*Original Article*

# A new flash-free orthodontic adhesive system:
## *A first clinical and stereomicroscopic study*

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**ABSTRACT**

**Objective:** To analyze the clinical and laboratory properties of the recently introduced APC flash-free orthodontic adhesive.

**Material and Methods:** After bonding of 80 brackets on human teeth (group A: APC flash-free adhesive n = 40, group B: APC Plus adhesive n = 40), the following measurements were recorded: time for bonding, stereomicroscopic evaluation of excess adhesive, color penetration (methylene blue, 0.5%/24 h), and Adhesive Remnant Index (ARI) score after debonding.

**Results:** The time needed for bonding differed significantly between the two groups (A: 19.5 s/tooth vs B: 33.8 s/tooth). The adhesive excess, which was metrically measured from the bracket edge, ranged from 166.27 μm to 81.66 μm (group A) and 988.53 μm to 690.81 μm (group B). After methylene coloration in group A, 52 of 80 measurements showed discoloration on the bracket-adhesive and/or adhesive-enamel interface, while for group B, 78 of 80 were coloration positive. The ARI scores did not differ, with an average ARI score of 2.0 for group A and 2.8 for group B.

**Conclusion:** The flash-free adhesive significantly reduced the time needed for the bonding process. The excess resin expanded 0.16 to 0.08 mm over the bracket margin. The new technology seems to facilitate a smooth and sufficient marginal surface of the adhesive, which clinically might improve reduction of plaque accumulation. (*Angle Orthod.* 2016;86:260–264.)

**KEY WORDS:** Orthodontic bracket; Adhesive excess; Flash-free; Stereomicroscopy; ARI

## INTRODUCTION

For decades, various orthodontic adhesive and bonding techniques have been developed and have been subject to multiple in vivo and in vitro studies. The three main components that have to be considered for sufficient orthodontic bonding are the surface of the tooth (morphology, preparation of enamel), the base of the individual orthodontic attachment (mechanical and material properties), and the bonding material itself (shear bond strength, material composition).[1–6] A wide variety of light-activated, chemical-cured, differently filled resins and other cements are available to the orthodontist. The main goal is to achieve a sufficient marginal seal and less bonding material around the bracket to avoid caries or white-spot lesions under the bracket and in its periphery.

Until recently, the practitioner, while bonding the orthodontic bracket, had to remove excess resin or bonding material directly after placing the attachment using the positioning instrument or dental probe before curing the material. In 2014, 3M Unitek (Monrovia, Calif) introduced the APC flash-free technology (APC Flash-Free Adhesive Coated Appliance System), which supposedly eliminated the need for excess material removal. The system can be applied to any orthodontic bracket base during the fabrication process and is realized through a nonwoven mat, which is

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saturated with resin adhesive. When pressed on the enamel surface, the transparent and low-viscosity resin forms a channeling border at the edges of the bracket.

The proposed advantages of this adhesive system are the lack of necessity of adhesive cleanup, the reduced time for bracket positioning and bonding, and the improved ability to concentrate on bracket positioning. The manufacturer claims reliable bond strength of less than 2% bond failure, according to internal data. Nevertheless, there is only one study on the clinical features of the mentioned adhesive, focusing only on the debonding procedure.[7]

The present investigation examines for the first time the different aspects of the new APC adhesive technology. The time for bonding, adhesive remnant after debonding, the morphology of resin excess, and bracket-adhesive-tooth interface were evaluated. The findings were compared with a regular adhesive system of the same company with removal of excess resin.

## MATERIALS AND METHODS

For measurement of all parameters, 40 brackets (group A; Clarity Advanced, 3M Unitek) with APC flash-free adhesive (APC Flash-Free Adhesive Coated Appliance System, 3M Unitek) and 40 brackets (group B) with regular adhesive (APC PLUS Adhesive Coated Appliance System, 3M Unitek) were bonded on extracted human teeth (defect and caries-free premolars and incisors). After 30 seconds of enamel etching with 35% phosphoric acid (Unitek Etching Gel, 3M Unitek), a primer (Transbond XT, 3M Unitek) was applied in strict accordance with the manufacturer's instructions. Prior to the bonding process, the teeth were positioned in a typodont and put in a phantom head to simulate real clinical setting. The situation in both the upper and lower jaw was simulated. The procedure was carried out under standardized conditions by a specialized orthodontist. The time for the individual steps was measured.

### Stereomicroscopy

Twenty brackets of each group were used for digital stereomicroscopic evaluation (VHX-S50, Keyence Corporation, Osaka, Japan) of the degree of excess adhesive in relation to bracket edge margin. Therefore, the bracket was positioned in a plasticine-filled holding device, and the objective focus was aimed in 90° in two planes on the bracket and tooth surface in relation to the slot. With the computer measurement tool (VHX-1000D, Keyence Corporation) of the microscope, the distance (μm) between the bracket edge and the most/least leaked adhesive margin was metrically registered for both groups. For every side of the bracket, multiple (minimum/maximum) values were measured (Figures 1 and 2).

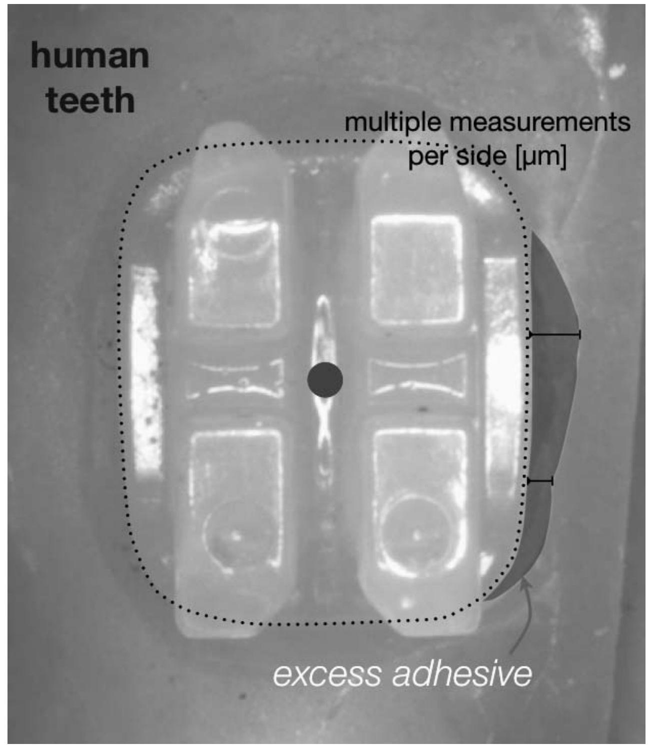


**Figure 1.** Schematic description of the measurement procedure.

### Color Penetration

After bonding, 10 brackets of each group were stored in methylene blue (0.5%) for 24 hours. The specimens were thoroughly rinsed with distilled water and dried with an air blower before they were examined under the microscope at 20× magnification. Photos of cervical and incisal as well as mesial and distal views were obtained with the help of the recording tool. Both the bracket-adhesive and adhesive-tooth interface were checked for discoloration and penetration of the coloring agent on each side. Areas with at least one discolored spot were considered positive in a yes or no decision.

### Debonding

Ten brackets of each group were carefully debonded after being positioned in the dental simulating head. Once the brackets were debonded, a single-calibrated physician evaluated the Adhesive Remnant Index (ARI)[2,8] by visual inspection and, if magnification was necessary, using a dental loupe. The following scores were given: 0 = no adhesive left on the tooth, 1 = less than half of the adhesive left on the tooth, 2 = more



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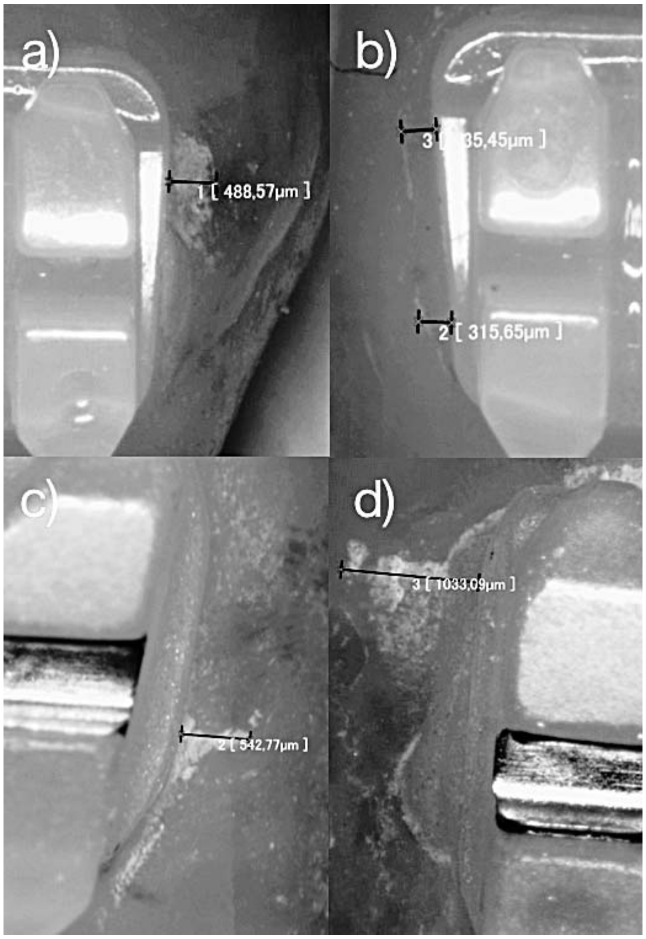


**Figure 2.** Exemplary images of stereomicroscopic measurements for a) + b) brackets with flash-free adhesive (group A) and c) + d) brackets with conventional adhesive (group B).

than half of the adhesive left on the tooth, 3 = all adhesive left on the tooth.

### Statistical Analysis

All statistical tests and calculations were made using SPSS software (version 18.0, SPSS Inc, Chicago, Ill). Maximum, minimum, mean values, and standard deviations were calculated as part of the descriptive analysis. Statistical significances were measured using a nonpaired *t* test, with *P* values of less than .05 considered statistically significant.

## RESULTS

### Time for Bonding

Brackets of group A (flash-free) were bonded in an average time of 19.5 s/tooth (min: 14 s, max: 25 s, SD: 3.66 s) in the upper and 14.3 s/tooth (min: 13 s, max: 17 s, SD: 2.16 s) in the lower jaw. The brackets with the conventional adhesive system required 33.8 s/tooth (min: 27 s, max: 50 s, SD: 6.53 s) for the upper teeth and 40.0 s/tooth (min: 31 s, max: 58 s, SD: 7.33) for the lower. The time saving effects in both the upper ($P = .0008$) and lower ($P > .0001$) jaw were significant.

### Severity of Excess Adhesive

The average linear measurements of the different adhesive excess for each tooth are shown in Table 1. The measured distances for group A range from 545.05 μm to no excess measured. For group A, the average over all teeth for maximum excess was 166.27 μm and for minimum excess was 81.66 μm. For group B, the overall maximum excess was measured at 1392.52 μm and minimal excess at 239.18 μm, with an average between 988.53 and 690.81 μm for all teeth.

There were significant differences in both the most severe resin excess (maximum, $P > .0001$) and the amount of bracket areas with no measurable excess (minimum, $P < .0001$) between group A and B.

### Color penetration

Overall, 80 measurements (four sides of each bracket, two interfaces, 10 teeth) for each group were examined. In group A, 52 of 80 measurements overall were without color penetration of any kind, resulting in 65% without and 35% with a positive (color penetration) decision. For group B, 78 of 80 interfaces showed some amount of discoloration, resulting in 97.5% with a penetration positive finding.

**Table 1.** Excess Adhesive Measurements

| APC Flash-Free, Group A | Maximum Excess Measurement (Average of Four Measurements per Side), μm | Minimum Excess Measurement (Average of Four Measurements per Side), μm |
|---|---|---|
| Mean | 166.27 | 81.66 |
| SD | 177.68 | 122.09 |
| Min | 0.00 | 0.00 |
| Max | 644.64 | 477.58 |
| APC Plus, Group B | | |
| Mean | 988.53 | 690.81 |
| SD | 353.7 | 311.57 |
| Min | 171.26 | 119.39 |
| Max | 429.5 | 1254.78 |



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**Table 2.** Adhesive Remnant Index Score After Debonding

| APC Flash-Free Group A | APC Plus Group B |
|---|---|
| 2.00 | 3.0 |
| 2.00 | 3.0 |
| 1.00 | 2.0 |
| 3.00 | 3.0 |
| 2.00 | 3.0 |
| 2.00 | 2.0 |
| 3.00 | 3.0 |
| 2.00 | 3.0 |
| 1.00 | 3.0 |
| 2.00 | 3.0 |
| 2.0 (average) | 2.8 (average) |

## Adhesive Remnant Index

As seen in Table 2, group A showed a lower average ARI value (2.0, SD = 0.71) than group B (2.8, SD = 0.45).

## DISCUSSION

In an effort to reduce chair time both for the patient and the practitioner, multiple innovations have been brought to the orthodontic community. With regard to the bonding process of conventional brackets, not only orthodontic adhesive and self-etching priming systems but also high-quality light-curing devices have to be mentioned.[9–12] The introduced flash-free adhesive system was able to significantly reduce the time that was needed to position the bracket. The recent study proposes a 64.25% time-saving effect for the lower and 42.3% for the upper jaw. These results are in line with internal tests of the manufacturer, which have been carried out at three US and Canadian clinics.

According to the manufacturer, this promising approach is realized by a nonwoven, polypropylene fiber mat, which is directly positioned on the base of the bracket. This mat is soaked with a low-viscosity resin. The purpose of the mat is to be slightly compressible while being pushed on the tooth but to hold back excess adhesive that is squeezed out during bracket application. Recent stereomicroscopic images revealed remarkable less excess material in group A (flash-free), with an average amount of visible resin between 0.16 and 0.08 mm measured in the bracket periphery. Furthermore, the filleted edge that is formed by the resin microscopically seems to form a smooth and well-locking shape. No clinically relevant amount of excess resin was detected in the recent in vitro study.

However, this is the first investigation on the properties of flash-free adhesive systems with a quantification of adhesive excess. While the areas surrounding the brackets and excess adhesive are critical for plaque accumulation,[13] it has been shown that the influence of material (ceramic or metal brackets) on microbial accumulation is not significant, and the common species are equally existent.[14] However, the shape and surface of both bracket and adhesive are important factors for plaque accumulation.[15] In the recent microscopic study, the investigation of the direct bracket periphery showed significant less excess resin material for the flash-free group, which might be in favor of reducing plaque accumulation. Further clinical studies are needed to prove this hypothesis.

A key point for minimizing bracket loss and achieving an optimal marginal integrity is the interface between the tooth surface and bracket base. Furthermore, the tighter the seal between the bracket-adhesive-enamel, the less microleakage of plaque bacteria is possible with a reduction of demineralization and white spot lesions.[16–19] In the recent study, more than half the brackets of group A and almost all brackets of group B showed discoloration of some kind at any bracket edge. Although the protocol was used before,[20] showing a lower incidence of microleakages for conventional adhesive-bracket combination, this might be because in this study, only a yes/no decision was obtained. For further studies, the sensitivity of this specific testing procedure should be increased. To the best of our knowledge, no study was found that considers this interesting topic with regard to the flash-free technology.

For time-saving purposes, not only the bonding procedure is interesting but also debonding, and cleaning up remaining resin off the tooth surface is crucial for an efficient and optimum work flow. The more adhesive that remains on the base of the bracket, the less removal time is needed, and the procedure appears safer and easier.[21,22] The ARI, as introduced by Artun and Bergland,[2] is a three-scaled scoring method to quantify adhesive left on the tooth. It is one of the most frequently used indices in orthodontic adhesive testing.[8] It has been modified and extended to a five- and six-scaled method.[23–25] To our knowledge, only one study has analyzed remaining adhesive during use of the flash-free adhesive system.[7] That study found that 94% of 100 brackets bonded showed a significant amount of resin left on the tooth, which is indicated by an ARI score of 2 or 3. The recent findings of an average ARI score of 2 for group A are in line with these findings. According to Grünheid et al.,[7] there is a significant difference between the ARI scores of conventional vs flash-free adhesives. This could not be verified in our study, with an average ARI score for group B of 2.8. It appears that the mesh coating of the flash-free technology might pose a failure point during the debonding process, which leads to a fairly unpredictable amount of adhesive left on the tooth. In the discussion of the benefit of low or high ARI scores, it has to be mentioned that high ARI scores (ie, more adhesive left on the tooth) indicate a reduced risk of

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enamel tear, which might be beneficial for the patient.[26,27] Nevertheless, lower ARI scores (ie, more adhesive remaining on the bracket) appear to be favorable if the chair time should be reduced.[7] Further studies measuring forces during debonding and shear strength for the flash-free adhesive are needed.

To our knowledge, the recent study is one of the first trials to investigate the characteristics of the newly introduced APC flash-free adhesive. In the future studies of the adhesive-tooth interface, possible benefits for reduction of plaque accumulation and properties during bracket removal should be subject to further trials.

## CONCLUSION

- The APC Flash-Free Adhesive System is able to reduce the time needed during orthodontic bracket bonding.
- There is no need to clean up excess adhesive, which simplifies the bracket-positioning process. The resulting adhesive layer and resin-bracket margins facilitate a smooth and narrow surface, which extends 0.16 to 0.08 mm over the bracket edge. This appears to improve marginal integrity and might reduce plaque accumulation. Further clinical and in vitro studies are needed to increase the evidence on this interesting technology.

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