Does the antioxidant treatment affect the shear bond strength of orthodontic brackets: An in vitro study

Abeer Abdullah Alrafaa,[1] Rabia Bilal,[2] Ibrahim Alshahrani[3]

Abstract

Objective: To determine the shear bond strength of orthodontic brackets after anti-oxidant treatment on previously bleached teeth.

Method: The experimental in-vitro study was conducted in Saudi Arabiaat Qassim University, Al-Qassim, and King Saud University, Riyadh, from December 2016 to March 2017, and comprised extracted maxillary and mandibular premolars which were divided randomly into three groups. In Group A, which was the control group, the teeth were etched and bonded, while those in Group B were bleached, etched and bonded. Group C was subjected to bleaching, followed by treatment with anti-oxidant 10% sodium ascorbate solution, then etched and bonded. All three groups were then tested and analysed for bond strength using the Instron, Universal testing machine. SPSS 23 was used for data analysis.

Results: There were 60 teeth with 20(33.3%) in each of the three groups. Group C had the maximum mean shear bond strength of 12.231±2.1Mpa, followed by Group A with 10.948+/-2.1Mpa and Group B with 7.621±1.8Mpa.

Conclusion: Anti-oxidant treatment had a positive effect on the shear bond strength of orthodontic brackets after tooth bleaching.

Keywords: Anti-oxidant. Bleaching, Brackets, Extracted premolars, Shear bond strength. (JPMA 69: 82; 2019)

Introduction

Nowadays, aesthetics are very important for many age groups, particularly women and younger people, for whom tooth discolouration has taken centre stage as a major problem. Such tooth stains, whether due to food, tetracycline staining fluorosis,[1] or another cause, give rise to a negative yet avoidable effect on one's personality. To this end, bleaching is an effective and safe method of treating discoloured teeth, and has become quite a popular procedure in dentistry.[2]

Aesthetic demands have increased overall among the general populace, as people prefer well-aligned and shiny, white teeth in order to be perceived as healthy and youthful. Tooth bleaching and orthodontic therapy are common treatments eagerly sought by patients who desire a beautiful smile. The number of adults seeking orthodontic treatment is rising daily, and so is the likelihood of their reporting a previous history of bleaching.[3] However, tooth bleaching prior to orthodontic treatment produces a considerable reduction in, or loss of, bond strength between the orthodontic brackets and the tooth enamel.[4] This is most probably caused by peroxide solutions which create a change in the surface morphology, structure and characteristics of the enamel.[5,6] Such an undesirable situation means that clinicians need to be aware of the possibility that peroxide bleaching may have detrimental effects on enamel, consequently causing a change in bonding efficiency over time. However, several studies have produced conflicting views.[1,4] In some cases, both bleaching and orthodontic treatments were performed within a short period of time, thus having an immediate effect on the outcome of the other. Other authors have reported a decrease in the shear bond strength of the brackets to the tooth enamel after bleaching,[7,8] while still others have suggested that bleaching has no detrimental effects on the bracket-enamel bond strength.[9,10]

Hence, in view of the increasing demand by orthodontic patients who wish to undergo dental bleaching and because of the correspondingly multiplied need to provide efficient and effective orthodontic treatment to such patients, the current study was planned to evaluate the shear bond strength of orthodontic brackets after anti-oxidant treatment on bleached teeth.

Materials and Method

This experimental in-vitro study was conducted in the Department of Orthodontics, College of Dentistry, Qassim University, and the Department of Orthodontics and Department of Physics, King Saud University (KSU), Saudi

[1]College of Dentistry, Qassim University, [2]Department of Orthodontics, College of Dentistry, Qassim University, [3]Department of Pediatric Dentistry and Orthodontics, College of Dentistry, King Khalid University, Abha, Saudi Arabia.
Correspondence: Ibrahim Alshahrani. Email: ishahrani@kku.edu.sa

Arabia. Approval was taken from institutional review board of Qassim University. The study comprised non-carious, sound maxillary and mandibular premolars extracted for therapeutic orthodontic purposes. Teeth with hypoplastic areas, fluorosis or gross irregularities of the enamel structures were excluded. No pre-treatment with chemical agents such as alcohol, formalin, or hydrogen peroxide, or any other form of bleaching was allowed. The teeth were cleaned of blood and tissue debris and stored under refrigeration at 4°C in artificial saliva solution. The artificial saliva was refreshed daily to avoid bacterial contamination.

For the purpose of mounting on an Instron testing machine, the samples were prepared. Brass bars with dimensions of 80mm×10mm×5mm were fabricated and invested in dental plaster to produce a mould. Open-ended cylinders of 20mm height and 15mm internal diameter were cut out of poly vinyl chloride (PVC) pipe. Each PVC cylinder was filled with orthodontic resin into which a premolar tooth was embedded, leaving its crown exposed and parallel to the long axis of the cylinder. All the teeth were embedded in the acrylic and groups were colour-coded. The teeth in all the groups were mounted in such a way that the buccal surface was exposed, and a jig was fabricated for mounting onto an Instron universal testing machine (Model no: 5965 K).

The sample was randomly divided into three equal groups. Group A (black) was the control group, and the teeth were etched with 37% phosphoric acid gel (Dentsply, York, PA, USA) for 30 seconds. After that, the teeth were rinsed for 20 seconds and then dried with a stream of air for 20 seconds to appear opaque and frosty. For those teeth that did not show a white frosty appearance, the procedure was repeated. Then the pre-adjusted edgewise brackets (Gemini brackets, 3M Unitek, Monorovia, California, USA) of 3.3mm diameter and mesh base were bonded to the etched enamel using light cure composite resin (Megafill MH, Megadenta) as per the manufacturer's instructions. The brackets were seated and positioned firmly in the middle third of the buccal enamel surface.

The brackets were fixed on the tooth surface with a bracket placing plier (3M unitek) and the excess material was removed with a scaler and light-cured for 40 seconds with alight-emitting diode(LED) light-curing unit at 800mW/cm2 (Demi LED Light Curing System, Kerr Corp, Orange, CA, USA) from a 5mm distance.

In Group B (red), 22% carbamide peroxide gel (Opalescence; Ultradent Products, South Jordan, Utah, USA) was placed on the buccal surfaces of the teeth at 1mm thickness for two hours at 37°C and 100% humidity. After removing the bleaching gel, the teeth were rinsed and dried. Afterwards, the steps were performed as for Group A.

In Group C (green), the teeth were bleached in the same procedure as Group B, after washing away the bleaching agent for two hours, 10% sodium ascorbate solution was applied to the enamel surface of the embedded teeth as an irrigation solution for 10min at a flow rate of 1ml/min. After the anti-oxidant treatment, the enamel surface was thoroughly rinsed with distilled water for 30s then acid-etched for 30s, rinsed, and the brackets bonded using LED light cure unit carried out as was the case with groups a and B.

After bonding the brackets, all the samples were storedin artificial saliva at 37°C for 24 hours. Afterwards, the teeth in all the groups were mounted individually on a universal testing machine for the debonding procedure. All the procedures were observed by a group of four dentists; three of them were orthodontists and one was a general dentist. This was done to minimise bias and error. These observers were kept blind to the group to which the particular teeth under study belonged.

The shear bond strength was tested at KSU, 24h after the bracket bonding procedure for all the three groups. The Instron testing machine was used in this study to record the maximum load necessary to debond the bracket, using a 5mm metallic rod; shear force was applied parallel to the height of contour of the teeth to the interface of the tooth-bracket in an occluso-gingival direction, with a 1-kn load cell at the crosshead speed of 0.5mm/min. The maximum load in which the brackets were debonded was recorded by calculating the load in the unit surface area of each sample. Shear bond strength was reported in Mega Pascal (Mpa). A trained and calibrated observer performed the whole procedure.

SPSS 23 was used for data analysis. Means and standard deviations were calculated using descriptive statistics and compared using analysis of variance (ANOVA). Inter-group comparison was performed by a Bonferronit-test (post hoc test).

Results

There were 60 teeth with 20(33.3%) in each of the three groups. Group C had the maximum mean shear bond strength of 12.231±2.1Mpa, followed by Group A 10.948±2.1Mpa and Group B 7.621±1.8Mpa (Figure). The difference among the groups was significant (p=0.000) (Table-1). On inter-group comparison, a significant difference was found between the mean shear bond

Table-1: Comparison of mean shear bond strength of three groups.

Group	N	Mean bond strength	Range		SD	F	P (<0.05)
			Min	Max			ANOVA
Group A	20	10.948	9.06	13.56	2.1	65.1	0.000
Group B	20	7.612	6.81	10.43	1.8		0.000
Group C	20	12.231	8.02	17.24	2.1		0.000
Total	60	11.60	6.81	17.24	3.7		0.000

One-way ANOVA test: SD: Standard deviation.

Table-2: Inter-group comparison of shear bond strength of specimen of 3 groups.

Group	Inter group comparison		Mean	P (<0.05)
Control Group	4.09884 Bleach Group	-3.52672 Bleach + Anti-oxidant Group	10.948	.000
Bleach Group	-2.09884 Control Group	-4.62556 Bleach + Anti-oxidant Group	7.612	.000
Bleach + Anti-oxidant Group	2.52672 Control Group	5.62556* Bleach Group	12.231	.000

*The mean difference is significant at the 0.05 level
Bonferroni multiple comparison test (Post hoc test).

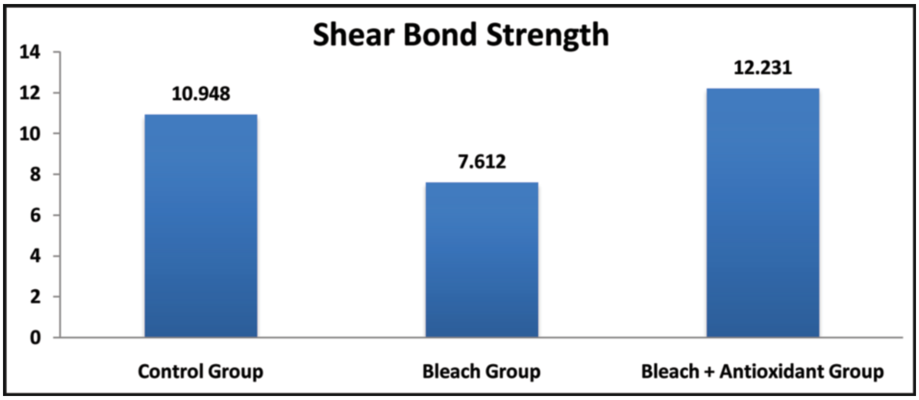

Figure: Representing the mean shear bond strength of three experimental groups.

strength of Group A and Group B, and that of Group C and Group A (Table-2).

Discussion

The desire to have aesthetically pleasing looks has become widely popular, and this in turn has raised an intense desire among people of all age groups and genders, particularly the youth, to have beautifully aligned, brighter teeth. This is the reason why orthodontists are subjected to treating a considerably higher number of patients who do not require any tooth whitening procedure but wish to look better and hence demand teeth bleaching.

The practice of bleaching is spreading extensively with the hike in demand for aesthetic dentistry.[11] Hence, in all probability, an orthodontist who faces patients who may have undergone vital tooth bleaching means that it is essential for them to assess whether bleaching has had any effect on the shear bond strength of orthodontic bracket adhesives on the tooth surface. There thus arises a need for orthodontists to seek and practise ways of reversing the effect of bleaching so that efficient and successful orthodontic treatment outcomes are achieved. A significant reduction in the shear bond strength of composite resin to enamel after bleaching with 35% hydrogen peroxide has been reported in previous studies by Cavalli et al.[12] and Nour El-din etal.[13] Hence, the present study was undertaken to assess the effect of anti-oxidant treatment on shear bond strength of bleached teeth further.

The present study found that the mean shear bond strength in Group B was 7.612 Mpa while that of the control group (Group A non-bleached) was 10.948 Mpa. The difference between the mean values of the shear bond strength between the two groups was statistically significant. This finding was in accordance with previous research, wherein a decrease in shear bond strength was observed after tooth bleaching. Lai et al.[14] found that a reduction in resin enamel bond strength in bleached and etched enamel is likely to be caused by the delayed release of oxygen which affects the polymerisation of resin components. In 2007, Adanir et al.[15] found that there is reduced bond strength when the teeth are treated with 35% hydrogen peroxide and immediately bonded with the light cure composite for the bonding procedure.

The reduced shear bond strength of Group B has been attributed to the release of free radicals in the form of nascent oxygen or hydroxyl ions during caramide-peroxide-bleaching.[11] It was documented earlier that post-caramide peroxide bleaching of teeth results in the release of nascent oxygen and hydroxyl or per-hydroxyl ions. Free radicals give rise to an increase in reactivity due to the presence of one unpaired electron, and, hence, during the bleaching process, they catalyse the oxidation of the macro-molecules of stains, such as to split them into linear fragments, which in turn diffuse across the hard dental tissues.[14] The free radicals hinder the resinpolymerisation or interfere in the penetration of resin tags into the etched enamel.[16] The fall in bond strength has also been attributed to the change in proteins and mineral content of the upper layers of tooth enamel.[16]

The current study applied 10% sodium ascorbate solution to the bleached tooth surface for 10min, as it has been considered to be sufficient time for the application of anti-oxidant and also it is clinically comfortable for patients.[17,18] The results of the current study show that the mean shear bond strength of the Group C specimen treated with anti-oxidant was 12.231 Mpa, and was the highest value of shear bond strength of all three groups. Such findings are in line with studies[19,20] conducted earlier, wherein 10% sodium ascorbate was found to reverse the action of bleaching of teeth with carbamideper oxide. The phenomenon is due to its characteristic feature of allowing free-radical polymerisation of the adhesive resin to advance without early termination, by restoring the redox potential of the oxidised bonding substrate, which consequently reverses the compromised bonding.[21] Ascorbic acid not only reduces the residual oxygen component but also etches the tooth surface and thereby maintains the shear bond strength of resin material.[22] Moreover, vitamin C and its salts are biologically acceptable and extensively used as such by food industries as anti-oxidants; hence, its intra-oral use is not at all harmful in anyway.[17] Also, 10% sodium ascorbate hydrogel has the potential to neutralise the residual oxides, whether produced as a by-product of oxygen of bleaching procedure or that of oxygen from normal atmosphere.[23]

The mean shear bond strength of group C (Bleached +anti-oxidant treated teeth) was higher than Group A (control) in the present study. The reason might be attributed to the fact that bleaching may have reduced the sodium bisulfite (SBS) to a lesser extent and after anti-oxidant treatment, the SBS raised to a good amount even higher than the control group. Moreover, after anti-oxidant treatment to the teeth in group C, the reversal effect may have caused the increase in SBS even more than Group A. It is mentioned in previous studies that bond strength values were not affected adequately by in-office bleaching types (10% carbamide peroxide and 35% hydrogen peroxide).[9,24]

In this study, even though Group B specimen was found to have the least mean bond strength of 7.612 MPa compared with the other two groups, this value of shear bond strength was still above the clinical requirement for successful bonding, i.e. 6-8 Mpa against the reported maximum bond strength (14 Mpa) to prevent enamel fracture.[25,26]

In view of the increased incidence of adults with a previous history of bleaching seeking orthodontic treatment, this study brings to light the possibility of reversing the reduction in bond strength of orthodontic brackets after bleaching. This would enable orthodontists to avoid delays in the bonding procedure after bleaching, and also enable practitioners to add the aesthetics of bleaching without hampering the mechanical and physical integrity of bond formation.

Conclusion

Although bleaching with 22% carbamide peroxide reduces the bond strength, it does not reduce the bond strength below the minimum required clinical level of 6-8Mpa. It was also found that post-bleaching sodium ascorbate treatment adequately increases the shear bond strength of brackets to teeth.

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Conflict of Interest: None.

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