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Microleakage Comparison among Three Orthodontic Brackets and Two Orthodontic adhesives

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الخلاصة

الأهداف:تهدف الدراسة الى تقييم ومقارنة التسرب المجهري في منطقة التداخل عند الحافتين الإطباقية واللثوية بين الحاصرات التقويمية: اللؤلؤية، البلاستيكية، والفولاذية، مع نوعينِ من اللواصق التقويمية . **المواد وطرائق العمل**: تمَّ اختيار اثنين وسبعين سنّاً من الضواحك العلوية المقتلعة حديثاً كعيناتٍ للدراسة، وقسمت هذه العينات إلى مجموعتين رئيسيتين، ولكل مجموعة 36 عينة؛ فالمجموعة الأولى لُصِقت باللاصق (Resilience) ، بينما استخْدِم مع الأخرى اللاصق (Biofix). قُسِّمت كل مجموعة منهما إلى ثلاثِ مجموعاتٍ ثانوية شملتْ كلٌّ واحدة منها (12) عينةً بَحَسبِ نوعِ الحاصرات التقويمية: اللؤلؤية،البلاستيكية والفولاذية. بعد البَلْمَرة الضوئيّة للعينات تمَّ تعريضُها للتدوير الحراري، سُدَّت باستخدامِ طلاءِ الأَظافر، ثمَّ غُمِرَت في صبغة الميثلين الزرقاء ذاتِ التركيز 2%، ومِنْ ثَمَّ قُطِّعَت تقطيعاً إطباقيّاً لثويّاً. بعد ذلك فُحِصَت تحت المجهر المجسَّم لقياس مقدار التسرب المجهريّ، وتمَّ حسابُ النتائج ثم تحليلُها إحصائياً باستخدامِ اختبار (t) عند مستوى معنويّة (p≤0.05). **النتائج**: كلُّ المجموعاتِ أَظهرتْ تَسرُّباً مجهريّاً؛ لا يوجد فروقٌ معنويّةٌ، سواء بين نوعي اللواصق التقويميّة، أو بين أنواع الحاصرات التقويمية الثلاث. أَظهرَتْ الجهةُ اللثويةُ للحاصراتِ اللؤلؤيةِ زيادةً معنويّةً تحت اللاصق (Biofix). **الاستنتاجات**: ظهورُ التسرب المجهري بمقاديرَ متقاربه نسبيّاً تحت الجيل الرابع والخامس من المواد اللاصقة، كذلك الأمر مع الحواصر التقويميّة الثلاث بينما يزدادُ التسرب المجهري تحت اللاصق (Biofix) في الجهةِ اللثويّة..

ABSTRACT

AIMS: To evaluate and compare the microleakage occlusally and gingivally under bracket-composite interface of sapphire ceramic, stainless steel and composite orthodontic brackets bonded with two different generations of orthodontic adhesives. **MATERIALS AND METHODS**: Seventy-two freshly extracted premolars were utilized in this study. Three types of orthodontic brackets were used as follows: sapphire ceramic, composite and stainless steel. The samples were divided into two main groups of 36 samples; one group was bonded with Resilience® adhesive, while the other was bonded with Biofix adhesive. Each group was further subdivided into three subgroups of 12 samples according to bracket types. After photopolymerization, the samples were thermocycled. Samples were sealed with nail varnish, stained with 2% methylene blue dye then sectioned occlusogingivally, examined under a stereomicroscope and measured for microleakage at the bracket-adhesive interface from both occlusal and gingival margins, evaluated statistically with t- tests at $p \leq 0.05$ levels of significance. **RESULTS**: All groups showed various degrees of microleakage, however, no significant differences either between the two adhesives or among the three bracket types were recorded. Microleakage beneath sapphire brackets was significantly higher under the Biofix adhesive at the gingival side. **CONCLUSION**: No significant differences were recorded between the occlusal and gingival sites in all of the study groups. However, the 5th generation adhesive showed higher microleakage with significant difference under sapphire ceramic brackets at the gingival margin.

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INTRODUCTION

In contemporary orthodontic treatments, resin composites are widely used for bracket bonding. One of the major disadvantages of these materials is polymerization shrinkage, which may cause leakage between the tooth-adhesive or adhesive-bracket interfaces, resulting in the penetration of bacteria and fluids in these areas.(1) The polymerization shrinkage of the adhesive material may cause gaps in the contact of the adhesive material with the enamel surface and in the contact of the adhesive with the bracket lead to microleakage (2,3), thus facilitating the formation of white-spot lesions under the bracket surface area.[4] Over time, Caries and demineralization continue to be a serious problem during treatment under orthodontic appliances.[5] Demineralization around orthodontic appliances may present an esthetic problem, even more than 5 years after the treatment.[6] Microleakage beneath orthodontic brackets can have severe consequences such as enamel decalcification, discoloration, corrosion and decreased bond strength.[1] Therefore, although the area around a bracket is critical to the development of decalcification, the area beneath the bracket also requires investigation.[7]

There are many important variables affecting bonding, include conditioning procedure, type of adhesive, bracket base design, and treatment of the bracket base.[8] The bracket design affect on bonding and marginal gap site formation. So, bracket designs with different surface characteristics create different bonding environments. [9]

Recently, new generations of orthodontic adhesives were presented. The 5th generation of bonding systems is similar in principle to the 4th generation materials, except that it has been designed to require fewer stages in their placement in an attempt to reduce technique sensitivity and treatment time.[9] According to our best knowledge, no studies compared the microleakage among this complex combination of brackets and orthodontic adhesives.

Thus the aims of this study were to evaluate and compare the microleakage occlusal and gingivally under bracket adhesive interface of sapphire ceramic, stainless steel and composite orthodontic brackets bonded with two different generations of orthodontic adhesives.

MATERIALS AND METHODS

The samples consisted of 72 freshly human upper right first premolars of normal shape and size which were newly extracted for orthodontic treatment purposes. The teeth were free of caries, cracks, restorations or fissures, had not subjected to any kind of orthodontic or endodontic treatment.[10,11] The extracted teeth were stored in distilled water immediately after extraction and at room temperature [12,13], for a maximum period of one month.[14] The water was changed weekly for the rest of the experiment to avoid bacterial growth. [11, 15] The teeth were randomly divided into two equal groups of 36 teeth. Group (A) was used for testing of the orthodontic adhesive (Resilience®, Ortho-Technology, USA) which considered as the 4th generation. This group was subdivided randomly into three equal subgroups of 12 teeth; A1 which was bonded with sapphire (Pure®) brackets, A2 was bonded with composite (OrthoFlex ™) brackets and A3 was bonded with stainless steel (marquis™) brackets. Group (B) was used for testing of the orthodontic adhesive (Biofix, Biodinimica, Brazil) which considered as 5th generation, and also it subdivided randomly into three equal subgroups of 12 teeth; B1 was bonded with sapphire brackets, B2 was bonded with composite brackets and B3 was bonded with stainless steel brackets. The three brackets used are standard with slot size of 0.022 inch (Ortho Technology, USA).

Each sample was fixed on a glass slide in a vertical position using soft sticky wax at the root apex, so that, the middle third of the buccal surface was oriented to be parallel to the analyzing rod of the surveyor.[16] Then a plastic ring (20 mm diameter) placed surrounded the sample. Separating medium applied to the inner surface of the ring, the powder and liquid of the cold cured acrylic were mixed and poured around the samples to the level of the cement-enamel junction of each sample. After mounting, the samples were stored in normal saline solution to prevent dehydration until bonding. [17] The enamel surfaces of the samples were cleaned with pumice slurry for 10 seconds [2], rinsed with running water and dried with a moisture-free air syringe. After enamel etching, brackets were bonded in two manners: In groups (A) the samples were bonded with Resiliance® orthodontic adhesive; a Resilience bonding resin was applied to the etched surface in a thin film and light cured for 10 second, after that the bracket base was coated with adhesive paste while in group (B) the samples were bonded with Biofix's composite was applied on the etched enamel surface. The bracket was placed on the tooth surface, adjusted to its final position, and pressed firmly by thumb finger.(12,14) Excessive adhesive was removed from the periphery of the bracket, each margin of the bracket (mesial, distal, occlusal, and gingival) cured with light for 10 seconds, for a total of 40 seconds using LED light curing unit.(18) After 24 hours, the samples thermocycled by using of two water baths 5 ± 1oC to 55 ±1oC for 300 cycles with a dwell time of 20 seconds and a transfer time of 10 seconds.(19) After being subjected to thermocycling, the samples were coated with two coats of nail varnish up to 1 mm away from the bracket margins.(2, 12, 20) When all the samples were ready, they were immersed in 2% methylene blue dye solution (21,22), for 24 hours. After being removed from the solution, the samples were rinsed with distilled water and the superficial dye was removed with a brush and the sticky wax and nail varnish were removed with a sharp instrument.(6, 12, 19)

Before molding of the two samples of the same group in one mold, each sample sectioned from about the cement-enamel junction using a diamond disk (HoRico, Italy). Then a ready-made two-side opened plastic box used as a casting mold, straight metal plate of 1 mm thickness used as a guide for fixation of the two samples at the same plane as presented in Figure (1). When the two brackets were at the same level horizontally and vertically, a clear powder and liquid of self-cured acrylic were mixed and poured around the teeth to the level of the edges of the molds except under the first tooth in the mold that filled with pink-colored acrylic for differentiation as shown in Figure (2). Four parallel longitudinal sections were made with a low-speed diamond saw (Minitom,Streurs, Denmark) in the buccolingual direction, according to Arhun et al. (7), provided six faces to be examined under stereomicroscope at 40×magnifications. Each section was evaluated from both the occlusal and gingival margins of the bracket in bracket-adhesive interface, recorded the amount of microleakage in millimeter using Motic software (Figure 3).

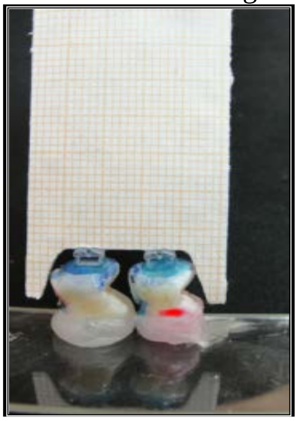

Figure (1): Final adjustment of the samples for molding by using graduated ruler.

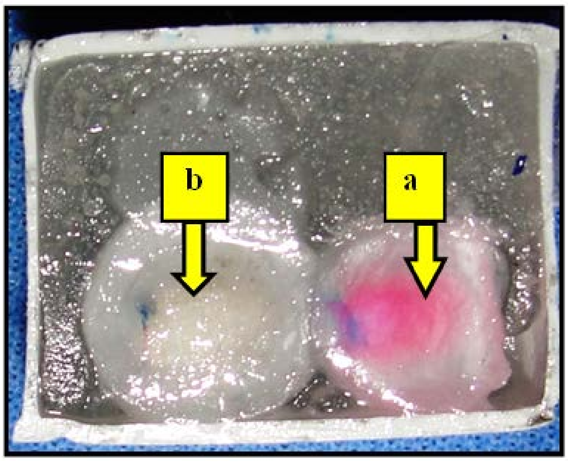

Figure (2): Final shape of the mold:
(a) The first sample with pink acrylic, (b) The second sample with clear acrylic.

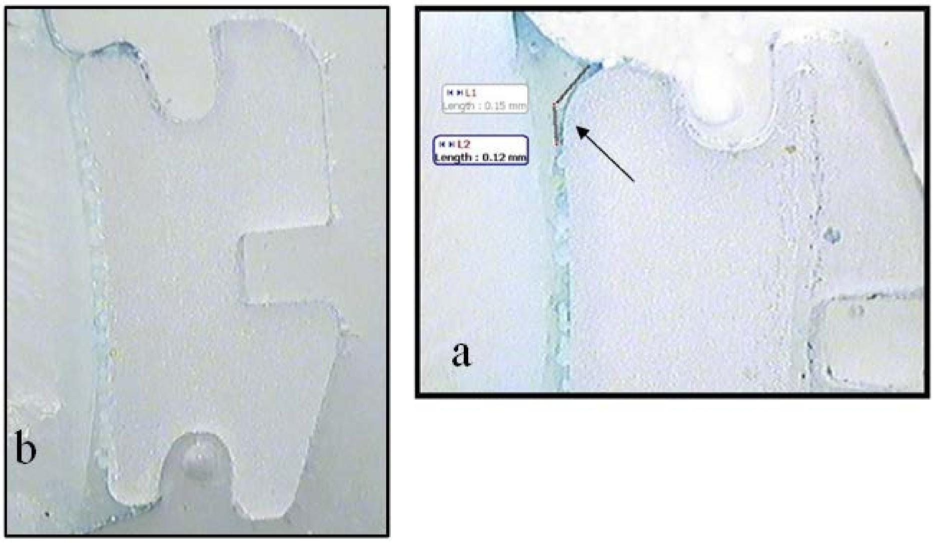

Figure (3): Microleakage recording under sapphire bracket:
(a) No microleakage and (b) Gingival bracket-adhesive microleakage

To test the intra-examiner reliability, the variables of 5 samples were measured twice in 2 weeks interval by same examiner. The method error was calculated by paired t- test with no significant difference in trend according to area. Statistical analysis was carried out by using SPSS software (version 18.0, SPSS, Chicago, Ill). The means and standard deviations of each sample were computed. The microleakage values between the test groups were evaluated statistically with student t- test for bracket-adhesive interface at $p \leq 0.05$ levels of significance.

RESULTS

All groups exhibited a variation in the amounts of microleakage, however, the the statistical analysis showed that the gingival microleakage under the stainless steel, composite, and sapphire ceramic brackets had a relatively higher values than occlusalmicroleakage with no statistical significant difference, as shown in Table (1).

Table (1): Microleakage comparisons between the three types of brackets occlusally and gingivally regardless adhesive type.

Bracket	Site						t– value	*p*– value
	Occlusal			Gingival				
	No.	Mean	SD	No.	Mean	SD		
Stainless Steel	24	0.12	0.05	24	0.13	0.06	0.81	0.425
Composite	24	0.13	0.09	24	0.14	0.07	0.36	0.720
Sapphire	24	0.11	0.07	24	0.12	0.08	1.11	0.277

Regarding the comparison between occlusal and gingival microleakage in each adhesive, the gingival microleakage had a relatively higher value than the occlusalmicroleakage with no significant difference under Biofix adhesive. The Resilience composite showed comparable values occlusally and gingivally with no significant difference (Table 2).

Table (2): Microleakage comparisons between gingival and occlusal side according to adhesive type.

Adhesive	**Site**						**t– value**	***p*– value**
	Occlusal			**Gingival**				
	No.	**Mean**	**SD**	**No.**	**Mean**	**SD**		
Resilience	36	0.11	0.06	36	0.11	0.07	0.13	0.894
Biofix	36	0.13	0.08	36	0.15	0.06	1.64	0.111

The comparisons of microleakage between the 2 adhesives under the three types of brackets showed no significant differences. However, the gingival margin under Biofix in contact with sapphire ceramic bracket showed a significantly higher microleakage than under Resilience adhesive (Table 3).

Table (3): Microleakage comparisons between the three types of brackets occlusally and gingivally with the two adhesive types.

Bracket	**Adhesive**						**t– value**	***p*– value**
	Resilience			**Biofix**				
	No.	**Mean**	**SD**	**No.**	**Mean**	**SD**		
				Occlusal				
Stainless Steel	12	0.12	0.04	12	0.11	0.05	0.77	0.447
Composite	12	0.13	0.05	12	0.14	0.12	0.25	0.803
Sapphire	12	0.09	0.09	12	0.13	0.04	1.55	0.136
				Gingival				
Stainless Steel	12	0.13	0.07	12	0.13	0.05	0.93	0.927
Composite	12	0.12	0.08	12	0.16	0.05	1.62	0.120
Sapphire	12	0.09	0.07	12	0.16	0.06	2.58	0.017*

DISCUSSION

In the oral cavity, the teeth expand and contract when they are heated and cooled by the ingestion of hot or cold foods. This repeated expansion and contraction at different coefficients results in fluids being sucked in and pushed out at the margins of the bracket. [23] In the present study, the dye penetration method was chosen to assess microleakage as it has been used in most of the previous orthodontic studies.[6, 9, 24] In general, study by Arhun and Arman[25], concluded that metal brackets contract and expand more than ceramic brackets producing microgaps between the bracket and the adhesive system causing leakage of oral fluids and bacteria beneath the brackets, leading to the formation of white spot lesion.

The present study revealed relatively increase microleakage in gingival side more than occlusally with no significant differences under both types of adhesives. These results agreed with Ramoglu et al. [20] and Hamamci et al. [12]. This may be related to the angulation of the buccal area of the teeth and lower bracket fitness in the gingival side rather than in the occlusal side. The present study showed relatively higher microleakage in the gingival sides than the occlusal side under three types of brackets where the lowest microleakage was observed under sapphire brackets at the occlusal and gingival side followed by stainless steel brackets and the highest microleakage was observed under composite bracket with no significant differences between them. The results may be viewed in light of the retention means provided with each bracket base. The sapphire ceramic bonding base is coated with Zirconia powder creating millions of undercuts that mechanically lock with the bracket adhesive, the stainless steel bracket supported by mesh bonding pads for easy and accurate bracket placement and micro-etched pylons and the composite bracket has three dove tail grooves only. This result confirmed the results of the studies of microleakage done by Ramoglu et al. [20]

which concluded that there were no significant differences observed between metallic and ceramic brackets. Whereas, studies by Arikan et al. [26] and Arhun et al. [7] disagreed with this study and concluded that microleakage under metal brackets significantly more than under ceramic brackets and they interrupted those differences due to effect of curing that may prevent complete polymerization beneath metal bracket which do not conduct the light as well as ceramic brackets lead to increase microleakage under metal brackets more than ceramic brackets. This disagreement can be explained by the method of light curing of composites used in those studies in two sides of brackets only (mesial and distal) as not similar curing done in this study from four sides (mesial, distal, occlusal and gingival). In the present study, microleakage under composite bracket showed the highest leakage this may be due to the limited dimensional stability of that bracket [27], and/or exposing to hot and cold media during thermocycling. In literature, there was no available study evaluated microleakage beneath the sapphire ceramic or composite brackets. Generally speaking, there are two types of ceramic brackets, polycrystalline alumina brackets, the most common type, and single-crystal alumina or sapphire brackets. Even though all ceramics are hard, the synthetic sapphire used for monocrystalline brackets has high fracture strength and suggested that it it should be selected for clinical use. [28]

The results of this study revealed that there was relatively higher microleakage under 5th generation adhesive with three bracket types in occlusal and gingival margins than the 4th generation with a significant differences between them at the gingival side of the sapphire brackets. Despite being very small at 0.16 mm, it is significantly higher than with the 4th generation adhesive of 0.09 mm, these differences may be due to increase polymerization shrinkage, viscosity and/or changes in the filler size of both adhesives. Calheiros et al. [29] stated that increase polymerization shrinkage leads to microleakage and Burgess et al.[30] concluded that polymerization shrinkage varies from composite to composite depends on the percentage of filler, the diluents, the percentage of the monomer conversion in the specific composite resin, and the photo-polymerization type.

CONCLUSION

No significant differences were recorded between the occlusal and gingival sites in all of the study groups, however, the 5th generation adhesive showed higher microleakage with significant difference under sapphire brackets at the gingival margin.

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