

The effects of various beverages on the shear bond strength of light-cured orthodontic composite (An in vitro comparative study)

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ABSTARCT

Background: This study was conducted to assess the effects of various beverages on the shear bond strength of light-cured orthodontic composite used to bond stainless steel orthodontic brackets on human teeth and to determine the site of bonding failure of this material.

Materials and Methods: Fifty extracted human premolars were selected and randomly divided into five equal groups each with 10 teeth according to the beverage type (Control, One Tiger, Milk, Green tea and Coffee). After bonding, the teeth were immersed in specific beverages for 5 minutes twice daily with equal intervening intervals then washed and stored in distilled water at 37° C for the remainder of the day. The process was carried out for 30 days. The samples were then tested for shear bond strength using Tinius-Olsen testing machine with a crosshead speed of 0.5mm/minute. For adhesive remnant index, the enamel surface and bracket base of each tooth were inspected under magnifying lens (20X) of a stereomicroscope.

Results: Milk, coffee and one Tiger energy drink reduced the shear bond strength of the light-cured composite significantly unlike the green tea. The predominant site of bond failure was between the bracket base and the adhesive leaving the composite on the tooth rather on the brackets base.

Conclusions: Orthodontic patients should be instructed to reduce the intake of acidic and fatty beverages to prevent debonding of the orthodontic brackets.

Keywords: Shear bond strength, beverages, orthodontic adhesive. (J Bagh Coll Dentistry 2014; 26(3):144-148).

الخلاصة

الخلفية: أجريت هذه الدراسة لتقييم تأثير المشروبات المختلفة على القوة القاصصة لحاصرات تقويم الاسنان الفولاذية ، وتحديد موقع فشل الارتباط مع الاسنان. المواد والأساليب: تم اختيار خمسون من الضواحك البشرية والتي قسمت عشوائيا إلى خمس مجموعات متساوية كل منها 10 أسنان وفقا لنوع الشراب (ماء مقطر ، مشروب الطاقة النمر الاول ، الحليب ، الشاي الأخضر والقهوة). تم غمر الاسنان في المشروبات لمدة 5 دقائق مرتين يوميا ثم تم غسلها وتخزينها في الماء المقطر في درجة حرارة 37 ° وقد أجريت عملية لمدة 30 يوما . تم اختبار القوة القاصصة لحاصرات تقويم الاسنان باستخدام آلة اختبار خاصة و بمعايير معينة. النتائج: كانت القوة القاصصة لحاصرات تقويم الاسنان الفولاذية في الحليب ، القهوة و مشروب الطاقة النمر الاول اقل بشكل ملحوظ مما هي عليه في المجموعة الضابطة على عكس الشاي الأخضر.

الاستنتاجات: يجب الإقلال من تناول المشروبات الحمضية والدهنية لمرضى تقويم الأسنان. الكلمات المفتاحية: القوة القاصصة ، المشروبات، حاصرات تقويم الأسنان.

INTRODUCTION

Soft drink consumption has gradually increased in recent decades in both western and developing countries. The tendency is most apparent among children and adolescents. This rise in soft drink consumption has raised concerns among health care professionals including dental practitioners. Dental problems, such as caries, enamel erosion and corrosion of dental materials, may be associated with soft drink utilization. Because orthodontic appliances limit toothbrush access, patients undergoing orthodontic treatment need special oral care and counsel ⁽¹⁾.

Bond failure of brackets during orthodontic treatment is a frequently encountered dilemma. The frequency of this has been found to fluctuate between 0.5 and 17.6 per cent ⁽²⁻⁴⁾. A mixture of factors can contribute to bond failure, including poor operator technique, variation in the enamel surface, saliva contamination, bracket properties, masticatory forces and patient behaviour ⁽⁵⁻⁸⁾. Acidic and alcoholic foods and drinks in the diet of the patient can also be a causative factor for bond failure ⁽⁹⁻¹¹⁾.

Many studies had evaluated the effect of various soft drinks on the bond strength, adhesive

remnant or the microleakage beneath orthodontic brackets. Oncag *et al.* ⁽¹⁰⁾ investigated the effects of Coca-Cola, Sprite and control (artificial saliva) on the resistance of metal brackets to shear forces in vitro and in vivo. They found that both acidic soft drink groups had a reduced debonding resistance in vivo and in vitro compared with their control subgroups. Comparison of the debonding resistance between the in vivo and in vitro groups showed no statistical difference. On the other hand, their findings revealed that the areas of defect due to erosion were observed on the enamel surface around the brackets in both the in vitro and in vivo groups. They concluded that acidic soft drinks such as Coca-Cola and Sprite had a negative effect on bracket retention against shearing forces and enamel erosion.

Ulusoy *et al.* ⁽¹²⁾ evaluated the effects of some types of herbal tea on the shear bond strength of orthodontic brackets to enamel surfaces. They found that rosehip fruit tea may be a causative factor in bracket – enamel bonding failure.

Navarro *et al.* ⁽¹³⁾ studied the effects of Coca-Cola and Schweppes Limón and found that there was no significant difference in shear bond strength and adhesive remnant between the groups. The drinks produced enamel erosion, loss of adhesive and microleakage.

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Khoda *et al.* ⁽¹⁴⁾ evaluated the effects of Pepsi, 7 up, carbonated and non-carbonated yoghurts on the shear bond strength of orthodontic brackets and found that these soft drinks did not decrease the bond strength of the brackets.

This study is the first in Iraq and conducted to assess the effects of some beverages on the shear bond strength of light-cured orthodontic bonding material (composite) that used to bond stainless steel orthodontic brackets on human teeth, and to verify the site of bonding failure of this material.

MATERIALS AND METHODS

Materials

Teeth

Fifty human premolars were collected and stored in a solution of 0.1% (weight/volume) thymol. The criteria for tooth selection included undamaged 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. These teeth were fixed in self-cure acrylic blocks.

Brackets

Fifty 0.022" stainless-steel edgewise orthodontic brackets {Bionic®} from Orthotechnology Co., USA with a base surface area 10.9 mm² were used in this study.

Beverages

Five groups of beverages were used in this study. Group 1: Control (Distilled water), Group 2: One Tiger energy drink, Group 3: Milk, Group 4: Green tea and Group 5: Coffee (Table 1).

Table 1. Information about the beverages

Beverages	Manufacturer	Country	pH	Ingredients
Distilled water	Poisoning center	Iraq	7	Water
One Tiger	Crystal Cola Co.	Turkey	6.7	Carbonated water, sugar, citric acid, sodium citrate, benzoic acid, taurine, glucuronolactone, caffeine, inositol, caramel, acidity regulators, stabilizer, natural fruit flavors, vitamins B2, B5, B6 and B12.
Milk	KDD Co.	Kuwait	6.7	8.5% non-fat milk solids, 3% butterfat (full cream milk), Vitamins D and A, butterfat, purified water, stabilizer and emulsifier.
Green tea	Ahmad Tea Ltd	England	6.8	Pure China green tea with mint flavoring granules.
Coffee	Al-Ameed Co.	Jordan	6.4	Roasted ground coffee with cardamom

Methods

Bonding, immersion and storage

The teeth were cleansed and then polished with pumice slurry and rubber prophylactic cups for 10 seconds then thoroughly washed and dried ⁽¹⁵⁾.

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) was applied by a 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.

Immediately after applying the adhesive to the bracket base, the bracket was placed gently onto the centre of the labial surface using a clamping tweezers.

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 ⁽¹⁶⁾. The excess then removed from around the bracket with sharp scaler.

A super LED; Flash Max 2 light cure unit (CSM dental Aps, Denmark) with an optical output well above 4.000 mW/cm² was used to cure the adhesive. Six seconds; three seconds from mesial and three seconds from distal sides were used to cure the adhesive with a minimum separation distance (1-2) mm. ⁽¹⁷⁾.

The initial pH of each liquid (Table 1) was tested using an electronic pH meter (HANNA pH 211 Microprocessor pH, S.N. 752219, Romania). The pH meter was calibrated using phosphate buffer powder prior to testing.

To prepare the green tea, one tea bag was added to 250 ml. of boiling tap water and stirred for 5 minutes then the bag removed. The volume of 250 ml. was chosen as this represented the average volume of a typical tea mug. For the coffee, 4 full tea-spoons of coffee were added to

250 ml. of water (with little amount of sugar for both the tea and coffee) and stirred over the fire until boiling. The solution was allowed to cool until it reached 37°C before testing⁽¹⁸⁾. One Tiger and milk were used cold, directly from the refrigerator, at each session.

The sample were immersed in specific beverages twice daily for 5 minutes with equal intervening intervals then washed and stored in distilled water at 37° C for the remainder of the day. The process continued for 30 days.

De-bonding and examination of adhesives remnants

The samples were tested for shear bond strength using Tinius-Olsen testing machine H50KT. A crosshead speed of 0.5mm/minute was used and readings were recorded in Newtons. The force was divided by the surface area of the bracket base to obtain the stress value in Mega Pascal units.

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 the classification of Wang *et al.*⁽¹⁹⁾ and as follows:

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 analyses

Data were analyzed using SPSS software version 19. In this study the following statistics were used:

- Descriptive statistics: including means, standard deviations, minimum and maximum values, frequency, percentages and statistical tables.
- Inferential statistics: including: Independent samples t- test: to test any statistically significant difference in the shear bond strength between the control and study groups.

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

P > 0.05	NS	Non-significant
0.05 ≥ P > 0.01	S	Significant
P ≤ 0.01	HS	Highly significant

RESULTS AND DISCUSSION

There is increasing community concern in the dental effects of soft drinks, sports drinks, energy drinks and flavored waters due to the escalating consumption by children and adolescents over the last period⁽²⁰⁾.

It has been reported that acidic and alcoholic soft drink consumption during orthodontic treatment decreases the retention of brackets by enamel softening around the brackets^(9,10) or adhesive resin/composite resin degradation or softening⁽¹¹⁾. Therefore, patients with fixed orthodontic appliances are advised not to consume acidic soft drinks during treatment⁽¹⁰⁾.

In this study, the effect of different beverages on the shear bond strength of light-cured orthodontic composite used to bond stainless steel brackets on human teeth was assessed.

The descriptive statistics were shown in table 2. Generally the amount of shear bond strength (SBS) was less than proposed by Reynolds⁽²⁰⁾ (6-8 MPa) in all study groups except in control and green tea groups.

Table 2. Descriptive statistics of the shear bond strength (MPa) for the tested beverages

Beverages	Mean	S.D.	Min.	Max.
Control	7.67	1.08	6.5	9.4
One Tiger	5.30	0.69	4.59	6.42
Milk	4.77	0.30	4.45	5.18
Green tea	7.18	0.48	6.74	7.88
Coffee	4.40	1.02	3.16	5.94

Comparison the effect of tested beverages on the SBS with the control was demonstrated in table 3. The results showed highly significant difference for milk, coffee and one tiger whereas there was non-significant difference with green tea.

Table 3. Comparison between the control and studied beverages

Beverages	t-test	d.f.	p-value
One Tiger	4.521	18	0.001 (HS)
Milk	6.338	18	0.000 (HS)
Green tea	1.010	18	0.336 (NS)
Coffee	5.391	18	0.000 (HS)

Coffee showed the least mean value of SBS; this is because of its acidic nature⁽²¹⁾.

One Tiger energy drink contains three types of acids namely citric acid, benzoic acid and taurine. These acids in addition to the caffeine and carbonated water (which contains carbonic acid as a result of the dissolved carbon dioxide) have negative effects on the brackets- enamel bonding

by causing enamel demineralization around the brackets⁽¹⁰⁾. This could be explained by the presence of high concentration of refined carbohydrates will promote greater degrees of acid production, in addition to that, citric acid and citrate have the talent to bind to calcium in the tooth keeping the pH low for longer periods of time).

Oltjen⁽²²⁾ stated that researches supported that a beverage's composition and total acid content, rather than beverage pH, determine the actual aggression toward enamel.

The higher acidity may act as the best plasticizer that accelerates the rate of water sorption by reducing the polymer inter-chain interactions. Acidic pH solution has already proved to influence the degradation of the composite which may result a decrease in the mechanical properties⁽²³⁻²⁷⁾. The solution diffuses into a polymer network and separates the polymer chains creating an expansion that affects the dimensions of the bulk material. In addition, acidic solution may provide a sufficient concentration of protonated protons to induce the hydrolysis of ester portion presents in the resin matrix⁽²⁸⁾. The reaction may lead to a chain scission process in which polymer chains are cleaved to form oligomers and monomers. The process of plasticization and swelling of the matrix would take place and causes the formation of pores inside the material at the area of organic substances has been released⁽²⁷⁾. All these circumstances led to increase the rate of water diffusion and therefore higher diffusion coefficients were obtained.

Green tea was tested for the first time in orthodontics. It has a pH up to 6.8 i.e. it is nearly neutral. It did not cause any decrease in the amount of SBS, so in addition to its benefit to health as anti-oxidant, it has no effect of the SBS. Ulusoy *et al.*⁽¹²⁾ found that the shear bond strength had been lowered after exposure to

Rosehip fruit tea, while other types of herbal tea did not affect the SBS. Rosehip fruit tea is rich in ascorbic acid and had the lowest pH in the tested herbal teas.

Milk used in this study contains fats (full cream). In spite of the bonded teeth were rinsed with profuse amount of water after immersion, the fats in milk would remain on the surface of the bonded teeth since it is insoluble in water. Accumulation of fat causes softening of the resin which may weaken the material and reduced the shear bond strength.

The most predominant failure site was located at bracket base and adhesive (score I) in milk, coffee and one Tiger (Table 4). This means that most of composite remained on the tooth after bracket debonding. From this finding, it was apparent that there was a affiliation between lower SBS means values and percentage failure between bracket base and adhesive. On the other hand, cohesive (score II) and adhesive (score III) failure could be seen more with increasing SBS mean values (control and green tea groups). This may be accredited to the enamel erosion around the brackets and softening/ degradation of the adhesive resin due to the immersion in the tested beverages; this means that resin penetrated into the undercuts of the bracket base was unable to resist the shear stress when weakened causing bond failure.

In conclusion, the acidic and fatty beverages reduced the SBS of the light-cured composite while the green tea did not. Orthodontic patients should be instructed to reduce the intake of acidic and fatty beverages to prevent debonding of the orthodontic brackets. Further studies are needed to test the effects of the same or other beverages on the shear bond strength of ceramic and sapphire brackets bonded with orthodontic composite (no-mix, light-cured or self-etched) and resin modified glass ionomer cement.

Table 4. Frequency and percentage of the adhesive remnant index (ARI) in the tested beverages

Scores	Beverages				
	Control	One Tiger	Milk	Green tea	Coffee
I	5 (50%)	8 (80%)	10 (100%)	4 (40%)	7 (70%)
II	3 (30%)	2 (20%)	0 (0%)	5 (50%)	2 (20%)
III	2 (20%)	0 (0%)	0 (0%)	1 (10%)	1 (10%)
IV	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

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