Original Article

Microleakage under Ceramic and Metallic Brackets Bonded with Resin-Modified Glass Ionomer

Sabri Ilhan Ramoglu[a]; Tancan Uysal[b]; Mustafa Ulker[c]; Huseyin Ertas[d]

ABSTRACT

Objective: To test the null hypothesis that there is no significant difference between the microleakage of adhesive interferences at the occlusal and gingival margins of both ceramic and metallic brackets bonded with light-cured resin-modified glass ionomer and a conventional adhesive.

Materials and Methods: Sixty freshly extracted human maxillary premolar teeth were randomly divided into four groups of 15 teeth each. Metal and ceramic brackets were bonded to groups 1 and 2 with resin-modified glass ionomer adhesive (RMGIA). Metal and ceramic brackets were bonded to group 3 and group 4 with a conventional adhesive (CA) system. A dye-penetration method was used for microleakage evaluation. Microleakage from the occlusal and gingival margins was determined by a stereomicroscope for the enamel-adhesive and bracket-adhesive interfaces. Statistical analysis was performed using the Kruskal-Wallis test and the Mann-Whitney *U*-test with a Bonferroni correction.

Results: The gingival side of all groups exhibited higher microleakage scores compared with the occlusal side for both adhesive interfaces. All bracket and adhesive combinations displayed statistically significant differences in microleakage between the enamel-adhesive and adhesive-bracket interfaces at the occlusal and gingival sides of the brackets ($P < .001$). When the adhesive systems were compared, the RMGIA showed more microleakage than the CA between the different interfaces.

Conclusions: The hypothesis is rejected. RMGIA results in more microleakage between enamel-adhesive interfaces. (*Angle Orthod.* 2009;79:138–143.)

KEY WORDS: Microleakage; Glass-ionomer; Adhesive; Metallic; Ceramic

INTRODUCTION

Since visible-light-activated composite materials became widely available in the mid 1970s, their use in dentistry has exploded.[1] Parallel to the increasing rate of usage in general dentistry, bracket bonding with light-cure materials also became increasingly popular in orthodontics.[2,3]

The most important factors for this popularity are longer material working time and flexibility in initiating the polymerization process, which means extended bracket positioning time.[2–4] However, polymerization shrinkage is one of the major disadvantages of these adhesives.[3,5,6] Polymerization shrinkage of the adhesive will result in oral fluid leakage between the tooth and the adhesives.[2,6] A path of microleakage between the adhesive and enamel leaves the potential for microbial ingress and consequent enamel decalcification.[6,7]

Demineralization of the labial surfaces of the teeth during orthodontic therapy is a problem of clinical importance,[8] and it may present an esthetic problem as much as 5 years after treatment.[9] O'Reilly and Featherstone[10] reported that measurable decalcification areas could be seen around orthodontic appliances after only 1 month. Enamel decalcification and white spot formation occur because of mineral loss in the surface

[a] Assistant Professor, Department of Orthodontics, Faculty of Dentistry, Erciyes University, Kayseri, Turkey.
[b] Associate Professor and Department Chair, Department of Orthodontics, Faculty of Dentistry, Erciyes University, Kayseri, Turkey.
[c] Assistant Professor, Department of Conservative Dentistry, Faculty of Dentistry, Erciyes University, Kayseri, Turkey.
[d] Research Assistant, Department of Conservative Dentistry, Faculty of Dentistry, Erciyes University, Kayseri, Turkey.
Corresponding author: Dr Tancan Uysal, Erciyes Üniversitesi Dişhekimliği Fakültesi, Ortodonti A.D. Melikgazi, Kampüs Kayseri, 38039 Turkey
(e-mail: tancanuysal@yahoo.com)

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or subsurface of enamel; the white appearance of initial carious lesions is an optical phenomenon.[9]

Fluoride is one of the most effective agents in caries prevention. Fluoride inhibits the metabolism of the bacteria causing caries and increases the resistance of enamel and dentine to caries. Porous enamel and softened dentine can be remineralized in the presence of fluoride.[9] Forsten[11] emphasized the importance of using fluoride during treatment with fixed orthodontic appliances to prevent development of white spot lesions. Usually the fluoride is applied as a solution, paste, or varnish aimed at the whole dentition.[11] Orthodontic attachments should be bonded with materials that release fluoride.[12]

The anticariogenic and remineralizing effects of the continuous fluoride release from conventional glass ionomer cements can be predicted, and there are indications that resin-modified glass ionomer (RMGI) cements have similar effects. RMGI cements can be used in cases where a strong initial fluoride effect is desired in addition to a long-term effect.[11]

Arhun et al[5] studied microleakage at the tooth-adhesive-bracket complex when metal or ceramic brackets were bonded with a conventional and an antibacterial adhesive. They reported that metal brackets cause more leakage between the adhesive-bracket interface, which may lead to lower clinical shear bond strength and white spot lesions.

To our knowledge, no studies have investigated the effects of RMGI adhesives (RMGIA) on microleakage scores beneath brackets. Therefore, the aim of this study is to compare the amount of microleakage associated with metallic and ceramic brackets bonded with light-cured RMGIA to microleakage associated with a conventional light-cured adhesive system. The null hypothesis was that there is no significant difference between the microleakage of adhesive interferences at the occlusal and gingival margins of ceramic and metallic brackets bonded with RMGIA and conventional adhesive (CA).

MATERIALS AND METHODS

Sample Preparation

Sixty freshly extracted human maxillary premolar teeth, free of caries and surface defects, were collected and stored in a distilled water solution immediately after extraction. The teeth were prepared by removing soft-tissue remnants, calculus, and plaque. They were then separated into four groups of 15 teeth each.

A 37% phosphoric acid gel (3M Dental Products, St Paul, Minn) was used for etching. The acid gel was applied for 30 seconds, rinsed with water from a 3-in-1 syringe for 30 seconds, and dried with an oil-free air source for 20 seconds. A quartz tungsten halogen light unit (Hilux 350, Express Dental Products, Toronto, Ontario, Canada) with a 10-mm diameter light tip was used for curing the specimens for 40 seconds. The etching and curing procedure was the same for all groups. Both ceramic and metallic premolar brackets (3M Unitek, Monrovia, Calif) were used in this study. Transbond XT (3M Unitek) was applied as the CA and GC Fuji Ortho LC (GC Company, Tokyo, Japan) was used for RMGIA system. Bracket and bonding material distribution for the groups are as follows:

Group 1: Metal brackets bonded with RMGIA
Group 2: Ceramic brackets bonded with RMGIA
Group 3: Metal brackets bonded with CA
Group 4: Ceramic brackets bonded with CA

All bonding procedures were done according to the manufacturer's instructions. Special care was taken to remove excess resin around the brackets before the adhesive was polymerized.

Microleakage Evaluation

After the tooth apices were sealed with sticky wax for dye penetration, they were rinsed in tap water and air dried. Nail varnish was then applied to the entire surface of the tooth, except for an area approximately 1 mm away from the brackets. The teeth were replaced in water as soon as the nail polish dried to minimize dehydration of the restorations. They were then immersed in a 0.5% solution of basic fuchsine for 24 hours at room temperature. After they were removed from the solution, the teeth were rinsed in tap water, and the superficial dye was removed with a brush and dried. Four parallel longitudinal sections were made through the occlusal and gingival surfaces with a low-speed diamond saw (Isomet, Buehler, Lake Bluff, Ill) in the buccolingual direction according to Arhun et al.[5] Each section was scored from the occlusal and gingival margins to the brackets between the enamel-adhesive interface and the adhesive-bracket interface.

Microleakage was determined by direct measurement using an electronic digital caliper. The data were recorded to the nearest value as a range from 0.5 to 5 mm.

Statistical Analysis

Both enamel-adhesive and adhesive-bracket interfaces were investigated at the gingival and occlusal sides. For each specimen, the microleakage scores of the gingival and occlusal sides were obtained by calculating the mean microleakage scores for each side measured from four sections. Statistical analysis was performed using Kruskal-Wallis test and Mann-Whitney *U*-test with Bonferroni correction (Statistical Pack-

Table 1. Comparison of the Microleakage Scores between Occlusal and Gingival Sides for Enamel-Adhesive and Adhesive-Bracket Interface[a]

			Occlusal		Gingival		Statistical Evaluation	
Interface	Groups[b]	N	Mean (mm)	SD	Mean (mm)	SD	*P* value	Significance
Enamel-Adhesive Interface	Group 1	15	1.35	1.11	1.61	1.00	.005	**
	Group 2	15	0.96	1.02	1.65	1.01	.005	**
	Group 3	15	0.00	0.00	0.08	0.15	.059	NS
	Group 4	15	0.01	0.06	0.05	0.14	.414	NS
Adhesive-Bracket Interface	Group 1	15	1.01	0.99	1.35	0.73	.097	NS
	Group 2	15	1.50	0.77	1.53	0.66	.858	NS
	Group 3	15	0.00	0.00	0.08	0.26	.180	NS
	Group 4	15	0.00	0.00	0.08	0.12	.025	*

[a] N indicates sample size; NS, not significant.

[b] Group 1 = Fuji + metallic bracket; group 2 = Fuji + ceramic bracket; group 3 = Transbond XT + metallic bracket; group 4 = Transbond XT + ceramic bracket.

* $P < .05$; ** $P < .01$.

age for Social Sciences, SPSS version 13.0, Chicago, Ill). The level of statistical significance was set at $P < .05$.

RESULTS

Comparisons of the microleakage scores between the occlusal and gingival sides for adhesive interfaces are shown in Table 1. The gingival side of all groups exhibited higher microleakage scores than the occlusal sides for both the enamel-adhesive and adhesive-bracket interfaces, and some of the differences were statistically significant. Groups 1 and 2 (bonded with RMGIA) showed statistically higher microleakage between the enamel-adhesive interface at the gingival side ($P < .01$). Group 4 (ceramic brackets + CA) showed higher microleakage only between the adhesive-bracket interfaces at the gingival side.

Statistical comparisons of the microleakage scores among the four groups at the occlusal and gingival sides for both adhesive interfaces are shown in Table 2. All groups displayed statistically significant microleakage differences for both adhesive interfaces at the occlusal and gingival sides of the brackets ($P < .001$). No significant differences were found in microleakage scores between the metallic and ceramic bracket groups for both the RMGIA and CA. However, when the adhesive systems were compared, the RMGIA showed more microleakage than the CA. Group 1 (metallic brackets + RMGIA) had statistically significant higher scores than group 3 (metallic brackets + CA)

Table 2. Multiple Comparisons of the Microleakage Scores between Groups for Occlusal and Gingival Sides in Enamel-Adhesive and Adhesive-Bracket Interface[a]

							Multiple Comparison		
Interface	Side	Groups[b]	N	Mean (mm)	SD	Significance (*P*)	Group 2	Group 3	Group 4
Enamel-Adhesive Interface	Occlusal	Group 1	15	1.35	1.11	.000	NS	***	***
		Group 2	15	0.96	1.02			**	**
		Group 3	15	0.00	0.00				NS
		Group 4	15	0.01	0.06				
	Gingival	Group 1	15	1.61	1.00	.000	NS	***	***
		Group 2	15	1.65	1.01			***	***
		Group 3	15	0.08	0.15				NS
		Group 4	15	0.05	0.14				
Adhesive-Bracket Interface	Occlusal	Group 1	15	1.01	0.99	.000	NS	***	***
		Group 2	15	1.50	0.77			***	***
		Group 3	15	0.00	0.00				NS
		Group 4	15	0.00	0.00				
	Gingival	Group 1	15	1.35	0.73	.000	NS	***	***
		Group 2	15	1.53	0.66			***	***
		Group 3	15	0.08	0.26				NS
		Group 4	15	0.08	0.12				

[a] N indicates sample size; NS, not significant.

[b] Group 1 = Fuji + metallic bracket; group 2 = Fuji + ceramic bracket; group 3 = Transbond XT + metallic bracket; group 4 = Transbond XT + ceramic bracket.

* $P < .05$; ** $P < .01$; *** $P < .001$.

and group 4 (ceramic brackets + CA) at the occlusal and gingival sides for both adhesive interfaces ($P < .001$). Group 2 (ceramic brackets + RMGIA) showed statistically significant higher microleakage at the occlusal side than group 3 and group 4 at the enamel-adhesive interfaces ($P < .01$). Group 2 also showed statistically significant more microleakage than groups 3 and 4 at the gingival side between the enamel-adhesive interfaces and at both the gingival and occlusal sides between the adhesive-bracket interfaces ($P < .001$). According to our findings the null hypothesis was rejected.

DISCUSSION

Persons undergoing orthodontic treatment have significantly more teeth with white spot lesions than untreated persons,[9] and this rapidly demineralization process occurs around brackets after only 1 month.[10] These enamel decalcifications can occur as a result of retained bacterial plaque on the enamel for a prolonged period.[8] Although the areas around the brackets are critical, the areas under the brackets also need attention.[5] Microleakage around the orthodontic brackets may increase a patient's risk of decalcification.[6]

General-use materials that release fluoride are advised for orthodontic practice.[12] The compomer and RMGIA appear to offer viable alternatives to the more commonly used resin adhesives.[13] However, although some studies presented the bond strength of RMGI, no studies have compared the microleakage of metallic and ceramic brackets bonded with RMGIA and CA.

In the present study, microleakage of the bonded specimens was determined by one of the most common microleakage assessing method[14]: the dye penetration method, which has been used in previous studies.[7,15–17] To evaluate the measurement error, two researchers evaluated all specimens twice. The inter- and intraexaminer kappa scores for assessing microleakage were high; all values were greater than 0.75.

Thermal cycles are widely used to simulate temperature changes in the mouth, generating successive thermal stresses at the tooth-resin interface. In restorative dentistry, Kubo et al[18] investigated the microleakage of self-etching primers after thermal and flexural load cycling and found that the marginal integrity of self-etching primers did not deteriorate even after thermal cycles (5000 and 10,000 cycles) and flexural loads. Similarly, several researchers found that an increase in the number of thermal cycles was not related to an increase in microleakage of restorations.[19–21] Therefore, thermocycling was not performed in this study.

Similar to the previous study,[5] we observed higher microleakage scores at the gingival sides for all specimens at both adhesive interfaces (Table 1). Microleakage at the adhesive-bracket interface may have a role in bracket failure caused by bond degradation. However, the adhesive-enamel interface is more critical as it may result in white spot lesions.[3] For the adhesive-bracket interface, only the ceramic bracket bonded with CA showed statistically significant increased microleakage at the gingival side ($P < .05$). Despite being very small at 0.08 mm, it is significantly higher than the occlusal score of 0.00 mm. However, the RMGIA showed statistically significant microleakage between the adhesive-enamel interface at the gingival side for the metallic and the ceramic brackets, with scores of 1.61 mm and 1.65 mm, respectively. A previous study showed that low-intensity light followed by a final cure with high-intensity light significantly decreased the marginal gap length for restorative materials,[17] but for orthodontic bonding adhesives high-intensity light did not cause more microleakage.[6] It is thought that the polymerization shrinkage of adhesive material in orthodontics is probably an advantage compared with the materials used in restorative dentistry. This is because the adhesive layer is very thin, and there is usually an excess of resin at the edges of the adhesive area so that some of the shrinkage is absorbed. In addition, the bracket is free floating on adhesive, and shrinkage will pull the bracket closer to teeth.[22]

The purpose of our applying the curing device from the occlusal side was to determine the effect of the increased distance between the adhesive and the light source, which will cause a degradation of light intensity on the gingival side. In addition, the curing effect of light decreases at the deeper portions as the intensity of light decreases as it passes through the material.[23] When those factors are considered, the excess microleakage might be attributable to insufficient polymerization, but microleakage occurs as a result of polymerization shrinkage. Arhun et al[5] related the differences between the gingival and the incisal scores to the surface curvature anatomy, which may result in relatively thicker adhesive at the gingival margin. Similarly, we thought that lower or no microleakage scores at the occlusal side may be attributable to a relatively thinner adhesive on the occlusal side. However, these factors would affect the Transbond XT groups in the same way, and no statistically significant changes were noted. Thus, the specifications of the material may play an important role in the microleakage event.

A study should be designed to investigate the proper reason for the difference in the amount of microleakage between the gingival and occlusal sides of the orthodontic brackets. We believe polymerization, which starts initially at the adhesive material close to the light source, will harden in this region and move the free-floating bracket closer to the teeth so that the shrinkage characteristic of the adhesive farther away from the light source will be changed and will lead to more microleakage.

When the microleakage scores among groups at the occlusal and gingival sides between the adhesive interfaces were examined, we found that Transbond XT showed less microleakage than Fuji Orto LC, regardless of the bracket material on both sides and interfaces. According to our findings, Transbond XT causes less microleakage than Fuji Orto LC. However, as previously mentioned, RMGI cements are effective in remineralizing demineralized enamel,[11] so the risk of enamel demineralization caused by microleakage between adhesive-enamel interface might be counteracted. Further investigation should be performed.

Some studies[24–26] have found that ceramic brackets produce stronger bonds than metallic brackets. Whereas Arhun et al[5] thought that increased strength and difficulty in debonding for ceramic brackets may be attributable to close adhesion of the ceramic bracket to the adhesive in the absence of microleakage, James et al[6] could not find a correlation between bond strength and microleakage.

In this study we could not find any difference in microleakage between ceramic and metallic brackets for both adhesives at the interfaces investigated. This is similar, in part, to the study of Arhun et al,[5] which reported statistically higher microleakage for metal brackets only in the gingival region for adhesive-enamel interface but found that metallic brackets showed increased microleakage at both sides for the enamel-bracket interface.

Arıkan et al[3] reported finding similar to those of Arhun et al[5] and showed less microleakage; the lower microleakage was not statistically significant for the adhesive-enamel interface for ceramic brackets but was statistically significant for the adhesive-bracket interface. They attributed this difference to incomplete polymerization of the adhesives under the metallic brackets, which do not conduct the light as well as ceramic brackets. When the materials and methods are examined, two factors may play a role in the different findings between our study and these studies; first, different brands of ceramic brackets were used, and second, we applied no thermocycling to our specimens. Because thermocycling is not related to the amount of microleakage, the difference may be attributable to the difference in bracket material.

It is impossible to extrapolate the results of an in vitro study to the actual oral environment, but hypothesis need to be tested in the laboratory setting before instituting clinical studies. Our results identify a possible risk factor for white spot lesions, which may be important for some fraction of the patients treated.

CONCLUSIONS

- The gingival sides in all groups exhibited higher microleakage scores compared with those observed on occlusal sides for both adhesive interfaces.
- No differences were observed between metallic and ceramic brackets.
- Using the CA systems in orthodontics practice is safer than using RMGIA as they show less microleakage.

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