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In vitro Evaluation of Effect of Dental Bleaching on the Shear Bond Strength of Sapphire Orthodontics Brackets Bonded with Resin Modified Glass Ionomer Cement

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ABSTRACT

Aim: *This study aimed to assess the effect of various types of bleaching agents on the shear bond strength of sapphire brackets bonded to human maxillary premolar teeth using resin modified glass ionomer cement (RMGIC) and to determine the site of bond failure.* ***Materials and Methods:*** *Thirty freshly extracted maxillary human premolars were selected and assigned into three equal groups, ten teeth in each. The first group was the control (unbleached) group; the second group comprised teeth bleached with hydrogen peroxide group (HP) 37.5% (in-office bleaching) while the third group included teeth bleached with carbamide peroxide group (CP) 16% (at-home bleaching). The teeth in the experimental groups were bleached and stored in water one day then bonded with sapphire brackets using RMGIC with the control group and left another day. De-bonding was performed using Instron universal testing machine. To determine the site of bond failure, both the enamel surface and bracket base of each tooth were examined under magnifying lens (20X) of a stereomicroscope.* ***Results:*** *Results showed statistically highly significant difference in the shear bond strengths between control group and both of bleaching groups being low in the control group. Score III was the predominant site of bond failure in all groups.* ***Conclusions:*** *RMGIC provides adequate bond strength when bonding the sapphire brackets to bleached enamel; this bonding was strong enough to resist both the mechanical and masticatory forces. Most of the adhesive remained on the brackets, so it reduced the time required for removal of the bonding material's remnants during enamel finishing and polishing.*

Keywords: Teeth bleaching, Resin modified glass ionomer cement, Sapphire brackets

INTRODUCTION

Discoloration of teeth creates a broad sort of aesthetic problems and the dental profession and the public disburse significant amounts of time and funds in endeavour to perk up the appearance of discoloured teeth [1]. The International Organization for Standardization (ISO) defines tooth bleaching as "removal of intrinsic or acquired discolorations of natural teeth through the use of chemicals, sometimes in combination with the application of auxiliary means" [2].

Generally, two types of bleaching agents are available nowadays; one that applied externally on the enamel surface (vital bleaching). The other applied internally inside the pulp chamber (non-vital bleaching) [3]. Modern tooth bleaching materials are comprised primarily either of hydrogen peroxide or carbamide peroxide. Both of them alter the inherent colour of the teeth although have various contemplation for safety and efficacy. Generally, most in-office and at-home bleaching techniques revealed to be valuable, yet results may vary depending on numerous aspects such as the types of stains, the patient's age, the concentration of the active agent and treatment time and frequency [4].

The procedures of at-home vital bleaching were reported first by Haywood and Heymann [5] using night guards (custom tray) and 10% carbamide peroxide. Ten per cent carbamide peroxide will degrade into 3% hydrogen peroxide and 7% urea, generating free radicals that oxidize larger pigmented molecules in a tooth into smaller less pigmented molecules [6].

For bonding orthodontic brackets, not only composite resin is used, resin-modified glass-ionomer cement (RMGIC) is also available and preferred by some orthodontists because of its advantages over composite. RMGIC is characterized by releasing fluoride and preventing the formation of white spot lesions on the enamel surface. Moreover, it is hydrophilic and can be used reasonably in areas hard to isolate from moisture [7].

In Iraq, several researches, have studied the shear bond strength and sites of bond failure of different orthodontic brackets bonded to bleached enamel with different bleaching agents [8-11]. The purpose of this study was to evaluate the effect of in-office and in-home bleaching agents on shear bond strength of sapphire brackets bonded on human premolars with RMGIC and to establish the bond failure site.

MATERIALS AND METHODS

Materials

Teeth

Thirty human maxillary premolars extracted for orthodontic purpose were selected among seventy teeth. They were examined under magnifying lens to exclude the cracks and caries then stored in distilled water with 0.1% thymol to prevent dehydration until bonding. The teeth must not be immersed in any pre-treatment chemical agents, e.g. hydrogen peroxide, carbamide peroxide and antioxidant agents.

Brackets

Sapphire brackets (Perfect SB (clear®)) from Hubit Co., South Korea with base surface area 12.807 mm^2 were utilized in this study.

Bleaching agents

In-office bleaching kit (Pola office: 37.5% hydrogen peroxide from SDI, Australia), contains: two Pola office syringes, 1st syringe was 2.8 ml tooth whitening system which is composed of 37.5% hydrogen peroxide and 2nd syringe is 1 g gingival barrier syringe for protection of gingiva.

At-home bleaching kit (Pola night: 16% carbamide peroxide gel tooth whitening system from SDI, Australia), contains one syringe which is composed of 16% carbamide peroxide gel 3 g, equivalent to 5.3% hydrogen peroxide.

Methods

Preparation of the samples

Firstly, retentive wedge-shaped cuts were made along the root surface of each tooth using turbine handpiece to increase the retention of the teeth inside the acrylic blocks. The teeth were then fixed on glass slide using soft sticky wax at the root apex. The middle part of the buccal surface was adjusted to be parallel to the analysing rod of the surveyor making the buccal surface parallel to the force of testing machine [12]. The two parts of the L-shaped metal plates were painted with separating medium and placed opposite to each other in such way to form a box around the vertically positioned tooth. The powder and liquid of self-cure acrylic was mixed and poured around the teeth to the level of the cement-enamel junction [13].

After acrylic setting, the parts of the box were separated and the sticky wax at the root apex was removed and replaced with acrylic to fill the holes. After mounting, the specimens were colour coded and stored in distilled water to prevent dehydration until bleaching [14,15].

The teeth were divided into three main groups each containing ten teeth, these groups are: control (unbleached) group, in-office bleaching method group with hydrogen peroxide group (HP) 37.5% and at- home bleaching method group with carbamide peroxide group (CP) 16%.

Bleaching procedure

Prior to bonding, the buccal surface of each tooth was cleaned using non-fluoridated pumice/water slurry in a rubber cup attached to a slow-speed hand piece for 5 seconds washed for 10 seconds and dried for 10 second using an air water syringe [15].

For in-office bleaching, a thin layer of gel was applied to the buccal surface using brush applicator and left for eight

minutes, and then the teeth were cleaned with gauze [15]. This was repeated three times so the total time of bleaching was 24 minutes. The tooth surface was then washed with air/water syringe for one minute and dried with compressed air for 30 seconds [16].

For at-home bleaching, a layer of the bleaching gel was applied to the buccal surface of the teeth one application per day for 6 hours for 5 consecutive days. All bleaching procedures were performed in a moist atmosphere at 37ºC. After each bleaching, the samples were washed under tap water for 30 seconds [17].

After bleaching completion, the specimens were stored in distilled water in a sealed container at room temperature for 24 hours before bonding was initiated. The samples of control group were not bleached and were stored under identical conditions as the experimental groups [18].

Bonding

After the bleaching procedure, the teeth were polished with a blend of water and pumice using a rubber polishing cup, rinsed with water to remove the pumice, and dried [19]. The teeth were then bonded with the RMGIC (GC Fuji Ortho LC, GC Corporation, Japan) according to the manufacturer's instructions. The standard powder to liquid ratio was 3.0 g/1.0 g was mixed (1 level large scoop of powder to 2 drops of liquid) which was mixed by dividing the powder into two equal parts; the first part was mixed with all the liquid and mix for about 10 seconds. The other part of powder was incorporated and mixed thoroughly for an additional 10-15 seconds (total mixing is 25-30 seconds) the final mixture was having creamy honey-like consistency. Instantly after applying the adhesive to the bracket base, the bracket was placed gently onto the centre of the labial surface using a clamping tweezers.

To guarantee seating the brackets under an equivalent pressure and to make sure an even thickness of the adhesive and avoid air entrapment which may influence bond strength, a load of about 300 g was attached to the vertical arm of the surveyor to standardize the pressure applied on the brackets during bonding [20]. The surplus was then removed from around the bracket with dental probe. The adhesive was cured using Flash Max 2 light cure unit (CSM Dental Aps, Denmark) with intensity reaching up to 4.300 mW/cm^2 (measured by radiometer) with six seconds curing; three seconds from mesial and three seconds from distal sides with 1-2 mm distance from the bracket [20]. Each tooth was left undisturbed for half an hour then the blocks stored in distilled water in a preserved container at room temperature for 24 hours [16,20].

De-bonding and examination of adhesives remnants

The samples were tested for shear bond strength using an Instron universal testing machine with a crosshead speed of 0.5 mm/minute. Readings were recorded in Newton. To get the value of shear bond strength, the force was divided by the surface area of the bracket base.

To determine the adhesive remnant index, both the de-bonded bracket base and the enamel surface of each tooth were examined under a stereomicroscope (magnification 20X).

The sites of bond failure were scored according to Wang et al. classification [21] and as followed:

Score I: The site of bond failure was between the bracket base and the adhesive.

Score II: Cohesive failure within the adhesive itself, with some of the adhesive remained on the tooth surface and some remained on the bracket base.

Score III: The site of bond failure was between the adhesive and the enamel.

Score IV: Enamel detachment.

Statistical analysis

Data were collected and analysed using SPSS software version 19. The following statistics were used:

Descriptive statistics: Means, standard deviations, frequencies, percentages, and statistical tables.

Inferential statistics: One-way ANOVA test: to test any statistically significant difference of the shear bond strengths among groups.

Tukey's HSD test: Used after ANOVA if gave significant difference.

RESULTS

Table 1 showed the SBS of all groups in MPa. The mean value in the control group was 4.53 MPa and was the least in comparison with the two experimental groups (home bleaching 16.06 MPa and office bleaching 14.47 MPa).

Table 1 Descriptive statistics and groups' difference of the shear bond strength (MPa)

Groups	Descriptive statistics		Groups' difference	
	Mean	S.D.	F-test	p-value
Control	4.53	0.8	109.53	0.00*
At-Home bleaching	16.06	1.62		
At-Office bleaching	14.47	1.44		
*P ≤ 0.01: Highly significant				

ANOVA test showed statistically highly significant difference among the groups, while Tukey's HSD test showed highly significant difference between control group and both of bleaching groups, and non-significant difference between the two bleaching groups (Table 2).

Table 2 Tukey's HSD test after ANOVA

Groups		Mean Difference	p-value
Control	At-Home bleaching	-11.536	0.00*
	At-Office bleaching	-9.94	0.00*
Home bleaching	Office bleaching	1.596	0.083**
*P ≤ 0.01: Highly significant; **P>0.05: Non-significant			

Regarding the ARI, score III was the predominant score for all groups (Table 3).

Table 3 Frequency and percentage of ARI

Scores	Control	At-Home bleaching	At-Office bleaching
I	0 (0.00%)	0 (0.00%)	0 (0.00%)
II	0 (0.00%)	0 (0.00%)	0 (0.00%)
III	10 (100%)	10 (100%)	10 (100%)
IV	0 (0%)	0 (0%)	0 (0%)

DISCUSSION

The most frequently used bleaching agents in dental clinics and at home are hydrogen peroxide and carbamide peroxide. There is some qualm is still about the influence of such agents on SBS in some studies these bleaching agents decrease the adhesive force and in other studies the reversible effects would showed (increased SBS), while the other reported there is no alteration in the SBS could be seen.

The results of present study cannot be compared with other similar studies either due to difference in teeth types (bovine teeth used in most studies) or difference in types of brackets, concentrations of bleaching materials and the time elapsed between bleaching and bonding [22-26].

The mean value of the SBS of the control group was very close to that reported by Mohammed-Salih, et al. (4.67 MPa) and less significantly than the bleached groups as indicated by ANOVA tests [27].

Reynolds reported that the minimum bond strength of 6 MPa to 8 MPa is considered adequate to endure masticatory and orthodontic forces [28]. In the present study, the bond strength values of bleaching groups were higher than this minimum requirement while control was low.

In this study, bleaching of the enamel prior to bonding seems to provide superior adherence to the treated surface and results in increased bond strength in the bleached group, this was perhaps because of the manufacturer's recommendation of not performing enamel etching and in the bleached groups the bleaching agents may act as acid etching so the SBS was higher than unbleached group.

Interestingly, RMGIC seemed to be sensitive to bleaching, the oxygen may not inhibit the polymerization of the resin and this comes in reversal to Bonett [29]. Also, the translucency of sapphire brackets enhanced total polymerization

with light curing in addition to the presence of zirconia particles coating the bracket base that generated millions of undercuts that locked the bracket in position due to the micro-mechanical retention means [20].

The most site of bond failure was score III, that is most of the adhesive remained on the brackets because RMGIC bonds better to the base of the bracket than to enamel, which may be safer, avoiding enamel fractures and maintaining the tooth's integrity.

CONCLUSION

RMGIC provided satisfactory bond strength when bonding the sapphire brackets to bleached enamel, and this bonding was strong enough to resist the mechanical and masticatory forces. Most of the adhesive remained on the brackets so it facilitates the removal of the bonding material's remnants during enamel finishing and polishing.

DECLARATIONS

Conflict of Interest

The authors and planners have disclosed no potential conflicts of interest, financial or otherwise.

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