Official Dental Journal of Suez Canal University
DENTAL SCIENCE Updates
Print ISSN 2636-3836
Online ISSN 2636-3844
www.dsujournals.ekb.eg
DSU — Vol. 6, No. 2, September (2025) — PP. 253:261

MICROLEAKAGE BENEATH ORTHODONTIC METAL BRACKETS BONDED AFTER THERMOCYCLING WITH TWO DIFFERENT ADHESIVE SYSTEMS OF DIFFERENT TEMPERATURES: AN IN-VITRO STUDY

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DOI: 10.21608/dsu.2025.252424.1209
Manuscript ID: DSU-2312-1209

KEYWORDS

Microleakage,
Preheating,
X-tra fil

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ABSTRACT

Introduction: The possibility of using traditional composite restoratives has been raised to bond orthodontic brackets. The higher viscosity observed with restorative composites compromised their ability to adhere to the bracket base. Pre-heating the restorative composites puts the monomers into a state of thermal agitation that increases molecular motion which enhances flowability. The first null hypothesis was that microleakage underneath brackets using bulk fill composite was comparable to that of conventional orthodontic adhesives. Additionally, a second null hypothesis was set up, that preheating bulk fill composite before polymerization decreased the polymerization shrinkage hence the microleakage scores. **Materials and methods:** A sample of 56 upper first premolars was collected and divided across 4 groups; I: Transbond XT at room temperature; II: Transbond XT preheated to 60ºC; III: X-tra fil at room temp; and IV: X-tra fil preheated to 60ºC. After thermocycling, roots were coated with wax while crowns with nail varnish then submerged into a solution of 2% methylene blue. After roots were cut off, the remaining crowns in every group were divided into 2 subgroups, those of one subgroup were longitudinally split into mesial and distal halves, while those of the other subgroup were transversely split into gingival and occlusal halves. Depth of dye penetration at the adhesive-enamel interface was measured under stereomicroscope at x45 magnification. **Results:** photopolymerization of x-tra fil after preheating has exhibited lesser microleakage when compared to Transbond XT, however the results rendered statistically insignificant. **Conclusion**: The X-tra fil proved to be a reliable adhesive for orthodontic brackets.

INTRODUCTION

Currently, brackets bonded to the teeth surfaces using an adhesive are the standard approach for fixed orthodontic appliances, resulting in two interfaces: one between the bracket and the adhesive, while the other between the adhesive and the enamel [(1)].

Marginal gaps at bracket-adhesive interface could lead to debonding of the bracket. However, gaps at the adhesive-enamel interface could lead to microleakage and accumulation of cariogenic bacteria in inaccessible area, which are responsible for some of the white spot lesions occurring in orthodontic patients[(2)].

The possibility of using traditional composite restoratives has been raised to bond orthodontic brackets. The shear bond strength (SBS) test has been used to evaluate the suitability of bonding brackets with restorative composites. Although similar results between restorative composites and traditional orthodontic adhesives have been achieved, other authors have reported lower SBS mean values for restorative composites. In fact, the higher viscosity observed with restorative composites tends to compromise their ability to adhere to the bracket base. Thus, if restorative composites were made more flowable to adhere readily to the bracket base, they could have been potentially used to bond orthodontic brackets[3] .

Viscosity is the property that determines the degree of molecular mobility of a resin composite. Pre-heating the restorative composites puts the monomers into a state of thermal agitation that increases molecular motion which enhances flowability [4].

MATERIALS AND METHODS

1. Study design

The present study was conducted on 56 human maxillary first premolars which were extracted for orthodontic reasons after approval of the Research Ethics Committee (99/2018), Faculty of dentistry, Suez Canal university.

Sample size was decided according to the following equation [5]:

$$n = \frac{((Z_\alpha)^2 x (S)^2)}{(d)^2}$$

n = total sample size; Zα = 1.96 at significant level 95%; S = standard diversion; d = least different between two groups.

The teeth included in this study fulfilled the following criteria: freshly extracted upper and low premolars, free from fillings, absence of enamel facets, enamel chipping, and caries when inspected visually by naked eye and free from visual enamel cracks when inspected by transillumination using LED unit.

The teeth were cleaned from blood or any remaining soft tissue and stored in distilled water that was changed weekly to avoid bacterial growth.

2. Materials (table 1)

Table (1) *Materials used in the current study.*

Material	Manufacturer	Country
Light cure adhesive primer	Transbond XT, 3M Unitek	USA
37% Phosphoric Acid Etchant	Any-Etch, Mediclus Co., Ltd.	Korea
Light cure adhesive paste	Transbond XT, 3M Unitek	USA
Light cure bulk fill composite	X-tra fil, Voco Gmbh, Germany	Germany
Light emitting diode (LED) curing device	Guilin woodpecker medical instrument co. ltd	China
Radiometer	Foshan stardent equipment co ltd	China
Stainless steel 0.022 inch slot preadjusted premolar brackets	Matt orthodontics llc	USA

3. Methodology

A) Sample grouping

The premolars were divided into four equal groups according to the adhesive used and the pre-polymerization temperature of that adhesive;

- Group I: Light cure adhesive paste, at room temperature.
- Group II: Light cure adhesive paste, pre-heated to 60ºC.

- Group III: Light cure bulk fill composite, at room temperature.
- Group IV: Light cure bulk fill composite, pre-heated to 60º C.

B) Bonding procedures

The premolars were polished by pumice for 10 seconds followed by washed for 30 seconds. then they were dried for 10 seconds with moisture-free air compressed air. An etchant gel of 37% phosphoric acid was applied to the middle of the buccal surface and maintained for 30 seconds before being washed for 30 seconds then dried for 10 seconds to a chalky frosty white appearance of the etched enamel to which a thin uniform layer of Transbond XT Light Cure Adhesive Primer was applied then cured with the LED unit for 10 seconds.

The above-mentioned procedures were the same for all groups, with one group at a time. When the group in hand was bonded, preparations of the next group were initiated.

C) Adhesive application and curing

Group I: for this group a syringe of Transbond XT adhesive composite was used, where at room temperature, a sufficient amount of the adhesive was applied to the base of a bracket then the latter was pressed firmly to the buccal surface of the premolar. After removing the excess of adhesive from around the bracket base with an explorer, the adhesive was cured for 5 seconds from every direction; gingival, mesial, distal and occlusal, for a total of 20 seconds using LED device.

Group II: a digital thermostatic water bath was required for this group, the water temperature was set at 60º C and upon reaching the desired temperature, two syringes of Transbond XT adhesive composite were vertically dipped in the water with the end of the plunger above the water surface. By the help of a stopwatch, after 20 minutes one syringe was retrieved and the adhesive applied to the bracket base then the bracket was pressed firmly to the buccal surface of a premolar. After removing the excess of adhesive from around the bracket base with an explorer, the adhesive was cured for 5 seconds from each of the gingival, mesial, distal and occlusal sides for a total of 20 seconds using a LED device.

The next bracket was bonded using the other syringe, as no syringe was used for bonding 2 consecutive brackets. For this group, with the help of an assistant, the retrieved syringe was placed back in the water bath after the adhesive was dispensed on the bracket base.

Group III: the X-tra fil light curing posterior filling composite was provided in the form of a compule that was loaded into a composite dispensing gun. The same steps as in group I were followed for this group.

Group IV: the same steps that took place for group II were followed for this group, but the 2 syringes were replaced with 2 two plastic composite dispensing guns, each loaded with one X-tra fil compule.

D) Thermocycling

After bonding, all teeth were stored in distilled water, then they were subjected to accelerated aging by means of 500 cycles of thermocycling between water baths temperatures of 5°C and 55°C.

E) Dyeing

After thermocycling, all teeth were dried and to avoid penetration of the dye through the apices they were sealed by dipping the roots in molten wax and left to solidify, then two consecutive layers of nail varnish were applied on the buccal surface except for a 1 mm margin around edges of the bracket base. Finally, the teeth were submerged in 2% methylene blue solution for 24 hours at room temperature then retrieved and rinsed thoroughly with distilled water and the superficial dye was brushed away.

F) Sectioning

Before sectioning the teeth, they were air dried, and roots were cut off. The remaining crowns in each group were divided equally into two sets of 7 each. Crowns of one set were sectioned longitudinally in buccolingual direction through the middle of the bracket using a low speed diamond disc. Crowns of the other set were sectioned transversely in buccolingual direction through the middle of the bracket using a low speed diamond disc.

G) Microscopic examination

Sectioned samples were evaluated under stereomicroscope at magnification x45 at the adhesive-enamel interface for depth of penetration of the dye in mm from margins of the bracket base.

The first null hypothesis was that microleakage scores underneath brackets using bulk fill composite was comparable to microleakage scores of conventional orthodontic adhesives.

Additionally, a second null hypothesis was set up, that preheating bulk fill composite before polymerization decreased the polymerization shrinkage hence the microleakage scores under brackets

Statistical Analysis

All collected data was calculated, tabulated and statistically analyzed. Qualitative data was presented as frequencies (n) and percentages (%). A normality test (Kolmogorov-Smirnov) was done to check normal distribution of the sample. Descriptive statistics was calculated in the form of mean ±Standard deviation (SD) Mann-Whitney test was used to compare between each group to another. Kruskal-Wallis Test was used to compare between the four items (occlusal, gingival, mesial and distal) under study. P value < 0.05 is considered be statistically significant. Statistical analysis was performed using the computer program SPSS software for windows version 25.0 (Statistical Package for Social Science, Armonk, NY: IBM Corp).

RESULTS

All groups showed some degree of microleakage. Moreover, comparison between the occlusal and gingival margins of the brackets revealed that the gingival margins displayed statistically higher microleakage than the occlusal ones. Comparison of microleakage among all four groups revealed that Group II (Transbond XT pre-heated) had the highest and Group IV (X-tra fil pre-heated) had the least microleakage values at the enamel-adhesive interface.

Table 2:

The Comparison of microleakage mean scores at the enamel-adhesive interfaces in mesiodistal and occlusogingival sections are shown in (table 2). Statistical analysis using Kruskal-Wallis Test at $P<0.05$ showed no significant difference between groups for Occlusal, Gingival, Mesial, Distal and overall. The high values were recorded in group I and group III for Occlusal, group II and group III for Gingival, group II and group IV for Mesial, group III for Distal finally group II and group III were the higher than others for overall. With regards to Occlusal, Gingival, Mesial, Distal and overall, statistical analysis showed no significant difference between them for each group except in group II (graph 1).

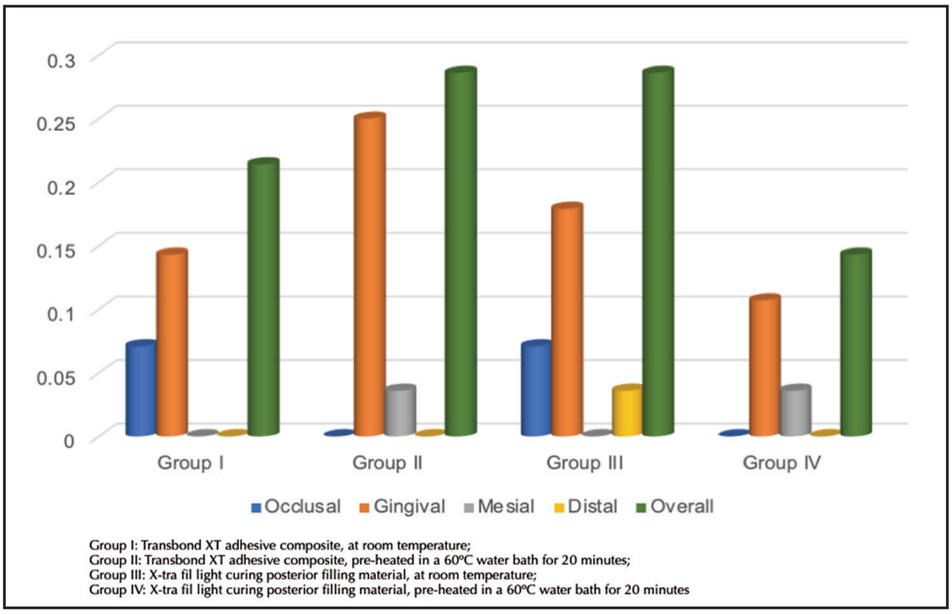
Table (2) *Comparison of microleakage mean scores (mm) between enamel-adhesive interfaces in mesiodistal and occlusogingival sections.*

Variable	Group I		Group II		Group ill		Group	IV	Kruskal-Wallis Test	P value
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD		
Occlusal	0.071	±0.267	0.000	±0.00	0.071	±0.267	0.000	±0.000	2.037	0.565
Gingival	0.143	+0.306	0.250	+0.427	0.179	±0.372	0.107	±0.289	0.989	0.804
Mesial	0.000	±0.000	0.036	±0.134	0.000	±0.000	0.036	±0.134	2.037	0.565
Distal	0.000	±0.000	0.000	±0.000	0.036	±0.134	0.000	±0.000	3.00	0.392
Overall	0.214	+0.379	0.286	±0.426	0.286	±0.469	0.143	+Q.306	0.903	0.825
Kruskal Wallis Test	8.99		12.88		7.1		6.15			
P value	0.061		0.012*		0.131		0.188			

SD, Standard deviation; •, P<0.05

Group I: Transbond XT adhesive composite, at room temperature;

Group II: Transbond XT adhesive composite, pre-heated in a 60°C water bath for 20 minutes; Group Ill: X-tra fil light curing posterior filling material, at room temperature;
Group rv: X-tra fil tight curing posterior filling material, pre-heated in a 60°C water bath for 20 minutes



Graph (1) Comparison of microleakage mean scores (mm) between enamel-adhesive interfaces in mesiodistal and occlusogingival sections

On the contrary, X-tra fil group subjected to heat (group IV) exhibited lesser microleakage scores compared to the room temperature group (group III), yet the statistical analysis using Mann-Whitney Test at P<0.05 showed no significant difference between groups for Occlusal, Gingival, Mesial, Distal and overall (table 3, graph 3).

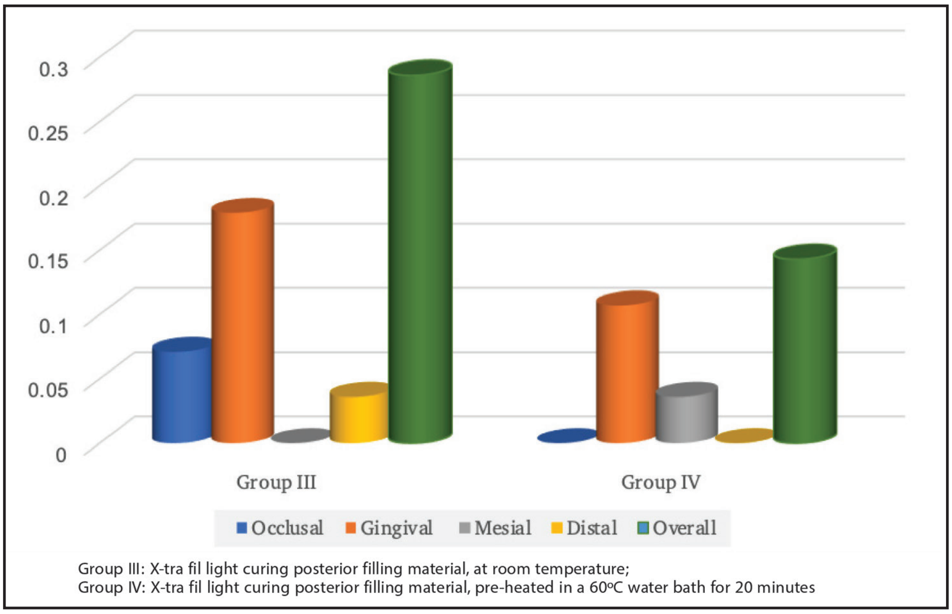
Table (3) *Comparison of microleakage mean scores (mm) between group III and group IV*

Variable	Occlusal		Gingival		Mesial		Distal		Overall	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Group III	0.071	±0.267	0.179	±0.372	0.000	±0.000	0.036	±0.134	0.286	±0.469
Group IV	0.000	±0.000	0.107	±0.289	0.036	±0.134	0.000	±0.000	0.143	±0.306
P value	0.769		0.734		0.769		0.769		0.635	

SD, Standard deviation;

Group III: X-tra fil light curing posterior filling material, at room temperature;

Group IV: X-tra fil light curing posterior filling material, pre-heated in a 60ºC water bath for 20 minutes.



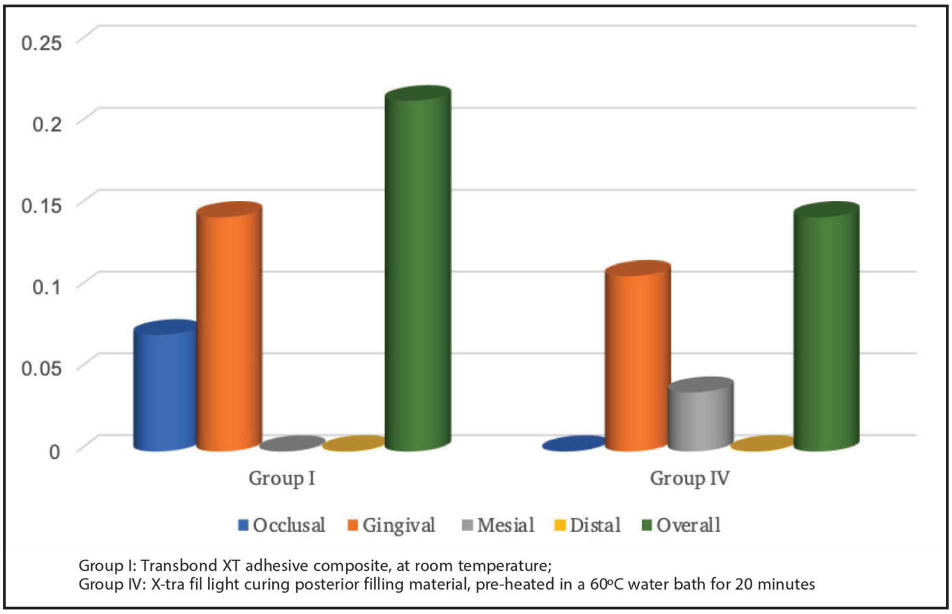
Graph (3) Comparison of microleakage mean scores (mm) between group III and group IV

Also the performance of X-tra fil composite after pre-heating (group IV) was compared against the Transbond XT at room temperature (group I) and it was found that the microleakage scores of former (group IV) lesser than those of the latter (group I), However, the statistical analysis using Mann-Whitney Test at P<0.05 showed no significant difference between groups for Occlusal, Gingival, Mesial, Distal and overall. (table 4, graph 4)

Table (4) *Comparison of microleakage mean scores (mm) between group I and group IV*

Variable	Occlusal		Gingival		Mesial		Distal		Overall	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Group I	0.071	±0.267	0.143	±0.306	0.000	±0.000	0.000	±0.000	0.214	±0.379
Group IV	0.000	±0.000	0.107	±0.289	0.036	±0.134	0.000	±0.000	0.143	±0.306
P value	0.317		0.654		0.317		1.000		0.628	

SD, Standard deviation;
Group I: Transbond XT adhesive composite, at room temperature;
Group IV: X-tra fil light curing posterior filling material, pre-heated in a 60ºC water bath for 20 minutes



Graph (4) Comparison of microleakage mean scores (mm) between group I and group IV

DISCUSSION

In accordance with the observations of the studies of **Majji et al.**[6], **Bayar and Çokakoğlu**[7] and **Ok et al.**[8] , this study exhibited significantly higher microleakage scores at the gingival than at the occlusal margins, which was attributed to the increased thickness of adhesive under the bracket due to anatomical variation of premolars buccal surface.

These findings were not different from those obtained by **Tudehzaeim et al.**[9], where the highest microleakage value occurred between the enamel-adhesive interface of the gingival portion for three different etching methods, sandblasting, an Er:YAG laser, and acid etching. **Hamamci et al.**[10] compared acid and laser-etching methods and reported that there was more microleakage in the gingival part than in the occlusal part. Also **Yagci et al.**[11] reported that there was more microleakage in the gingival part compared to the occlusal when evaluated the microleakage with indirect bonding techniques. Such observations are in accord with studies by **Ramoglu et al.**[12] and **Arhun et al.**[13] who evaluated the differences between the scores on incisal and gingival to surface curvature which might have resulted in comparatively thicker adhesive at the gingival margin.

Controversy to these results, **Atash et al.**[14] observed in their study that microleakage scores were higher on the occlusal side compared to the gingival. They questioned the findings of the other studies for not mentioning whether they used maxillary or mandibular premolars, or for the difference in direction and duration of light curing.

The microleakage scoring obtained in this study revealed that, group IV (X-tra fil, pre-heated) suffered microleakage the least (0.143 0.306±), whilst group II (Transbond XT, pre-heated) and group III (X-tra fil, room temperature) had the highest microleakage scores of (0.286 0.426±) and (0.286 0.469±) respectively. However, statistically there was no significant difference ($p<0.05$) in microleakage scores between both adhesives, implying that the X-tra fil could be reliably used as an adhesive for orthodontic brackets.

The first null hypothesis was that microleakage scores underneath brackets bonded by bulk fill composite were comparable to those of the brackets bonded with conventional orthodontic adhesive. It couldn‘t be rejected, as according to this study, although the X-tra fil showed higher microleakage scores compared to the Transbond XT, they were insignificant ($p<0.05$).

As per this study, pre-heating of X-tra fil composite prior to photopolymerization proved beneficial. The pre-heated X-tra fil (group IV) exhibited less microleakage scores when compared to both, itself at room temperature (group III) and Transbond XT at room temperature (group I). Although both comparisons were statistically unsubstantial, they implied that pre-heating bulk-fill composites prior to bonding orthodontic brackets decreases microleakage scores, hence rendering the second null hypothesis acceptable.

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