The Etching Effect of Co2 Laser on The Shear Bond Strength of Bleached Teeth

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ABSTRACT

Background: Tooth discoloration is one of the great esthetic problems in dentistry, Despite vital bleaching, is often considered a first step to improve the appearance of teeth, reports are controversial about the effect of bleaching on the shear bond strengths (SBS) of brackets. Etching of enamel surface can be carried out by acid or laser, there was controversial about the efficiency of CO2 laser as enamel surface etchant

Objective: The aim of the present study is to detect if there is a significant reduction in SBS of bleached teeth, and to detect the effect of CO2 laser as etchant on both bleached and normal teeth.

Methods and materials: Forty non-carious first premolars are divided into 2 main groups: None- bleached (A) and Bleached (B) groups, of 20 specimens for each group, then the groups were subdivided into 2 subgroups (10 specimens for each subgroup). Group (B) teeth were bleached with chemically activated 40% hydrogen peroxide, while group (A) teeth were left without bleaching. The subgroups teeth (A1 and B1) were etched with CO2 laser and the subgroups (A2 and B2) were etched with 37% phosphoric acid. After bracket bonding, samples were then thermally cycled for 500 cycles between(5°C and 55°C). Debonding was performed with a shearing force using the universal testing machine, then ANOVA and LSD test were used to specify if there was a significant difference between groups.

Results: there was the nonsignificant difference in mean SBS of both phosphoric acid etching and CO2 laser etching in both bleached and normal surface enamel specimens A and B groups. Whereas there was a significant difference in mean shear bond strength between the CO2 laser etched and the phosphoric acid etched groups with highest mean values in the phosphoric acid etched subgroups,

Conclusion: The results of this in vitro study suggest that hydrogen peroxide bleaching does not affect the shear bond strength of metal orthodontic brackets when bonding occurred 1 week after bleaching and CO2 laser etching has low shear bond strength values making it not suitable for clinical use.

Key words: Bleaching, Etching, CO2 laser, Shear bond strength.

المستخلص

خلفية البحث: تلون الأسنان هي واحدة من المشاكل الجمالية كبيرة في طب الأسنان، على الرغم من ان التبييض الحيوي غالبا ما يعتبر خطوة أولى لتحسين مظهر الأسنان، هناك دراسات مثيرة للجدل حول تأثيرتبييض الاسنان على قوة قص السندات لاقواس تقويم الاسنان. عملية تخديش سطح المينا في الاسنان سطح المينا يمكن ان تتم بواسطة استخدام مادة حامضية أوباستخدام الليزر، في الاونة الاخيرة هناك جدل حول فعالية ليزر ثنائي أوكسيد الكاربون للاستخدام في تخديش سطح المينا.

اهداف البحث: الهدف من اجراء البحث الحالي هو لبيان ان كان لتبييض الاسنان تأثير في تقليل قوة قص السندات لاقواس تقويم الاسنان, ولبيان تأثير ليزر ثنائي اوكسيد الكاربون في تخديش سطح المينا للاسنان التي تخضع لاجراء التبييض

المواد والطرق: تتألف عينة البحث الرئيسية من (40) سن ضاحك تم تقسيمها الى مجموعتين رئيسيتين: الضواحك غير خاضعة لعملية تبييض وتحمل الرمز (أ) وضواحك خاضعة لعملية التبييض وتحمل الرمز (ب) بواقع (20) ضاحك لكل مجموعة. ثم تم تقسيم كل مجموعة رئيسية الى مجموعتين فرعيتين (بواقع 10 ضواحك لكل مجموعة فرعية). الضواحك في المجموعة (ب) خضعت لعملية تبييض بواسطة مادة بيروكسيد الهيدروجين (تركيز 40%) والمحفزة كيميائيا بينما الضواحك في المجموعة (أ) تركت بدون اي معاملة كيميائية. بعدها تم تخديش سطح المينا للضواحك في المجموعتين الفرعيتين (أ1وب1) بواسطة ليزر ثنائي اوكسيد الكاربون في حين تم تخديش سطح المينا في الضواحك في المجموعتين الفرعيتين (أ2وب2) بواسطة حامض الفسفوريك بتركيز 37%. بعدها تم الصاق الاقواس التقويمية على الضواحك وحسب تعليمات الشركة المصنعة وتم اخضاع جميع العينات لعملية الدورة الحرارية مابين(55-5) درجة سيليزية وبواقع 500 دورة حرارية. تمت عملية فصل الاقواس التقويمية من سطح الضواحك بواسطة الة اختبار عالمية مخصصة لهذا الغرض وتم اخذ القياسات المطلوبة وتدقيقها احصائيا لاستخراج النتائج.

النتائج: اظهرت نتائج الدراسة عدم وجود فرق ملموس بين الضواحك الخاضعة للتبييض وتلك الغير معاملة كيميائيا فيما يخص قوة قص السندات لاقواس التقويمية , بينما هناك فرق ملموس من ناحية قوة قص السندات للاقواس التقويمية بين الضواحاك التي تم تخديش سطح المينا فيه بواسطة الليزر وتلك التي تمت علية التخديش فيها بواسطة حامض الفسفوريك مع وجود القيم الاعلى لقوة القص في العينات التي تم تخديشها بواسطة حامض الفسفوريك.

الاستنتاجات: ان عملية تبييض الاسنان بواسطة بيروكسيد الهيدروجين لايؤثر على قوة قص السندات لاقواس التقويم المعدنية في حال تمت عملية الصاقها بعد عملية التبييض باسبوع واحد, وليزر ثنائي اوكسيد الكاربون يقدم قوة قص سندات قليلة تجعله غير ملائم للاستخدامات التطبيقية على المرضى.

INTRODUCTION

Tooth discoloration is one of the great esthetic problems in dentistry. It has many etiologic factors that are usually classified as being intrinsic, extrinsic, or internalized in nature. Tooth bleaching is one of the treatment options to overcome this problem [1,2]. This can be done in 2 ways: either in-office or at home bleaching. In-office vital tooth bleaching has been used for many years in dentistry[3-5].

Teeth-bleaching procedures can lead further enhancement of patient's smile with orthodontic treatment, but these bleaching procedures may reduce the bonding forces of the brackets to enamel surfaces. [6,7], as the bleaching can be used before or after orthodontic treatment.

Despite vital bleaching is often considered a step to improve the appearance of teeth prior to orthodontic treatment. [8,9], reports are controversial about the shear bond strengths of brackets after bleaching. Some studies reported that the shear bond strength of orthodontic brackets with bleached enamel is significantly lower than that of unbleached enamel corresponding to the bleaching type or waiting period after the bleaching procedure[3,10,11]. However, others

did not find significant differences in mean shear bond strength between bleached and unbleached teeth[12-14]. This debate in a reduction in enamel bond strength has become a concern in orthodontics, [8,9]. However, it is generally agreed, to wait a period of one day up to three weeks to proceed with an adhesive procedure[15-17].

Sandblastind, acid etching and laser are methods used for enamel surface etching . However, some studies suggest that laser etching may produce bonding forces comparable to that produced by acid etching [18-20], while others found that lower bonding forces were produced by laser when used for enamel surface etching[21-23].

The CO2 laser had many applications in dentistry that might differ according to its wavelength bands. The three main CO2 laser wavelengths used in dental treatments are 9300, 9600, and 10600 nm. with a variety of hard and soft tissue effects. [24,25] Bond strength with different laser treatments is not consistent either. Some studies have suggested that there was significant decrease in shear bond strength with laser etching [26,27], while others concluded that laser etching can produce comparable results to those produced by conventional etching [28-30].

The aim of the presented study is to detect if there is a significant reduction in the shear bond strength of bleached teeth and to detect the effect of the CO2 laser as an etchant on both bleached and normal teeth.

METHODS AND MATERIALS

Forty non-carious first premolars extracted for orthodontic purposes were used in this study. The criteria for tooth selection included intact buccal enamel; no pretreatment with chemical agents such as derivatives of peroxide, acid, alcohol, or any other form of bleaching; no cracks from forceps; no caries; and no restorations. After extraction he teeth were kept in distilled water, that changed weekly to overcome bacterial growth. Each tooth was mounted horizontally in a self-cured acrylic so that the buccal surface of the crown was exposed, then polishing of the exposed surfaces of the teeth were done with non-fluoridated pumice using a low speed hand piece at (3,000 rpm) .

The sample was randomly divided into (2) main groups: None- bleached group assigned as (A) and Bleached group assigned as (B), of 20 specimens for each group, then the A and B groups were subdivided into 2 subgroups (A1, A2, B1, and B2), of 10 specimens for each subgroup . Group (B) teeth were bleached with chemically activated 40% hydrogen peroxide (BOOST, Opalescence®, Ultradent, INC. USA). The bleaching material was applied two times (20 minutes each time) for a maximum 40 minutes, then the teeth were washed and kept in distilled water for 7days before enamel etching. While group (A) teeth were left un bleached.

The subgroups (A1 and B1) were etched with CO2 laser (Ultra Dream Pulse Surgical CO2 laser System, DS-40U, Daeshin Enterprise Co., Ltd., Korea) emitting at (10600 nm and 5 watt power); the beam is focused by hand-piece with a focal length of 50 mm, Beam profile is a single-mode Gaussian (TEM00), with a spot size (0.2mm) and a distance of 10mm to the enamel surface. the area of 8mm2 (representing the designed bracket position on the buccal surface of the specimen) was irradiated for 20 seconds (sec.) , while the subgroups (A2 and B2) were etched with 37% phosphoric acid (Super etch, etchant gel, SDI ©, Chicago, USA) as the manufacturer guide for 30 sec. then the teeth were washed for 10 sec. then dried for 5 sec.

The same bonding procedure was done for all four subgroups with adhesive primer (Transbond XT; 3M Unitek, Monrovia, Calif, USA) applied to the etched surfaces of the teeth in all subgroups. Stainless steel, upper premolar, straight wire brackets type (Pinnacle™, Ortho Technology, Tampa, Florida33647, USA) with were used in this study, Immediately after applying the adhesive the bracket was placed gently on the middle third of the buccal tooth surface parallel to the long axis of the tooth, after bracket bonding, samples were then stored in distilled water at 37°C for 24hours.

Thermo cycling was applied for all subgroups of 500 cycles between 5°C and 55°C with the exposure to each bath was 30 seconds, and the transfer time between the two baths was 5-10 seconds (31).

Debonding was performed with a shearing force using the universal testing machine (Tinius-Olsen universal testing machine, H50KT, UK) with a cross-head speed of 0.5 mm/minute. The force required to cause bond failure was recorded electronically and measured in Newton (N), and converted into megapascal (MPa). After debonding , the surface of each tooth was examined under ×10 stereomicroscope (Leica/Meyer Instruments, Houston, TX, USA) and classified according to the adhesive remnant index (ARI) [32] as follows:

ARI 1: Between the bracket base and the adhesive.

ARI 2: Cohesive failure within the adhesive itself, with some of the adhesive, remained on the tooth surface and some remained on the bracket base.

ARI3: Adhesive failure between the adhesive and the enamel.

ARI 4: Enamel detachment.

The data were collected and statistically analyzed using SPSS (Statistical Package for Social Science),mean, standard deviation, minimum, maximum and percentage values were calculated for all groups One way analysis of variance (ANOVA) To test any statistically significant difference in the shear bond strength of different etching methods and the difference among surface treatment. Least significant difference (LSD) was used to test any statistically significant difference between each two subgroups within the same group.

RESULTS

The mean, standard deviation, minimum, maximum values of all groups are summarized in Table 1.

The one-way ANOVA test found that there was a significant difference in mean shear bond strength between the four subgroups with highest mean values in the phosphoric acid etched subgroups (A2 and B2) as shown in Table 2.

Table 1: Descriptive statistics of mean, standard deviation, minimum, maximum and percentage.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
A1	10	2.313000	1.2418792	.3927167	1.424613	3.201387	.8600	4.0570
A2	10	5.808500	4.5305273	1.4326785	2.567556	9.049444	1.1780	16.8800
B1	10	2.495330	1.3641854	.4313933	1.519451	3.471209	.4363	5.3700
B2	10	4.372500	3.1501938	.9961787	2.118987	6.626013	1.3090	11.9100
Total	40	3.747333	3.1513719	.4982756	2.739475	4.755190	.4363	16.8800

Table 2: Descriptive statistics of one way ANOVA test between and within groups.

	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	82.641	3	27.547	3.255	S
Within Groups	304.674	36	8.463		
Total	387.315	39			

S = Statistically significant at $p < 0.05$

The LSD test used to see where the significant difference exists between groups, the test showed that there is significant difference between the phosphoric acid etched normal enamel surfaces specimens (A2) group and both CO2 laser etched (A1 and B1) groups, where as there was non-significant difference in mean SBS of both phosphoric acid etching and CO2 laser etching in both bleached and normal surface enamel specimens (A2 and B2) groups, and A1 and B1 groups, as shown in Table 3.

Table 3: Descriptive statistics of LSD test to test any statistically significant difference between each two subgroups within the same group.

(I) Groups		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A1	A2	-3.4955000*	1.3010124	S	-6.134075	-.856925
	B1	-.1823300	1.3010124	N S	-2.820905	2.456245
	B2	-2.0595000	1.3010124	N S	-4.698075	.579075
A2	A1	3.4955000*	1.3010124	S	.856925	6.134075
	B1	3.3131700*	1.3010124	S	.674595	5.951745
	B2	1.4360000	1.3010124	N S	-1.202575	4.074575
B1	A1	.1823300	1.3010124	N S	-2.456245	2.820905
	A2	-3.3131700*	1.3010124	S	-5.951745	-.674595
	B2	-1.8771700	1.3010124	N S	-4.515745	.761405
B2	A1	2.0595000	1.3010124	N S	-.579075	4.698075
	A2	-1.4360000	1.3010124	N S	-4.074575	1.202575
	B1	1.8771700	1.3010124	N S	-.761405	4.515745

*. The mean difference is significant at the 0.05 level. Ns = Statistically non significant at $p > 0.05$

S = Statistically significant at $p < 0.05$

The sites of bond failure of all specimens were shown in Table 4, the adhesive- enamel interface failure ARI 3) was most predominant in group A1 (70%) and group B1 (90%). while the cohesive failure (ARI 2) was most predominant in group A2 (70%) and group B2 (80%), whereas (ARI 1 and ARI 4) were not identified during the examination.As shown in Table 4.

Table 4: Percentage of adhesive remnant index (ARI) remaining on the enamel after debonding

Groups	*ARI 1*	*ARI 2*	*ARI 3*	*ARI 4*
A1	0 (0.0)	3 (30.0)	7 (70.0)	0 (0.0)
A2	0 (0.0)	8 (80.0)	2 (20.0)	0 (0.0)
B1	0 (0.0)	1 (10.0)	9 (90.0)	0 (0.0)
B2	0 (0.0)	7 (70.0)	3 (30.0)	0 (0.0)

Values are presented as number (%)

DISCUSSION

A stable bracket–adhesive interference is biomechanically important in order to transfer the forces the activated archwire to the tooth, bonding of brackets has been a critical issue. In order to select good adhesive and bracket combination, an vitro investigation of shear bond strength is so important to evaluate the bonding efficiency of orthodontic adhesive systems [33]. With an increasing demand for adult treatment, some patients might not only with well-aligned teeth but also they want whiter looking teeth that could present challenges to orthodontist. A number of bleaching products and techniques are now available to patients via the clinicians and over the counter for use by consumers without professional supervision. These products differ in terms of agent, concentration, application frequency, product format, application mode, and light activation[34].

The one week waiting period after bleaching is applied in the present study [3,10,11,12, 35] as it was the mostly used waiting protocol in the majority of studies, but some authors used a more than one week waiting period from bleaching to the time of adhesive application[15,16,17,36].

Although, with this difference in the waiting period after bleaching agent application. the effect of the bleaching agents on the shear bond strength was a matter of controversy among authors , some studies showed that there was no significant difference between the bleached teeth and non-bleached teeth in one week waiting or less period [3,4,6,8,11,13,37,38,39] , the present study showed comparable results to the above-mentioned studies that in one week post-bleaching waiting there is no significant difference in the shear bond strength between bleached and not bleached teeth which comparable with above-mentioned studies, while some authors concluded that the bleaching agents lower the shear bond strength values in one week waiting period.[10,36,40]

It's well-known to the orthodontist that the etching technique has a direct effect on the shear bond strength of the brackets. The ability of laser irradiation to remove the smear layer and shorter etching procedure without the need for washing and dryness has been reported [18-20], but still there are some contradicting findings of the use of lasers for enamel etching.

Because of its thermal effects and its energy is absorbed by water , the use of (10600nm) CO2 laser as on the hard tissues like teeth is a matter of controversy, some authors suggested that (10600nm) CO2 laser were used only in the soft tissue surgeries[41-43], where as others used it in some in vitro studies [28,44-47]. This is the cause for selection of CO2 laser in this study due to the limited studies to test the efficacy of CO2 laser as an etchant on bleached teeth.

Regarding the shear bond strength, there is controversy considering the efficiency of using (10600nm) CO2 laser as enamel etchant , some authors suggested that CO2 lasers produce significantly high shear bond strength values but still not sufficient to meet the requirements of bracket bonding[28,45-47], whereas others [44,48,49] found that it presents lower shear bond values that were not satisfied the clinical levels. The results of the present study are comparable with the findings of the above studies[44,48,49] with mean value of (2.5MPa) but still lower than those values produced from acid etching groups

The clinical importance of ARI score is due to its ability to indicate the position of failure sites [33], in the present study ARI scores in the laser etched groups (ARI 3) these results mean that the mode of failure is closer to the enamel-adhesive interface, with decreasing time for adhesive removal from tooth surface.[44-47] Whereas in the acid etched groups (ARI 2) is predominant which means that the bond failure site is at the adhesive-bracket base interface, resulting in minimal risk for enamel fractures. [6,10-13]

The small sample size represents a limitation in the presented study this is due to that most of patients

who extract sound maxillary first premolar are orthodontic patients who their treatment plan include such kind of extraction and patients with aggressive periodontal diseases and the number of those patients are very low, this may explain this limitation in the presented study.

CONCLUSION

The results of this in vitro study suggest that hydrogen peroxide bleaching does not affect the shear bond strength of metal orthodontic brackets when bonding occurred 1 week after bleaching and CO2 laser etching has low shear bond strength values making it not suitable for clinical use.

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