Original Article

# Microleakage under ceramic flash-free orthodontic brackets after thermal cycling

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**ABSTRACT**

**Objective:** To compare microleakage under 3M Unitek's APC Flash-Free Adhesive Coated System bracket and the APC PLUS Adhesive Coated System bracket after thermal cycling.

**Materials and Methods:** Forty freshly extracted human maxillary premolars were randomly divided into two groups and bonded with either a Flash-Free bracket or a PLUS bracket. After bonding, the samples were incubated in a water bath at 37°C for 24 hours and thermocycled for 5000 cycles between 5°C and 50°C. All teeth were immersed in a 2% methylene blue solution for 24 hours, embedded in acrylic and sectioned in a buccolingual direction at approximately the center of the bracket. Microleakage was observed at the enamel-adhesive interface from the occlusal and gingival margins of the bracket base. Statistical analysis was conducted using the Mann-Whitney *U*-test.

**Results:** The median microleakage was higher in the Flash-Free group, but the difference between the two groups was not statistically significant ($P > .05$).

**Conclusion:** In a laboratory setting, there is no significant difference between the extent of microleakage under the APC Flash-Free Adhesive Coated System bracket and the APC PLUS Adhesive Coated System bracket after thermal cycling. (*Angle Orthod.* 2016;86:905–908)

**KEY WORDS:** Microleakage; Flash-free; Adhesive; Thermal cycling

## INTRODUCTION

A popular method to establish a reliable bond between an orthodontic bracket and the enamel is to utilize a self-etching primer and a light cure adhesive. The polymerization shrinkage associated with light cure adhesive leads to gap formation between the material and the enamel.[1] Microleakage of oral fluids and bacteria underneath orthodontic brackets ultimately contributes to the development of white spot lesions[1] (WSLs) and can reduce shear bond strength.[2,3]

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Microleakage under orthodontic brackets has been studied extensively using different bracket systems,[3,4] light curing units,[1,5,6] bonding methods,[7–9] and adhesives.[2,3,10] Unfortunately, there is minimal agreement among clinicians which method of bonding and material consistently allows the least microleakage. Metallic brackets[3] bonded with self-etching primers[4] or resin-modified glass ionomer[10] (RMGI) displayed decreased microleakage compared with ceramic brackets and traditional etch/liquid primer, while conventional adhesive appears to reduce microleakage regardless of bracket type.

The APC Flash-Free Adhesive Coated Appliance System developed by 3M Unitek (Monrovia, Calif) uses individually packaged brackets with a low viscosity resin applied to a nonwoven polypropylene mesh, which eliminates the need for flash removal and creates a seal to reduce microleakage. In vitro studies of this bracket system have demonstrated adequate bond strength,[8,11] reduced bonding time,[11,12] and microleakage[8] comparable to traditional bonding systems. Grunheid et al.[8] calculated the volume of silver nitrate microleakage under the Flash-Free system using microcomputed tomography, but they did not stress their samples prior to evaluation.

**Table 1.** Median, Mean, and IQR Values of Microleakage (mm) at the Enamel-Adhesive Interface Measured From the Occlusal and Gingival Borders of the Bracket Base

| | Flash-Free | | Control | |
|---|---|---|---|---|
| | Occlusal | Gingival | Occlusal | Gingival |
| Median[a] | 0.35 | 0.41 | 0.24 | 0.24 |
| Mean | 0.36 | 0.39 | 0.29 | 0.32 |
| IQR | 0.69 | 0.30 | 0.49 | 0.55 |

[a] Mann-Whitney *U*-test, $P > .05$.

The purpose of this study was to evaluate the microleakage beneath the APC Flash-Free Adhesive Coated Appliance System bracket and the APC PLUS Adhesive Coated System bracket after thermal cycling.

## MATERIALS AND METHODS

### Sample

*Teeth*. Forty freshly extracted human maxillary premolars were collected from Tufts School of Dental Medicine Department of Oral Surgery and various private practices. The teeth were deidentified and stored in a solution of 0.1% (weight/volume) thymol to inhibit bacterial growth. Inclusion criteria for tooth selection were intact buccal enamel, not subject to any pretreatment chemical agents (such as hydrogen peroxide), no cracks, no caries, and no previous orthodontic bonding. All teeth were washed with water, cleaned with curettes and nonfluoridated pumice for 10 seconds, and randomly divided into two groups (20 per group) using a random sequence generator.

*Brackets*. Ceramic APC Flash-Free Adhesive Coated Appliance System maxillary premolar brackets were used in the experimental (Flash-Free) group and ceramic APC PLUS Adhesive Coated System maxillary premolar brackets were used in the control (PLUS) group.

### Methodology

*Bonding procedure*. Transbond Plus Self Etching Primer (3M Unitek) was applied to the enamel surface and rubbed for 5 seconds on all teeth. A gentle burst of dry air was used to thin the primer. Brackets were bonded by a single operator according to one of the following two procedures:

1. Flash-Free group: APC Flash-Free brackets were applied to the teeth and positioned with an explorer at the ideal occlusogingival and mesiodistal position.
2. Control group: APC PLUS Adhesive Coated brackets were applied to the teeth and positioned as in No. 1. Excess adhesive resin was removed in both groups.

All adhesive resin was polymerized for 5 seconds through the bracket with a Demi Plus LED curing light (Kerr Corp, Orange, Calif) with a wavelength between 450 and 470 nm and at an intensity of 1100 mW/cm$^2$. After bonding, the teeth were incubated in a distilled water bath at 37°C for 24 hours to ensure complete polymerization of the bonding materials.

*Thermal cycling*. Sticky wax was used to block the root apices and prevent microleakage that could originate from the pulp chamber. Clear nail polish was applied in two layers on all tooth surfaces except for 1 mm around the orthodontic bracket base to prevent microleakage from other areas of the tooth. All teeth were thermocycled for 5000 cycles between 5°C and 50°C with a dwell time of 30 seconds, which simulated 6 months of intraoral environment.[13]

*Evaluation of microleakage*. All teeth were immersed in a 2% methylene blue solution for 24 hours to allow dye penetration and cleaned thoroughly with water and a toothbrush. The teeth were then embedded in a cold-cure acrylic resin mold and sectioned in a buccolingual direction through the occlusal surface at approximately the center of the bracket using a slow-speed diamond saw (IsoMet, Buehler, Lake Bluff, Ill). Microleakage at the enamel-adhesive interface was evaluated under a light microscope and measured in millimeters from the occlusal and gingival margins of the bracket base.

### Statistical Analysis

A pilot study was conducted initially on 12 teeth to calculate sample size and power. A power calculation was conducted using nQuery Advisor, version 7.0. Based on the effect size observed in the pilot study, it was determined that a sample size of $n = 20$ per group is adequate to obtain a type I error rate of 5% and a power greater than 99%. A Mann-Whitney *U*-test was conducted using SAS, version 9.3 (SAS Institute Inc, Cary, NC) to determine statistical differences between the two groups.

## RESULTS

Microleakage data collected from the study for all 20 samples in each of the groups are displayed in Table 1. In the Flash-Free group, 27.5% (11/40) of the surfaces exhibited no visible microleakage and 10% (2/20) of the samples showed no evidence of microleakage from either the occlusal or gingival aspects of the bracket. In the control group, 37.5% (15/40) of the surfaces exhibited no visible microleakage and 12.5% (5/40) of the samples showed no evidence of microleakage from either surface of the bracket. The greatest extent of microleakage was 1.38 mm and 0.99 mm for the Flash-Free and control groups, respectively. An example of

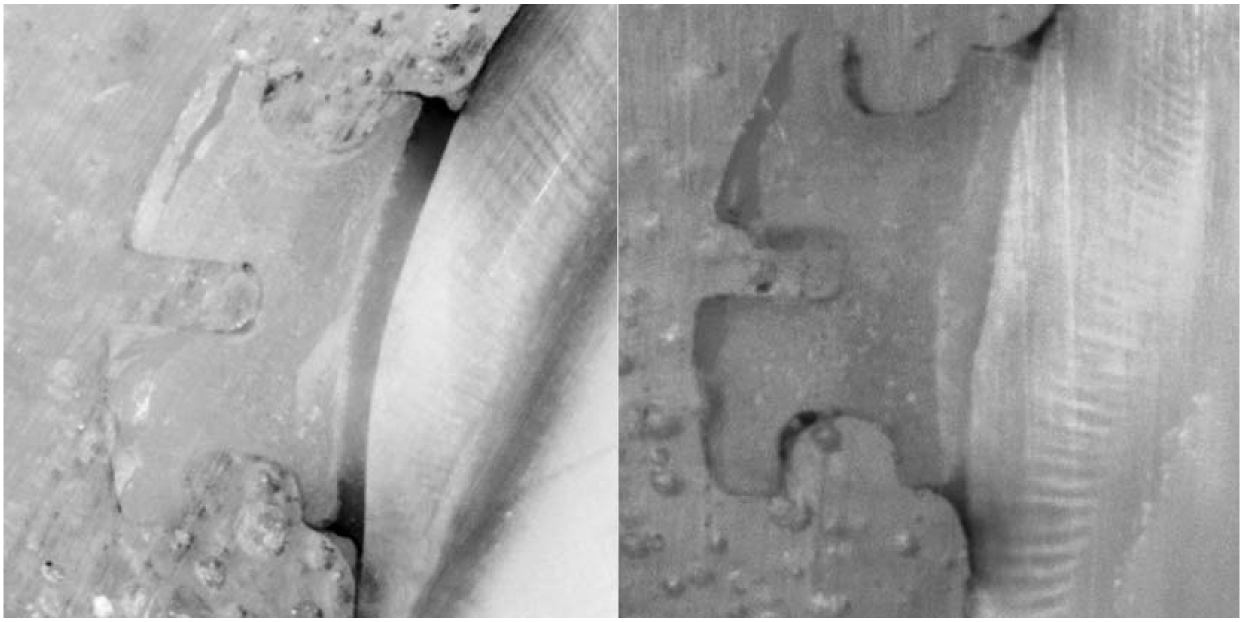

**Figure 1.** Sample No. FF4 showing microleakage of 0.76 mm and 0.71 mm from the occlusal and gingival border, respectively (left). Sample No. C19 showing 0 mm of visible microleakage (right).

microleakage underneath the bracket base can be seen in Figure 1.

The control group exhibited the same median microleakage (0.24 mm) from both the occlusal and gingival aspects of the bracket, with an interquartile range of 0.49 mm and 0.55 mm, respectively. The Flash-Free group demonstrated slightly greater microleakage from the gingival aspect (0.41 mm vs 0.35 mm), with an interquartile range of 0.3 mm and 0.69 mm, respectively. This difference was not statistically significant ($P > .05$). Median microleakage from the occlusal aspects of the Flash-Free and control groups were 0.35 mm and 0.24 mm, respectively. This difference was not statistically significant ($P > .05$). Median microleakage from the gingival border of the bracket was 0.41 mm and 0.24 mm for the Flash-Free and control groups, respectively. This difference was also not statistically significant ($P > .05$).

## DISCUSSION

This study evaluated microleakage at the enamel-adhesive interface from the occlusal and gingival aspects of APC Flash-Free Adhesive Coated Appliance System brackets after thermal cycling. The mean microleakage in our Flash-Free group was less than that reported by Arikan et al.,[5] who measured under ceramic brackets bonded with Transbond XT adhesive and cured with a LED curing unit. The values in our sample were also less than those reported by Arhun et al.[3] and Ramoglu et al.,[10] who measured the microleakage under ceramic brackets bonded with an antibacterial adhesive system and an RMGI, respectively.

The mean microleakage in our Flash-Free group was greater than those values beneath ceramic brackets bonded with conventional adhesive found by Ramoglu et al.[10] Uysal et al.[4] also reported less mean microleakage at the enamel-adhesive interface of ceramic brackets bonded with either conventional etch/Transbond XT liquid primer or Transbond Plus self-etching primer. Although we used the same Flash-Free bracket system as did Grunheid et al.,[8] our evaluation of microleakage was in two dimensions and could not be directly compared to their microcomputed tomography volumetric measurements.

Compared with the mean microleakage under stainless steel brackets, the mean values under our Flash-Free group were comparable with those cured by a plasma arc light curing unit[6] and less than those observed by Abdelnaby et al.,[2] Arhun et al.,[3] or Arikan et al.[5] The mean microleakage under stainless steel brackets bonded with RMGI was greater than the values found in this study,[10] but most of the results from previously published studies[4,6,7,10] demonstrate less microleakage beneath stainless steel brackets than the values observed in our Flash-Free group. Comparison of microleakage measurements between various studies can be unreliable. A future in vitro study that directly compares microleakage beneath the Flash-Free bracket system bonded with self-etching primer and conventional stainless steel brackets bonded with standard phosphoric etch and primer should be performed.

Due to its low cost, nontoxicity, and fast and direct measurement, dye penetration is a preferred method of studying microleakage in orthodontics. Foersch et al.[12] performed a similar study to ours and evaluated microleakage beneath the APC Flash-Free bracket using a yes-or-no-decision method to record color penetration at any bracket edge without sectioning. The researchers found that 35% of interfaces in the Flash-Free group displayed some color penetration, compared with 97.5% of interfaces in the control group, which were penetration positive. Although differences in methodology prevent direct comparison between results, our data reveal that at least 72.5% and 62.5% of interfaces were positive for microleakage in the Flash-Free and control groups, respectively.

Microleakage values from this study should be interpreted with caution, as the measurements were obtained at a single cross-section through the center of the bracket. While increasing the number of sections per tooth can provide more detail about the extent of microleakage, future studies should adopt the methods of Grunheid et al.[8] to evaluate microleakage in terms of volume, rather than as a linear measurement. Clinical research that compares the APC Flash Free Adhesive Coated Appliance System with conventional bonding with respect to development of WSLs, decalcification, and rate of bracket failure is necessary to help clinicians determine which bracket system is ideal for their patients.

## CONCLUSION

- There is no significant difference in the median microleakage under the APC Flash-Free Adhesive Coated System bracket and the APC PLUS Adhesive Coated System bracket after 5000 cycles of thermal cycling.

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