In Vitro Evaluation of Shear Bond Strength of Sapphire Brackets after Dental Bleaching

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ABSTRACT

Background: The present study was conducted to evaluate the effects of different bleaching methods on the shear bond strength of orthodontic Sapphire brackets bonded to human premolars teeth using light cured composite resin and to determine the predominant site of bond failure.

Materials and Methods: Thirty freshly extracted human premolars were selected and randomly divided into three groups (10 per group). These groups are: control (unbleached) group, hydrogen peroxide group (HP) 37.5% ; which is the in- office bleaching method group, carbamide peroxide group (CP) 16%; which is the at- home bleaching method group. After bleaching process was performed, all the teeth stored in distilled water in a sealed container at room temperature for 24 hours before bonding was initiated, then orthodontic brackets were bonded with a light cure composite resin, stored in distilled water at room temperature for another 24 hours before debonding then the brackets de-bonded and tested for shear bond strength using an Instron universal testing machine. For adhesive remnant index (ARI) the enamel surface and bracket base of each tooth were inspected under magnifying lens (20X) of a stereomicroscope.

Results and Conclusions: Non-statistically significant differences of shear bond strengths were found between the control group and the bleached groups, the dental bleaching in both methods did not affect the SBS of Sapphire brackets. The mode of failure was mostly between the adhesive and the enamel and the bond failure between the bracket base and the adhesive were also observed.

Keywords: Shear bond strength, tooth bleaching agents, orthodontic brackets, dental bonding. (J Bagh Coll Dentistry 2016; 28(1):158-163).

INTRODUCTION

Discoloration of teeth is one of the biggest esthetic concerns of dental patients [(1)]. With an increasing demand for adult orthodontics, orthodontists often encounter patients who are unsatisfied not only with the alignment but also with the color of their teeth. Bleaching with various whitening agents in the office and in the home has now gained worldwide acceptance and has become popular among clinicians and patients as a method for lightening teeth. However, the changes in enamel structure and composition induced by these bleaching agents may decrease the shear bond strength (SBS) of orthodontic brackets [(2)].

Bleaching is the simplest, most common, least expensive means for eliminating stains since there is no need to prepare the teeth so that the enamel and dentin structures remain largely un-touched[(3,4)]. There are three techniques of bleaching: In-Office, at Home, and Over-the-Counter. An in-office use high concentration of carbamide peroxide (35-37%) and hydrogen peroxide (30-35%), while 20% carbamide peroxide and 10% hydrogen peroxide are used for at-home bleaching. An over-the-counter product is available to consumers as strips, wraps, and paints-on containing hydrogen peroxide [(5)].

The main difference between in office and at home products is that the carbamide's latter product carbopal which improves adhesion and prolongs the oxygen release [(6)].

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In-office vital tooth bleaching has been used for many years in dentistry and is known to be a reliable technique for quickly lightening discolored teeth [(7,8)].

Today, the most commonly used tooth bleaching agents contain hydrogen peroxide as the active ingredient. Hydrogen peroxide acts as a strong oxidizing agent through the formation of reactive oxygen molecules; these reactive molecules attack long chained dark colored chromophore molecules and split them into smaller, less colored and more diffusible molecules**.** Hydrogen peroxide may be applied directly or produced by a chemical reaction from sodium perborate or carbamide peroxide [(9)].

At-home vital tooth bleaching also has been shown to produce a significant perceivable change in color, reducing chair time and, therefore, it has become very popular [(10,11)]. Carbamide peroxide also breaks down into urea and hydrogen peroxide in aqueous solution [(12)].

At-home bleaching was first described by Haywood and Heymann [(13)] in 1989 as night guard dental bleaching.

In its undiluted form, carbamide peroxide has the equivalent concentration of a 35% hydrogen peroxide. It has been proposed that at such concentrations, it can result in chronic inflammation, tooth hypersensitivity, and preneoplastic lesions [(14)]. However, the current at home bleaching systems use carbamide peroxide diluted to a 10% concentration [(15)]. The most dentists prefer to use carbamide peroxide in a 15% concentration [(16)].

The result of the bleaching procedure depends principally on the concentration of the bleaching agent, the ability to reach the discolored sites, and the degree of peroxide exposure time. Extended duration and frequency that the agent is in contact with the organic molecules provide similar bleaching results as highly concentrated, short-term power bleaching [17].

Bond strength can be defined as force per unite area required to break a bonded assembly with failure occurring in or near the adhesive/adherened interface, it is commonly reported in units of megapascals (MPa) [18,19].

In Iraq, only three studies [20-22] evaluated the shear bond strength on bleached teeth. These studies didn't use home bleaching and ceramic brackets except for one study that evaluate the SBS of sapphire brackets which are bonded to endodontic treated teeth bleached with both of hydrogen peroxide and carbamide peroxide [22]; so this in vitro study was carried out to evaluate the effects of different bleaching methods by using (37.5% hydrogen, 16% Carbamide peroxide as bleaching agents) on the shear bond strength (SBS) of orthodontic Sapphire brackets and to determine the predominant site of bond failure.

MATERIALS AND METHODS

Materials

Teeth

Thirty freshly extracted human premolars, stored in distilled water to prevent dehydration until bonding, were used in this study. The criteria for teeth selection included intact buccal enamel that had not been subjected to any pretreatment chemical agents, e.g. hydrogen peroxide, with no cracks due to the pressure of the extraction forceps, and no caries.

Brackets

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

Bleaching material

1. Pola office: 37.5% hydrogen peroxide from SDI, Australia was used Pola office. In-office bleaching kit contain: two Pola office syringes, 1st syringe is 2.8 ml tooth whitening system which composed from 37.5% hydrogen peroxide 2nd syringe is 1gm gingival barrier syringe for protection of gingiva.
2. Pola night: 16% carbamide peroxide gel tooth whitening system from SDI, Australia was used Pola night. At-home bleaching kit contain: one syringe which composed from 16% carbamide peroxide gel 3 gm equivalent to 5.3% hydrogen peroxide.

Methods

Teeth Mounting

Retentive wedge shaped cuts were made along the sides of the roots of each tooth to increase the retention of the teeth inside the self-cured acrylic blocks. Each tooth was fixed on a glass slide in a vertical position using soft sticky wax at the root apex, so that the middle third of the buccal surface was oriented to be parallel to the analyzing rod of the surveyor. This kept the buccal surface of tooth parallel to the applied force during the shear test[23].

Then the two L-shaped metal plates, were painted with a thin layer of separating medium (Vaseline) and placed opposite to each other in such way to form a box around the vertically positioned tooth with the crowns protruding. After that, the powder and liquid of the self cured acrylic were mixed and poured around the tooth to the level of the cemento-enamel junction of each tooth [24].

After setting of the self-cured acrylic resin, the two L-shaped metal plates were removed, the sticky wax used for fixation of tooth in the proper orientation removed too and the resulting holes filled with self cure acrylic. Slight adjustment of the acrylic blocks was done using the portable engine to adjust the acrylic block to make it fit properly in the testing machine. After mounting, the specimens were color coded [25], and stored in distilled water [26] to prevent dehydration until bonding.

The selected thirty teeth were randomly divided into three main groups each group containing ten teeth, these groups are: control (un bleached) group, hydrogen peroxide group (HP) 37.5%; which is the in-office bleaching method group, carbamide peroxide group (CP) 16%; which is the at- home bleaching method group.

Bleaching Procedure

The buccal surface of each tooth clean with a non-fluoridated pumice/water slurry in a rubber cup attached to a slow-speed hand piece for 5 seconds (for standardization one rubber cap for each groups) washed for 10 seconds and dried for 10 second using an air water syringe [26].

For in-office bleaching according to the manufacture's instructions as follow: Firmly attach a mixing nozzle to the pola office syringe then dispense a small amount of gel on to mixing pad until a uniform gel is extruded, by using the nozzle as a guide, directly apply a thin layer of gel to the buccal surface of teeth by using brush

applicator. Leave gel on buccal surface for 8 minutes, then the teeth were cleaned with gauze[26].

Then repeated this step three times so the total application time is 24 minutes. After that the gel was washed thoroughly from the tooth surface using air water syringe for one minute then the surface was dried with compressed air for 30 seconds[27]. Then the teeth were store in distilled water fore 24 hours at room temperature ' then the teeth pumiced then bonded then store in distilled water fore 24 hours then debonding[26].

For at-home bleaching: according to the manufacture's instructions a layer of the bleaching agent (16% carbamide peroxide) gel was applied by pola night syringe to the buccal surface of teeth of one application per day at 6 hours for 5 consecutive days. All bleaching procedures were conducted in a humid atmosphere at 37ºC, after each bleaching, the samples were washed under tap water for 30 seconds [28].

On completion of bleaching, all the specimens stored in distilled water in a sealed container at room temperature fore 24 hours before bonding was initiated. The control groups were not bleached and were stored under identical conditions as the experimental groups for 24 hours [26,28].

Bonding

The teeth were cleansed and then polished with pumice slurry and rubber prophylactic cups for 10 seconds then thoroughly washed and dried[29].

The bonding with composite (according to the manufacturer's instructions): 37% phosphoric acid gel was applied for 30 seconds, washed with air water spray for 20 seconds and then dried with oil/ moisture-free air until the buccal surface of the etched tooth appeared chalky white in color. Thin uniform coat of Resilience® sealant (Ortho technology Co., USA) were applied by brush on each tooth surface to be bonded. Small increment of Resilience® adhesive paste (Ortho technology Co., USA) then applied onto the bracket back using flat ended instrument.

A load of about 300g was attached to the vertical arm of the surveyor to standardize the pressure applied on the brackets during bonding to ensure seating under an equal force and to ensure a uniform thickness of the adhesive and prevent air entrapment which may affect bond strength [30]. The excess then removed from around the bracket with dental probe.

Each bracket was then light cured for 20 seconds (ten seconds on mesial and another ten seconds on the distal side) [31] using the "LED" light cure unit (Radii-cal light emitting diodes "LED" with wave length range 420 – 480 nm) (Woodpecher, China). Every tooth was left undisturbed for 30 minutes to ensure complete polymerization of adhesive material [32], then stored in distilled water in a sealed container at room temperature fore 24 hours [26].

De-Bonding and Examination of Adhesives Remnants

The samples were tested for shear bond strength using an Instron universal testing machine. A crosshead speed of 0.5mm/minute was used. Readings were recorded in Newton. The force was divided by the surface area of the bracket base to obtain the stress value in Mega Pascal units.

To estimate the adhesive remnant index, the de-bonded brackets and the enamel surface of each tooth were inspected under a stereomicroscope (magnification 20X) to determine the predominant site of bond failure.

The site of bond failure was scored according to Wang *et al.* classification [33] 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 analyzed using SPSS (statistical package of social science) software version 15 for windows XP Chicago, USA. In this study the following statistics were used:

1. **Descriptive statistics:** including means, standard deviations, frequencies, percentages and statistical tables.
2. **Inferential statistics:** including:
   a) **Independent sample t-test:** to test any statistically significant difference of the shear bond strengths between the control group and experimental groups.
   b) **Chi-square:** to test any statistically significant differences among the groups for the adhesive remnant index.

In the statistical evaluation, the following levels of significance are used:

Non-significant	NS	$P > 0.05$
Significant	S	$0.05 \geq P > 0.01$
Highly significant	HS	$P \leq 0.01$

RESULTS AND DISCUSSION

Esthetics of the teeth including colors are of great importance to patients. Orthodontists often face patients who are dissatisfied not only with the appearance, but also with the color, of their teeth. A number of methods and approaches have been described for bleaching teeth. These methods have various bleaching agents, concentrations, times of application, product format, application mode, and light activation. [34]. A balance in bond strength must be achieved when choosing a bracket-adhesive combination for fixed orthodontic treatment. Bond strength should not only be high enough to resist the forces during the course of orthodontic treatment but also low enough to allow the removal of the bracket without any complications at the end of orthodontic treatment. Therefore, high mean bond strength does not necessarily mean better clinical performance [35].

Ceramic polycrystalline brackets based on mesh are more common and popular than monocrystalline brackets. They present similar modes of failure and bond strength; however, monocrystalline brackets are stiffer and therefore have a higher risk of fracture during removal [36].

The findings of this study can not be thoroughly compared with other studies due to different bleaching material types and concentration, brackets type, bleaching technique, storage time and media and different adhesives used.

Although the SBS was higher that suggested by Reynolds [37] in all three groups in the present study (table 1) but there is no significant difference between control group and in-Office bleached group ($p>0.05$) and between control group and at- home bleached group ($p>0.05$).

This could be explained by the presence of zirconia particles coating the bracket base of the sapphire brackets which creates millions of undercuts that secure the bracket in place by micro mechanical retention means. The translucency of the sapphire brackets gives a better chance for complete polymerization of the adhesive with light curing, and sapphire brackets are Single-crystalline brackets so they are hard and offer great strength that prevents or reduces the peeling effects that may occur during brackets debonding thus give them high SBS values.

Although the mean value of SBS of this study is less than that of Abdulkareem and Al-Mulla [22] but both showed non-significant difference between the three groups. On the other hand, Oztas *et al.,* [38] found statistically non-significant differences between the shear bond strengths of metal and ceramic brackets bonded to bleached enamel after 24 hours, 14 days and unbleached enamel with light or chemical cure adhesives. Immerz *et al.,* [39] showed there was no significant difference noted in bonding strength between non-treated surfaces and those treated with peroxide.

While in Firoozmand et al., [40] there was a significant difference between bleached and unbleached enamel after 14 days of storage in saliva, and this is disagree with this study

The site of failure provides useful information about the bonding process. Ideally, in orthodontics, an adequate bond that fails at the enamel-cement interface is desirable because de-bonding and subsequent polishing procedures would become much easier [41].

Reviewing table 2, the results showed that the predominant scores were score I and score III with 20% score IV and so the results of ARI score comparisons indicated a highly significant difference in failure site between bleached and control groups; this come in agreement with others [39,40].

Immerz *et al.,* [39] found that the predominant score was I (all of the resin remains on the enamel surface after debonding), while in Firoozmand *et al.* study [40] was score III which mean score I in present study is in non-bleached group presented in a higher percentage of enamel-resin adhesion compared to the bleached group, so there is a significant associations between the distribution of ARI scores and the bleaching treatment.

Oztas *et al.,* [38].failure was mostly at the bracket/adhesive interface and cohesive failures within the resin, and this agrees in (bracket/ adhesive interface failure) but disagrees in (cohesive failures within the resin) with the present study.

As conclusion**:**

1. The vital bleaching in both methods (at-home bleaching method and in-office bleaching method) did not effect on SBS of the sapphire brackets in this study.
2. The mode of failure was mostly between the adhesive and the enamel and the bond failure between the bracket base and the adhesive were also observed.

Table 1. Descriptive Statistics and Group's Differences of the Shear Bond Strength (MPa)

Groups	Descriptive statistics		Groups' Difference	
	Mean	S.D.	t-test	p-value
Control	18.15	3.53	1.367	0.209 (NS)
At-home bleaching	15.38	2.84		
Control	18.15	3.53	1.143	0.286 (NS)
In-office bleaching	16.12	1.82		

Table 2. Distribution and Percentage of Adhesive Remnant Index

Groups	Scores				Comparison		
	I	II	III	IV	X^2	d.f.	p-value
Control	2 (20%)	0 (0%)	8 (80%)	0 (0%)	13.5	4	0.009 (HS)
In-office bleaching	8 (80%)	0 (0%)	2 (20%)	0 (0%)			
At-home bleaching	2 (20%)	0 (0%)	6 (60%)	2 (20%)			

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