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EVALUATION OF MICROLEAKAGE BETWEEN DIRECT AND INDIRECT BONDING TECHNIQUES USING APC™ FLASH FREE, APC™ II AND CONVENTIONAL BRACKETS

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ABSTRACT

Background: Minimizing microleakage under orthodontic bracket is essential in decreasing the incidence of the white spot lesion after fixed orthodontic treatment. This study aimed to evaluate microleakage between direct (DB) and indirect (IB) bonding techniques using APC™ flash free, APc™ II and conventional brackets.

Materials and methods: 66 extracted premolar teeth were randomly divided into two equal groups (n= 33) according to the bonding techniques used; direct (DB) and indirect bonding (IB) techniques. Then each group was subdivided randomly into three subgroups (n= 11) according to the used bracket type into; APC™ flash free, APc™ II and conventional. The microleakage was evaluated in each sub group using a stereomicroscope at a magnification of 30X. The data were statistically analyzed using a two-way ANOVA with significance level at $P \leq 0.05$.

Results: A significant interaction was found between bracket type and bonding technique on microleakage. Assessment of the main effect for bonding technique revealed that there was a statistically significant difference in microleakage between the two bonding techniques in APc™ II and conventional brackets but not in APC™ flash free. Analysis of main effect for bracket type showed a significant difference among the three types. Microleakage was higher in conventional > APc™ II > APC™ flash free in each of the two bonding techniques.

Conclusion: Direct bonding technique showed less microleakage values than indirect bonding technique in APc™ II and conventional brackets but the difference was not of significant difference in APC™ flash free brackets.

KEYWORDS: Microleakage, pre coated brackets, flash free, indirect bonding.

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INTRODUCTION

Since the development of the initial bonding systems, there has been an ongoing pursuit to enhance the quality of these materials. Researchers have formulated new adhesives in response to challenges, including the problem of enamel decalcification under and around brackets in fixed orthodontic treatments.[(1)] The occurrence of enamel demineralization known as white spot lesions, has been observed in up to 97% of patients following the completion of fixed orthodontic treatment.[(2)] Sometimes these white spot lesions may be temporary, when that areas of chalky white appearance can be neutralized by salivary proteins that re mineralize the surface of enamel again.[(3)] But unfortunately after post orthodontic treatment, these lesions frequently progress and become permanent, ultimately resulting in the development of dental caries.[(4)]

Also factors such as polymerization shrinkage and insufficient adhesion contribute to microleakage. Additionally, thermal fluctuations and mechanical forces in the oral cavity significantly affect it. These thermal changes occur due to hot and cold foods and beverages, causing the adhesives to be expanded and contracted. Typically, the oral cavity maintains an average temperature of about 35°C, with tooth surface temperatures ranging from a low of 0°C to a high between 55 and 60°C.[(5-8)]

The flash free adhesive precoated appliance system (APC™), innovated by 3M Unitek (Monrovia, California, USA) with features of individually wrapping each bracket that incorporate a resin with low viscosity applied to a nonwoven polypropylene mesh. This design eliminates the requirement for excessive adhesive removal and forms a good seal that helps decrease microleakage.[(9)]

The null hypothesis of this study was to combine APC™ flash free, APc™ II and conventional brackets with direct and indirect bonding techniques to compare the amount of microleakage between them.

MATERIALS AND METHODS

This in-vitro study was approved by The Ethical Committee of Research at Faculty of Dentistry at Mansoura University with code (J0205023OR). The required sample size was calculated by PASS Software (version 15, 2017), assuming an effect size of 0.400, a 2-tailed test, an α error of 0.05, and a power of 89%. It was calculated that a total of 66 subjects, or 11 subjects per cell, would be needed based on previous studies by Kim et al, [(9)] and Yagci et al, [(10)] The total sample (n=66) was then randomly split into two groups of 33 premolars each, according to the bonding techniques employed: direct and indirect. Then, each group was divided into three equal subgroups (n=11) according to the used bracket type: APC™ Flash-Free, APc™ II, and the conventional (uncoated) low-profile brackets of the Victory Series ™.

Bonding procedure:

Each set of five teeth was vertically embedded in a compound block tray. Polishing of buccal aspect of each tooth for 10 seconds with a rubber cup using fluoride-free pumice using a micromotor handpiece was done. Following the polishing, rinsing with water and drying with compressed oil-free air were employed.

Direct bonding groups:

A. Conventional brackets

Brackets were applied using the traditional direct bonding method. This began with etching the surface using 37% phosphoric acid Scotchbond Universal Etchant for 30 seconds. Following the etching, the surface was thoroughly rinsed for 15 seconds and then drying with compressed oil free air for another 15 seconds, until the appearance of enamel became chalky white. After drying, a thin layer of Transbond XT Light Cure Adhesive Primer was applied with a micro brush, followed by a light air burst to spread the primer evenly. Next, a sufficient amount of Transbond XT Light Cure Adhesive Paste was used to attach each bracket. Any excess adhesive around the bracket edges was then carefully removed with a sharp periodontal probe before proceeding to light-curing.

B. APC™ Flash-Free brackets

This group followed the same procedure of etching, rinsing, drying and applying primer as the previous group, with the exception that there was no need to add adhesive and remove excess adhesive around bracket edges after bonding because these brackets come pre-packed with the optimal amount of adhesive (figure 1).

C. APc™ II brackets

This group underwent the same preparation as the previous group, with the addition of an extra step involving the removal of excess adhesive from the brackets (figure 1).

Indirect bonding groups:

A. Conventional brackets

An alginate impression was taken of the teeth block, from which a stone model was produced. Marks were made on the model to indicate the positions for the brackets. Conventional brackets were then bonded using a water-soluble glue to

Fig. (1) APC plus and Flash free brackets for direct bonding techniques

their designated spots on the model. A transfer tray was created from a soft vacuum-formed sheet. The same preparatory steps—etching, rinsing, drying, and applying primer—were followed. The brackets were placed in the transfer tray, and a sufficient amount of adhesive paste was applied to the base of each bracket. The transfer tray was then fitted onto the teeth block using constant pressure, followed by the curing process.

B. APC™ Flash-Free brackets

The same preparatory steps were followed. The application of flash-free brackets was performed by holding the hooks of the brackets and inserted them carefully onto their positions in the transfer tray. They were then securely seated onto the teeth block using constant force before proceeding with the curing process.

C. APc™ II brackets

The procedures followed were the same as the previous group, with the additional steps of applying adhesive to and removing any excess from the base of each bracket before positioning them in the transfer tray

All samples were placed in water at room temperature for a day. Then they were thermocycled for 1000 cycles between 5°C and 55°C. Subsequently, microleakage was evaluated.

Specimen preparation

Every block of teeth was heated in hot water to separate every single tooth which was vertically placed in self-curing acrylic resin within a plastic ring at a level of 3 mm apical to the crown of the teeth. Two coats of nail varnish were applied to all exposed parts of the teeth, except for a 1 mm margin around the bonded brackets to prevent dye penetration on other surfaces. Then specimens were placed in 2% methylene blue dye for a day. After dye application, the specimens underwent thorough rinsing to remove any residual dye and stains then drying. Transparent chemical-cured acrylic resin was applied to cover the full crown with the bracket to avoid bracket detachment during sectioning (Figure 2). Each specimen was then bisected longitudinally through the center of the bracket in the occluso-gingival using the Isomet (Figure 3). Each half was then examined using a stereomicroscope at 30X magnification. Microleakage values were assessed by measuring linear dye penetration for each section at both occlusal and gingival sides along the enamel-adhesive interface using IS Capture image analysis software (Figure 4).

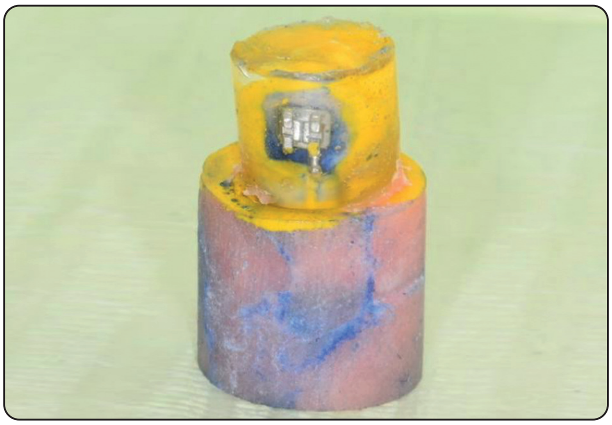

Fig. (2) A sample ready for sectioning for microleakage evaluation

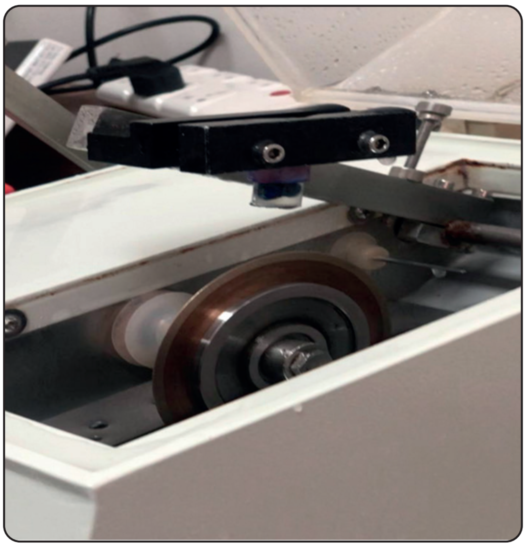

Fig. (3) Isomet used for sample sectioning

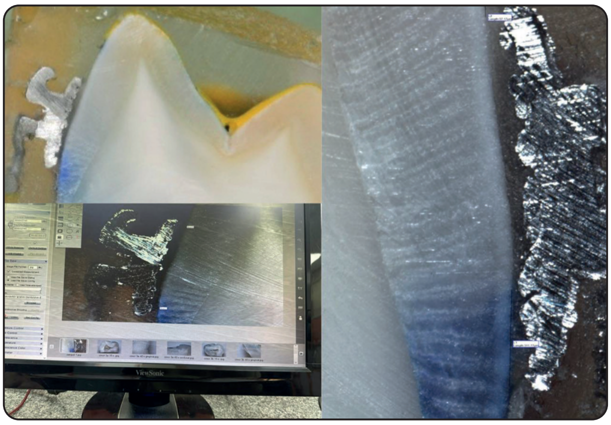

Fig. (4) Stereomicroscope with camera system for microleakage evaluation.

Statistical analysis

IBM-SPSS software version 26.0 was used for data analysis. A boxplot was utilized to analyze outliers, while the Shapiro-Wilk test was used to assess normality for each design cell, and the Levene test determined the homogeneity of variances. A two-way ANOVA test was performed to investigate the effects of two categorical factors on a quantitative variable.

RESULTS

A two way ANOVA was performed to investigate the effects of bonding technique and bracket type on microleakage. Residual analysis was conducted to verify the assumptions of the two way ANOVA. Outliers were identified through boxplot inspection, normality was detected using Shapiro Wilk's test for each design cell, and homogeneity of variances was evaluated with Levene's test. One outlier was detected. APc^{TM} II\IB which was included in the final analysis as similar results of the two-way ANOVA were obtained by the inclusion and exclusion of this outlier. Residuals were normally distributed $p > 0.05$ and there was homogeneity of variances in spite of significant Levene's test as there was a similar vertical spread of the residuals for each predicted mean value (figure 5).

(Table 1) reveals a significant interaction between bracket type and bonding technique on microleakage, $F(2, 60) = 13.419$, $p < .001$, partial $\eta^2 = 0.309$ with inclusion of the outlier, and $F(2, 59) = 13.493$, $p < .001$, partial $\eta^2 = 0.314$ after removing the outlier.

Analysis of simple main effect of bonding technique showed a statistically significant difference between the two bonding techniques in APc™ II and conventional types but, no significant difference between them in APC™ Flash-Free. Also, analysis of simple main effect of bracket type showed a statistically significant difference between these bracket types in both direct and indirect bonding technique. Accordingly, pairwise comparisons between the three bracket types in each bonding technique were run. Microleakage was higher in conventional > APc™ II > APC™ Flash-Free in each of the two bonding techniques (table 2).

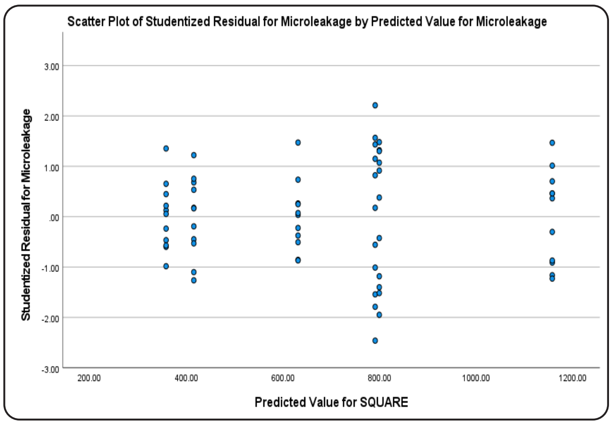

Fig. (5) Scatterplot of the residuals against predicted values

TABLE (1) Descriptive statistics of microleakage

Bracket type	**Bonding technique**	**Mean**	**SD**	**95% CI**
APC™ Flash-Free	**Direct**	358.1	63.8	315.2-400.9
	Indirect	415.5	75.2	364.9-466
APC™ II	**Direct**	631.2	66.1	581.8-652.4
	Indirect	799.3	126.1	714.5-883.9
Conventional	**Direct**	790.8	149.3	690.5-891.1
	Indirect	1157.3	89.5	1097.1-1217.4

Notes: SD = standard deviation. CI = confidence interval.

TABLE (2) Interaction and simple main effects of bonding technique & bracket type on microleakage

Effect	F	p-value	Partial h^2
Interaction	13.419	<.001	.309
Simple main effect of Bonding technique			
APC™ Flash-Free	1.803	.184	.029
APC™ II	15.469	<.001	.205
Conventional	73.498	<.001	.551
Simple main effect of Bracket type			
Direct	52.406	<.001	.636
Indirect	150.619	<.001	.834

Notes: Partial eta squared (h^2) is a measure of the effect size.

DISCUSSION

This study aimed to investigate whether the type of bonding technique that used to bond APC™ Flash-Free brackets might play a role in the quality of the seal between bracket-tooth interface in comparison to APc™ II and conventional brackets.

If the seal between bracket-tooth interface is deteriorated, so the resulting outcome is microleakage. From an orthodontic perspective, microleakage could lead to permit the entrance of bacteria and other oral fluids, which may initiate white spot lesions at the "adhesive-enamel" interface.

In this study, there was a significant interaction between bracket type and bonding technique on microleakage. Therefore, an analysis of simple main effects for Bonding technique and both Bracket type was conducted. Assessment of main effect for bonding technique regardless to bracket type showed that there was a statistically significant difference in microleakage for the used two bonding techniques in APc™ II and conventional groups but in case of flash free groups the differences were not statistically different. These results were in similar to results reported by Öztürk et al [10] Also Yagci et al [11] both studies were conducted on a group of DB and another of IB using transbond XT as the adhesive paste and Sondhi Rapid chemical cured primer. The type of bonding technique either DB or IB did not significantly affect the amount of microleakage between the adhesive and the enamel surface. These differences in results were in conventional and APc™ II groups and this might be because they used chemical cured primer in IB and larger sample size in each group.

Concerning the used bracket type, analysis of simple main effect of bracket type showed that there was a significant difference between the three types regardless the used bonding technique, microleakage was higher in conventional > APc™ II > APC™ Flash-Free in each of the two bonding techniques. In accordance to these results, Vaishnavi et al[12] conducted a study of two groups of APC™ Flash-Free and APC™ plus adhesive and they found that the marginal leakage was higher in APC™ plus adhesive group than APC™ Flash-Free group.

Also a study to Majji et al [13] showed similar results when they conducted a study on three groups of APC™ Flash-Free, APC™ plus adhesive and conventional brackets. They found that conventional brackets showed higher microleakage values when compared with other two groups but the difference of microleakage between the two other groups was not significant.

In contrast to these results, a study to Grünheid et al[14] showed that the difference in the amount of microleakage between APC™ Flash-Free and conventional brackets was not statistically significant.

Also Kim et al[9] performed a study to compare microleakage between APC™ Flash-Free and APC™ plus adhesive on forty freshly premolar teeth after 5000 cycles of thermocycling between 5°C and 50°C. Their study reported that the microleakage values were higher in APC™ Flash-Free but this difference was not significant, a possible explanation to these differences in results might be the large number of thermocycling they used.

CONCLUSIONS

From this in vitro study, we concluded that:

- Direct bonding technique showed less means of microleakage values than indirect bonding technique and this difference was significant.
- Flash free brackets showed no significance difference in microleakage between direct and indirect bonding technique.
- Flash free brackets showed less microleakage values than APc™ II than conventional.

Limitations of this study:

It is a vitro study with limitations of absence of intraoral elements such saliva and pH, further in-vitro and vivo studies with more different bonding techniques and larger sample size are needed to be evaluated.

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Author co ntributions:

Conceptualization: Ebrahim A .Elgamily, Ahmed A. Albialy. Methodology: Ebrahim A. Elgamily, Nehal F. Albelasy. Data curation: Ebrahim A .Elgamily. Investigation: Ebrahim A .Elgamily, Nehal F. Albelasy. Validation: Ebrahim A .Elgamily, Nehal F. Albelasy , Ahmed A. Albialy. Formal analysis: Ebrahim A. Elgamily, Nehal F. Albelasy, Ahmed A. Albialy. Supervision: Nehal F. Albelasy, Ahmed A. Albialy. Writing - original draft: Ebrahim A. Elgamily. Writing - review & editing: Nehal F. Albelasy, Ahmed A. Albialy.

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This article has all the data that was gathered or analysed during this investigation.

Declarations:

Ethics approval and consent to participate.

The Faculty of Dentistry at Mansoura University's Research Ethics Committee accepted the current study (J0205023OR). The processes were completed in accordance with the applicable laws and regulations.

Publication Consent:

Not valiabel.

Competing interests:

Authers announced no competing interests.

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