was found between the groups. The microleakage scores of the two-step self-etching primers are shown in Table 6. No statistically significant difference was found between the groups. The microleakage scores of the self-adhesive resin cements are shown in Table 7. No statistically significant difference was found between the groups. Statistically significant differences were found between the average values of the microleakages in the adhesive–enamel and bracket adhesive ınterfaces ($P < 0.05$). More microleakage was found in the adhesive-enamel interface than in the bracket adhesive ınterface [Table 8].

The gingival side in many groups showed higher microleakage scores than the occlusal side, but this result was not statistically significant. Statistical comparisons of the microleakage scores between the groups at the enamel–adhesive and adhesive–bracket interfaces indicated that the type of adhesive used did not significantly affect the amount of microleakage at the gingival or occlusal margin. Therefore, the null hypothesis is not rejected.

DISCUSSION

Described as the transition of liquids, ions, or molecules between a tooth and the restoration, microleakage cannot be clinically detected. It results in the formation of cavities and post-operative sensitivity.[11] In terms of orthodontics, microleakage may cause the decalcified area around the orthodontic brackets or decrease the bond strength of brackets.[12] White spot lesions were found in one of the four patients treated with fixed orthodontic appliances.[13]

Table 3: Microleakage scores and criteria

Score	Criteria
0	No dye penetration between the bracket-adhesive or the adhesive-enamel interface
1	Dye penetration restricted to 1 mm of the bracket-adhesive or adhesive-enamel interface
2	Dye penetration into the inner half (2 mm) of the bracket-adhesive or adhesive-enamel interface
3	Dye penetration into 3 mm of the bracket-adhesive or adhesive-enamel interface

Table 4: Comparison of the microleakage scores of conventional systems between adhesive-enamel, adhesive-bracket Interfaces from occlusal and gingival sides (Kruskal–Wallis test)

Interface	Test groups	Occlusal	Gingival	Mean±SD	*P*
Adhesive-enamel	Transbond XT	0.67±0.78	1.42±0.79	1.04±0.39	0.440
	Greengloo	1.00±0.60	1.50±0.90	1.25±0.62	
	Kurasper F	0.92±0.79	1.00±0.95	0.95±0.49	
Adhesive-bracket	Transbond XT	0.25±0.45	0.42±0.51	0.33±0.24	0.770
	Greengloo	0.50±0.52	0.50±0.67	0.50±0.47	
	Kurasper F	0.42±0.66	0.67±0.88	0.54±0.62	

SD: Standard deviation

Table 5: Comparison of the microleakage scores of one step self-etch adhesive systems between adhesive-enamel interfaces from occlusal and gingival sides (Kruskal–Wallis test)

Interface	Test groups	Occlusal	Gingival	Mean±SD	*P*
Adhesive-enamel	Transbond plus SEP	0.83±0.83	1.25±1.21	1.04±0.65	0.783
	Bond force	1.08±1.08	0.92±0.90	1.00±0.76	
	Clearfil S3	0.83±1.11	0.92±1.16	0.87±0.77	
Adhesive-bracket	Transbond plus SEP	0.58±0.51	0.33±0.49	0.45±0.39	0.701
	Bond force	0.42±0.51	0.50±0.79	0.45±0.49	
	Clearfil S3	0.83±1.03	0.50±0.52	0.66±0.65	

SD: Standard deviation, SEP: Self etching primer

Table 6: Comparison of the microleakage scores of two step self-etch adhesive systems between adhesive-bracket surfaces from occlusal and gingival sides (Kruskal–Wallis test)

Interface	Test groups	Occlusal	Gingival	Mean±SD	*P*
Adhesive-enamel	Clearfil SE	0.83±0.57	1.00±1.04	0.91±0.51	0.745
	Clearfil protect bond	1.33±1.15	1.08±1.24	1.20±0.89	
	Clearfil liner bond 2V	0.92±0.79	1.00±0.95	0.95±0.65	
Adhesive-bracket	Clearfil SE	0.42±0.66	0.75±0.86	0.58±0.41	0.767
	Clearfil protect bond	0.58±0.79	0.67±0.65	0.62±0.48	
	Clearfil liner bond 2V	0.42±0.51	0.67±0.88	0.54±0.54	

SD: Standard deviation, SE: Self-etch

Table 7: Comparison of the microleakage scores between self-adhesive resins cements adhesive-bracket interfaces from occlusal and gingival sides (Kruskal–Wallis test)

Interface	Test groups	Occlusal	Gingival	Mean±SD	*P*
Adhesive-enamel	Maxcem elite	1.08±0.99	1.42±1.16	1.25±0.62	0.857
	RelyX U100	1.50±1.00	1.00±0.85	1.25±0.78	
	Clearfil SA cement	1.08±0.99	1.67±1.15	1.37±0.74	
Adhesive-bracket	Maxcem elite	0.67±0.77	0.83±0.93	0.75±0.50	0.868
	RelyX U100	0.50±0.52	0.83±0.93	0.66±0.53	
	Clearfil SA cement	0.42±0.51	0.92±0.79	0.66±0.38	

SD: Standard deviation, SA: Self-adhesive

Table 8: Comparison of the mean values of microleakage scores between adhesive-bracket, adhesive-enamel interfaces (Wilcoxon signed tests)

Interface	*n*	$\bar{x}\pm S\bar{x}$	*P*
Adhesive-bracket	144	0.56±0.48	0.00
Adhesive-enamel	144	1.09±0.66	

In vitro studies can be used to evaluate microleakage under orthodontic brackets.[14-17] The dye penetration method, is the most preferred method to test the amount of microleakage. The availability of aqueous solutions, determination under visible light, fast, and direct measurement of microleakage, absence of reaction with hard structures, low cost, and nontoxicity are the advantages of this method. *In vitro* microleakage studies in orthodontics used a dye solution, and examine the sections under stereomicroscope to evaluate the dye penetration.[3,8,12,14,15,18] The dye penetration method was also used in the current study. The samples in the solution were heated for 24 h.

Uysal *et al*.[19] were used digital caliper to measure the amount of microleakage. Arhun *et al*. and Arıkan *et al*. reported that[8,12] the use of digital caliper only is not objective; scoring was made in addition to digital caliper measurements.

In *in vitro* microleakage studies, the microleakage under brackets was investigated at the occlusal and gingival directions in the enamel-adhesive and adhesive-bracket interfaces.[12,15] Our study used a similar working procedure.

The microleakage scores obtained from the occlusal and gingival margins of the brackets demonstrated differences, a result implying increased microleakage in the gingival side. However, these differences were not statistically significant. This finding may be related to the surface curvature anatomy of the teeth. In the literature, similar results were also reported.[3,8] The microleakage of the adhesive-enamel interface affects the formation of white spot lesions. The microleakage of the adhesive–bracket interface affects the bond strength of orthodontic brackets.[12] However, James *et al*.[20] reported that microleakage and bond strength were not related.

The results of our study indicate that the microleakage was identified in all groups and all interfaces. No significant differences were observed between the amounts of microleakage of the adhesive systems. These findings were similar to those obtained by Arhun *et al*.[8] Yagci *et al*.[21] evaluated the microleakage of orthodontic brackets between enamel-adhesive and adhesive–bracket interfaces at the occlusal and gingival margins; these brackets were bonded with indirect bonding systems with the use of a conventional direct bonding method. Yagci *et al*.[21] and Li *et al*.[22] reported that the bonding procedure did not affect the amount of microleakage under orthodontic brackets. This finding supports our results. The authors concluded that the microleakage does not depend on the type of adhesive used.[21,22]

Buyuk *et al*.[23] reported that the amount of microleakage under brackets bonded with low-shrinking composites was lower than that found in conventional systems. However, they reported that low-shrinking composites are unreliable for bonding orthodontic brackets because of their insufficient *in vitro* shear bond strength values. Low microleakage scores are inadequate to warrant the use of adhesive for orthodontic bonding.[23]

Our study compared the microleakage of orthodontic brackets between enamel-adhesive and adhesive-bracket interfaces. More microleakage was identified from the enamel-adhesive interface than the adhesive–bracket interface. Microleakage of the adhesive-enamel interface can result in the occurrence of white spot lesions. Some studies in the literature[3,15] support this view.

CONCLUSION

All of the brackets exhibited some amount of microleakage. This result means that the microleakage does not depend on the type of adhesive used.

The amount of the microleakage in the adhesive–enamel interface is higher than that in the adhesive-bracket interface.

Preventive treatment alternatives should be used to protect the tooth enamel against the formation of white spot lesions.

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