A Comparison of Shear Bond Strength Values of Recycled Self-Ligating Ceramic Brackets with a New Ones (An-in Vitro Study)

Zain Alabideen Ahmed[1], Mustafa M. Al-Khatieeb[2]

[1]Post Graduate/ Ministry of Iraqi Health, Baghdad, Iraq, [2]Assistant Professor, Department of Orthodontics, College of Dentistry, University of Baghdad, Iraq

Abstract

Background: The aim of the current study was to assess the effects of different recyclrd procedures on shear bond strength and morphological characteristics of deboned mechanically retaining self-ligating ceramic brackets' bases, then compare the results with the new brackets of the same company.

Material and Methods: Forty-eight mechanical retentive self-ligating ceramic brackets from Damon® Clear™ company were used, thirty-six of these brackets were bonded to non-etched and slightly damp buccal tooth surface in order to permit an easy debonding of these brackets by dental tweezer, these debonded brackets were then allocated into three experimental groups (12 per group): recycled by sandblasting, recycled via an Er, Cr: YSGG laser irradiation, and recycled by flame. After recycled, twelve new brackets (the control) plus the previously thirty six reconditioned brackets were bonded to the forty-eight premolar teeth following standardized bonding procedure.

Results: There were highly significant differences in the mean shear bond strength values among all groups using analysis of variance F-test; in addition, the mean shear bond strength of new brackets had the highest mean value of 22.90 Mpa, followed by Er,Cr:YSGG laser group 20.29 Mpa, then sandblasted group of 11.42 Mpa, while flame group had the lowest mean shear bond strength value of 7.63 Mpa; furthermore, the results showed a significant difference in adhesive remnant index (ARI) among all groups.

Conclusion: all recyclrd procedures would result in a clinically acceptable shear bond strength value. The Er,Cr:YSGG recyclrd procedure can effectively eradicate the adhesive from the bases of ceramic brackets without jeopardizing them; thus, this technique can be preferred over other recyclrd procedures.

Keyword: *Recycled; Reconditioning; Sandblasting; Er,Cr:YSGG laser; Flame; Shear bond strength; Ceramic self-ligating brackets; Scanning electronic microscope.*

Introduction

Aesthetic ceramic brackets have been available commercially for orthodontic use since 1980. They became more popular because of increasing number of adult patients who are seeking orthodontic treatment. The original ceramic brackets had a chemical type of retention. The bases of these brackets were coated with a saline coupling agent . In an effort to prevent enamel fracture, a new generation of ceramic brackets were made. The retention of these brackets depended on mechanical undercuts, which had a significantly less bond strength than the chemical bonding ceramic brackets [1,2] The bond strength of the mechanically retentive ceramic brackets is equal to or less than that of bond strength of metal (mechanically retentive) brackets [2,3]. Clinically, bond failure occurs about 17.6% [4]. In addition, during orthodontic treatment, the clinician might reposition some brackets that were not well placed to obtain optimal treatment results [5].

There is a tendency toward simplifying the technical methods in orthodontics for reducing treatment costs, like other fields of dentistry [6]. Thus, for rebonding a bracket, using the same non distorted bracket instead of a new one seems to be the most cost-effective method, although adequate bond strength must be maintained. The main purpose of the recycling process is to remove adhesives from the bracket base without damaging it, or changing the bracket slot dimensions [4,7,8]. The shear bond strength (SBS) of recycled brackets is affected by many factors involving microscopic destruction of bracket base features, bracket base design, and the amount of adhesive that remained on the base and also the method of bracket removal [4,9,13]. Different methods have been proposed to remove the remaining adhesive from the ceramic bracket base for rebonding [11]. In-office methods such as heating methods (direct heating), mechanical methods (sandblasting or using green stone or tungsten carbide bur) [12,13,14], and recently laser have been used for bracket recycling. Demand for use of laser in orthodontic had increased during the past years [15]. Lasers such as Er:YAG, Nd:YAG, Er,Cr:YSGG and CO2 are used for removal of adhesive remnants [10,16]. Development of Er:YAG laser and recently Er,Cr:YSGG enabled the removal of composite from the bracket base or tooth surfaces completely with no destructive side effect [17].

Materials and Methods

Teeth:

A total of 84 premolar teeth, extracted for orthodontic purposes which were cleaned with running water and stored in 0.1% (weight/volume) thymol solution at room temperature. The teeth were free of caries, restorations, and enamel defects and none of them had previous endodontic treatment. All samples were examined under dental unit lamp and any cracked teeth were excluded from the study.

Brackets:

Forty-eight upper premolar passive self-ligation ceramic brackets from Damon® Clear (Ormco Company, CA, USA) were used in this study. The brackets had a mechanical interlocking pads and the slot dimension are 0.022 ×0.028 of an inch and the base area of the bracket was 10.45 mm².

Shear Bond Strength Test:

Shear bond strength test was performed by using a Tinius-Olsen Universal testing machine (H50KT, England), with a load cell of 5 KN and the crosshead speed was 1 mm/minute [26,27], an occluso- gingival force at bracket-tooth interface was applied while the specimen was fitted in the lower jaw of the testing machine. The debonding forces were documented until bond failure occurred. The force was measured in Newton (N), which then was converted to Megapascal by dividing the force on the surface area of bracket's base (10.45 mm².).

Results

Table 1 showed the mean shear bond strength (SBS), standard deviation (S.D.), minimum (Min.), and maximum (Max.) values of all groups. The highest mean shear bond strength value was in the control group (22.899 ± 9.330 MPa), followed by Er,Cr:YSGG laser group (20.288 ± 5.563 MPa), then the sandblasted group showed the third place (11.415 ± 2.818 MPa, while flame group had the lowest mean shear bond strength value (7.624 ± 1.677 MPa).

Table 1: Descriptive statistics of the shear bond strength (MPa) for different groups

Groups	Mean	S.D.	S.E.	Min.	Max.
Control	22.90	9.330	2.693	10.05	36.52
Flame	7.63	1.677	0.484	5.54	10.85
Er,Cr:YSGG	20.29	5.563	1.606	9.88	27.27
Sandblast	11.42	2.818	0.814	7.9	15.95

As can be seen from table 2, Post hoc Tukey's HSD test showed that there were high significant differences between the control group and flame, and sandblasted groups ($p<0.01$), while there was no significant difference between the control and Er,Cr:YSGG groups ($p<0.05$), on the other hand there was a high significant difference between flame and Er,Cr:YSGG groups, however, there was no significant difference between flame and sandblasted groups, also there was a significant difference between Er,Cr:YSGG and sandblasted groups.

Table 2: Post hoc Tukey's HSD test for multiple comparisons.

Groups		Mean Difference	p-value
Control	Flame	15.275	0.000 (HS)
	Er,Cr:YSGG	2.612	0.717
	Sandblasted	11.484	0.000 (HS)
Flame	Er,Cr:YSGG	12.663	0.000 (HS)
	Sandblasted	3.791	0.369
Er,Cr:YGSS	Sandblasted	-8.873	0.001 (HS)

SEM pictures displayed variances between the three recyclrd procedures. Figure 1 presented a classic SEM photos of brackets' bases before bonding. Some residual adhesive was evident on the base of the bracket processed by flaming and micro structures was maintained (Figure 2). The brackets that were reconditioned by Er,Cr,:YSGG laser appeared with a bit amount of adhesive; however, there was no microcracks and the retentive micro structures of the base were unchanged, with a clean base surface, which closely resembles that of an unused brackets (Figures 3). SEM images of the base of sandblasted bracket revealed no adhesive remaining and micro-smoothening of the bracket base (Figure 4).

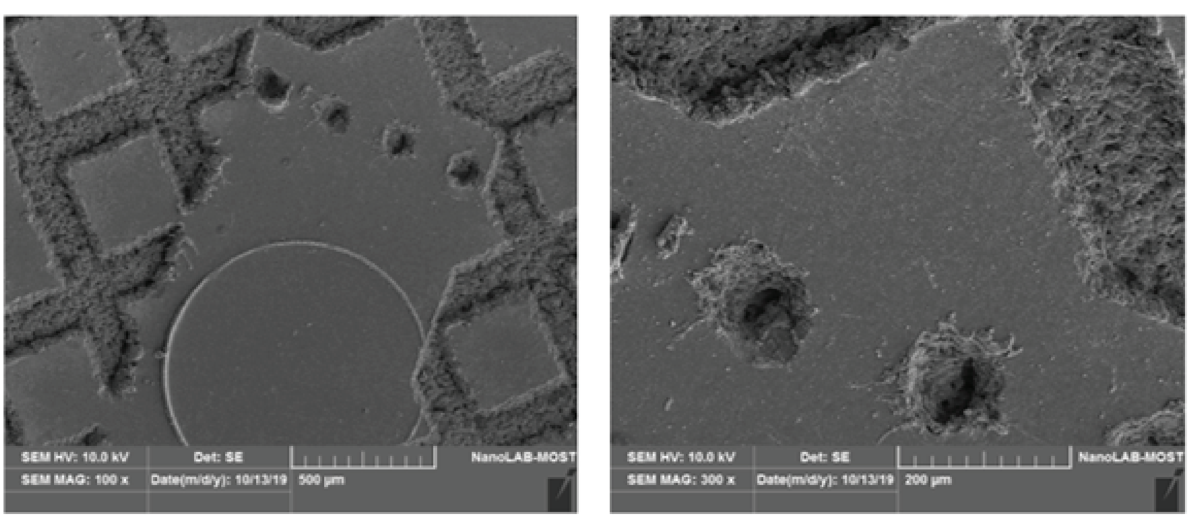

Figure 1: New bracket under x100. and x300. magnifications.

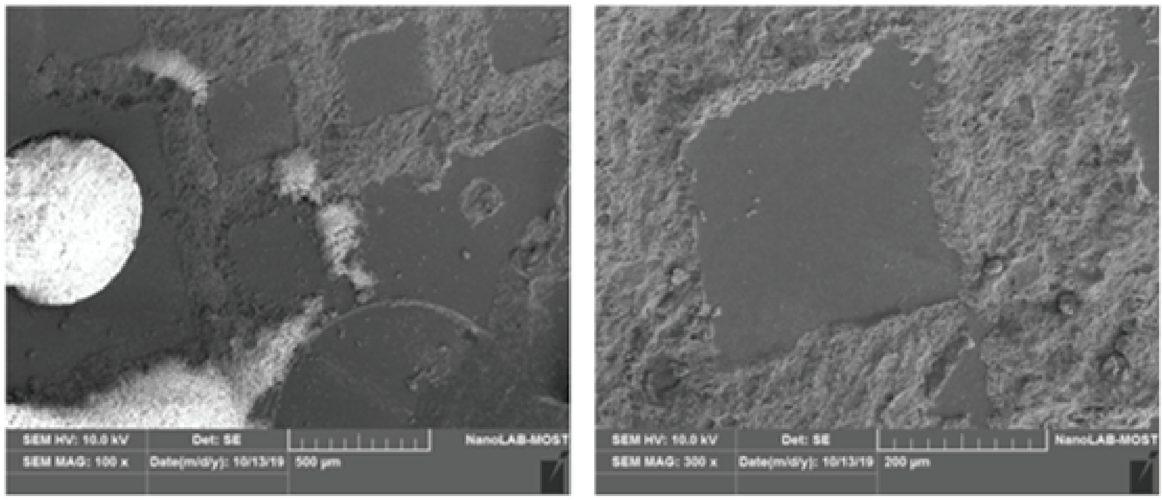

Figure 2: Flamed bracket under x100. and x300. magnifications.

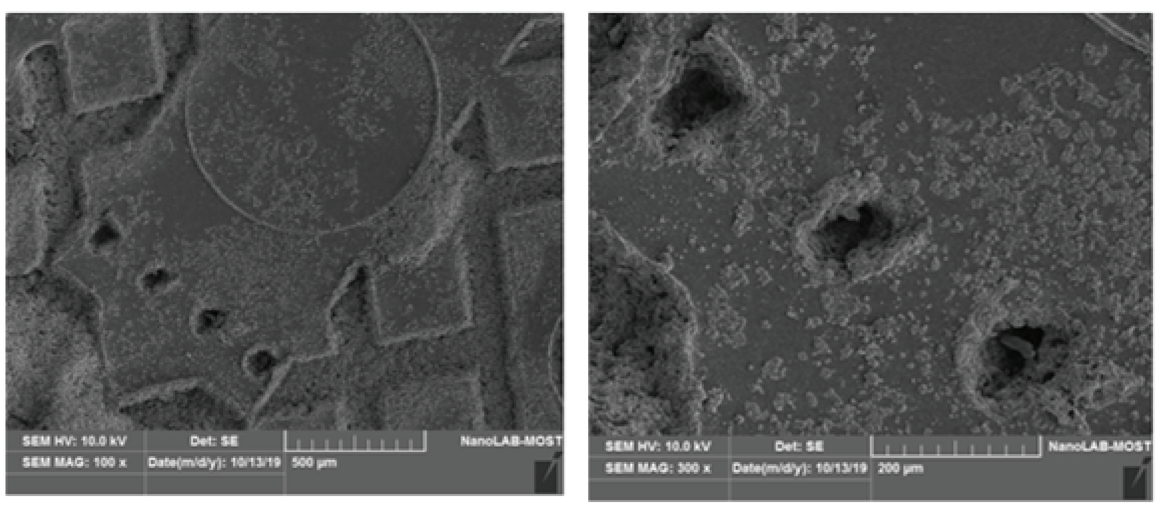

Figure 3: Er,Cr:YSGG laser bracket under x100. and x300. Magnifications.

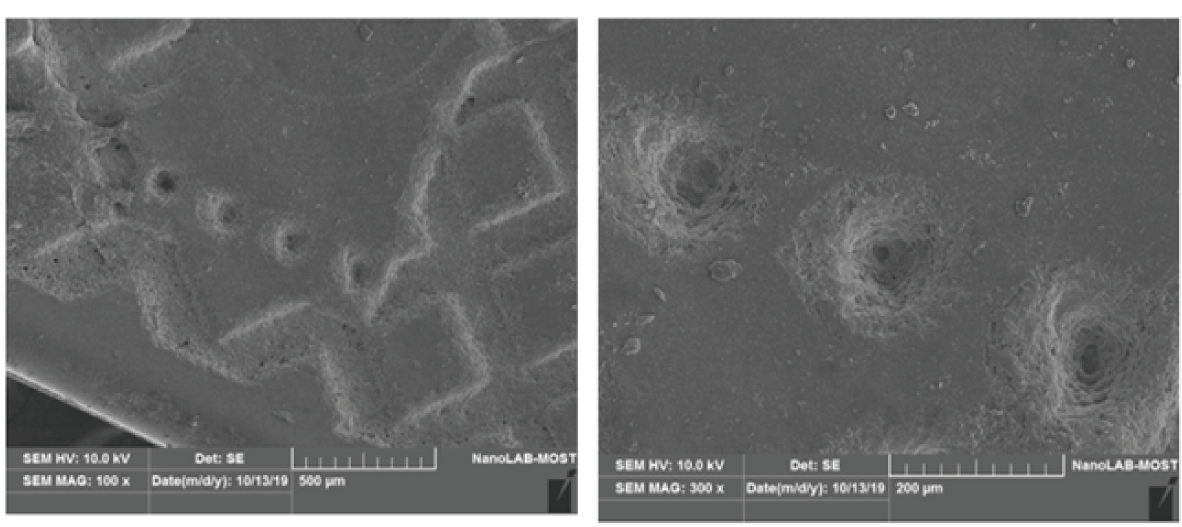

Figure 4: Sandblasted bracket under x500. and x1000. magnifications.

Discussion

Several techniques were used for recycling of orthodontic brackets to remove the remaining adhesives. These methods include air abrasion, wear by silicon carbide bur, microetching, lasers and industrial recycling procedures. Each method should provide acceptable bond strength, create less destructive side effects, be easy to use, and less time consuming. The purpose of recycling is to eliminate the remaining adhesives completely from the brace's base with no harm or change to the base features and slot dimensions. This study was intended to estimate and compare the shear bond strength of reconditioned ceramic brackets via flame, sandblasting, Er,Cr:YSGG laser and with new brackets of the same company. In this study, the mean SBS in all groups of brackets recyclrd procedures was higher than the clinically adequate SBS (5.9 to 7.8 MPa) as proposed by Reynolds [27].

Flaming is the oldest method used to remove adhesives from the ceramic bracket base. Lew et al. 1991 used this method for adhesive removal from the ceramic bracket base, they reported that bond strength of these processed ceramic brackets was significantly lower than that of other methods of bracket recycling, their results were in agreement with the results of our study. These finding was also similar to the results obtained by Han et al. [28], Mirhashemi et al. [11], and Martina et al.[23] Although ceramic brackets are the only type of brackets that can maintain their dimensions during flaming, Martina et al. [11] and AL-Lwezy et al. [8] reported that when ceramic brackets are heated, they showed high resistance and maintain their slot form and dimensions after recycling; but there were very slight change in the weight of the brackets. The decreased SBS of recycled ceramic brackets via flame may be due to the composite resin was cracked and displaced from the ceramic bracket, it partly eliminated the irregularities in the zirconium layer at the base of the bracket which were created by the manufacturers to increase bond strength by providing mechanical retention for the composite resin, in addition to that not all the adhesive were removed completely from the bases.

Sandblasting was mainly used for composite roughening, enamel etching and remove adhesives from the bracket base. In our study, the SBS of sandblasted group was a about 11.42 Mpa, which had third place of SBS value after the control and Er,Cr:YSGG laser groups. These readings agreed with those of Mirhashemi et al. [11], this was probably due to the fact that sandblasting worked on the entire surface of the base and might eradicate most of the gentle undercuts on the bonding pads of the ceramic brackets, in addition to the fact that the aluminum oxide particles may fill the small hallows that performances as a retentive mean for the brackets.

Sandblasted ceramic bracket's base appeared as that the overall construction of the retentive pattern (undercuts) was distorted and the entire surface was very smooth, while the depth of the small holes seemed to be less, which might be due to the aluminum oxide particles occupied these holes or may be these particles remove or scrape the outer layer of the bracket base.

There is an acceptance that reusing of non-damaged ceramic or metal brackets is cost-saving. One criticism of the use of reconditioned products is that it may increase the risk of cross-infection. However, Buchman in 1980 stated that any contamination due to the previous use of a recycled appliance is limited as the recycling treatment effectively cleans and decontaminates the appliances [29].

Conclusions

Based on the results of this study the following conclusions were produced:

1. All reconditioning procedures were effective for recycling of mechanically retentive ceramic brackets.

2. The SRS means of the sandblasted and flamed ceramic brackets, were though significantly lower than that of control group; but exceeded the minimum clinically adequate level.

3. The shear bond strength of brackets recycled with Er,Cr:YSGG laser and new brackets wedre very close an nearly the same.

Ethical Clearance: The Research Ethical Committee at scientific research by ethical approval of both MOH and MOHSER in Iraq

Conflict of Interest: None

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