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Research

Comparative evaluation of the shear bond strength of recycled ceramic brackets using three methods: An in vitro study

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ABSTRACT

Background: The aim of this study was to compare the effect of three recycling methods: conventional aluminum oxide sandblasting combined with silane, tribochemical silica combined with silane and heat application combined with silane, or the shear bond strength of rebonded ceramic brackets compared with newly bonded brackets.
Methods: Sixty mechanically retentive ceramic brackets (Inspire ICE) were divided into four groups (15 in each group) according to the method used for recycling: control new brackets (without silane), sandblasting with 50 μm aluminum oxide + silane, silica coating with 30 μm silicon dioxide + silane, and heat application + silane. The recycled brackets were bonded to extracted premolars and then the bonded teeth were thermocycled 5000 times between 5o̲C and 55o̲C. Shear force was directed at the bracket-tooth interface until debonding and the shear bond strength was evaluated.
Results: The highest bond strength was found in heat + silane group and the control new brackets (19.5 and 19.2 MPa, respectively), followed by the silica coating with 30 μm silicon dioxide + silane (11.8 MPa). The recycling using 50 μm aluminum oxide + silane resulted in significantly low bond strength (1.5 MPa).
Conclusion: There was no significant difference in the shear bond strength among heat + silane group, silica-coated + silane group, or the control new brackets group. Reconditioning with silica coating using 30 μm silicon dioxide with silane application is a promising method, as it is chair-side, time-effective, and shows good comparable bond strength to that of new brackets.

1. Introduction

Brackets may debond when subjected to excessive forces or because of poor bonding technique. Additionally, deliberate repositioning of brackets during the treatment is frequent. Therefore, Recycling of debonded ceramic brackets is an option available to orthodontists for cutting down treatment expenses.

A simple chair-side method for recycling debonded chemically retentive ceramic brackets was described by Kew and Djeng [1], using minitorch. The mean shear bond strength of the recycled brackets was 40%–50% lower than that of the new brackets, although it was clinically acceptable [1,2].

To improve the adhesion to porcelain restorations or dental devices, hydrofluoric acid etching was used to provide a retentive surface for better bonding; this procedure is considered the standard when bonding a bracket to a porcelain surface [3]. However, the few studies [4,5] that tested hydrofluoric acid as a ceramic bracket-base conditioner noticed a significant reduction in bond strength. The concentration of hydrofluoric acid used by Gaffey et al. [4] was low (3%) and it produced unacceptable bond strength in both hydrofluoric acid/silane group (1.6 MPa) and heat/hydrofluoric acid/silane group (0.7 MPa) when compared with new brackets (16.9 MPa). On the other hand, although Chung et al. [5] used a standard procedure of a higher concentration of hydrofluoric acid (9%), they had the same conclusion that hydrofluoric acid treatment on sandblasted rebonded brackets significantly lowered bond strength in both the sandblasted/hydrofluoric acid group (1.22 MPa) and the sandblasted/hydrofluoric acid/sealant group (0.82 MPa) when compared with new brackets (15.66 MPa). The authors concluded that they do not recommend the use of hydrofluoric acid in the process of rebonding ceramic brackets.

Another conditioning method is airborne particle abrasion, which was initially introduced as a method to roughen the surface of many dental materials before cementation to enhance bond strength [6–8]. More recently, air abrasion is being used in

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orthodontics to roughen the surface of bands, bracket bases, and enamel. The bond strength of sandblasted rebonded ceramic brackets with sealant applied on bases was not significantly different from new brackets [5].

Application of silane after sandblasting for improving the bond strength between the ceramic base and the adhesive resin was studied by many authors, yet controversy was found in the literature: silane was reported to decrease shear bond strength [9], also it was reported to increase it [10,11], and, moreover, it was stated that it had no effect on bond strength [5].

Another abrasive system, the tribochemical silica coating, provides not only a mechanical way of retention but also chemical retention. It is used in combination with a silane coupling agent [12]. The high-speed surface impact of the silica-modified aluminum particles used in air abrasion was found to change the surface of the debonded brackets, allowing micromechanical bonding between bracket and adhesive resin. Additionally, the silica-modified alumina particles appeared to deposit a layer of silica on the surface of the base of the ceramic brackets permitting reactions with the silane coupling agent. The silane agent applied to the surface reacts with surface hydroxyl groups, forming siloxane bond by condensation. Thus, the silicatization process can enhance bond strength results because it increases the number of hydroxyl groups on the silica-coated ceramic bracket base [13]. Few authors reported improved bond strength results of rebounded silicatized ceramic brackets compared with ceramic brackets that are sandblasted only with alumina particles [11,14,15].

Due to the controversy and the scarcity of data regarding ideal procedures for recycling ceramic brackets, the aim of this study was to determine an applicable method for chair-sided recycling of ceramic brackets with acceptable bond strength.

2. Methods and materials

Using a power of 0.8 to detect a clinically significant difference in the shear bond strength of rebonded ceramic bracket set at 2.9 MPa with standard deviation in heat group = 3.7 MPa, and in the silica-coated group = 3.8 MPa, the minimal required total sample size was calculated to be 56. The sample size was calculated using G.Power software [16].

This in vitro study was carried out on 60 extracted human premolars at the Faculty of Dentistry, Alexandria University, Egypt. They were collected in distilled deionized water. The inclusion criteria for tooth selection were as follows: intact buccal enamel, no previous treatment with any chemical agent, no caries, and no hypocalcification. All the test procedures were performed within 3 months after tooth extraction.

All teeth were cleansed of soft tissue and the buccal surface of each tooth was polished with a nonfluoridated pumice slurry and rubber prophylactic cup for 10 seconds. The premolars were randomly divided into four groups (15 each) according to the method of bracket recycling used: (1) control group (new brackets); (2) sandblasting with 50 μm aluminum oxide particles + silane (SBS); (3) silica coating with 30 μm silicon dioxide + silane (SCS); and (4) heat + silane (HS).

Mechanically retentive monocrystalline ceramic brackets (Inspire ICE; Ormco, Orange, CA) were used in this study. The debonded brackets were obtained by bonding new brackets with composite resin (Blugloo composite resin; Ormco) on unetched wet enamel surface. The brackets were light cured for 20 seconds. The bonded brackets were then separated from the tooth surface easily by using tweezers with light pressure. Each debonded bracket was later bonded to a virgin enamel surface.

Sandblasting with 50 μm aluminum oxide particles (DynaFlex, St. Ann, MO) was done vertically from a distance of 10 mm using an intraoral sandblaster (Microetcher II; Danville Materials, San Ramon, CA) at 5 bar pressure. Silica coating was performed using an intraoral sandblaster filled with 30 μm silicon dioxide particles (CoJet-Sand; 3M ESPE, Seefeld, Germany) using an intraoral sandblaster (Microetcher II; Danville Materials), done vertically at a distance of 10 mm at 2.5 bar according to the manufacturer's instructions.

Both procedures persisted until the bonding resin was totally removed from the bracket base and became no longer visible to the naked eye, then checked under a stereomicroscope at ×10 magnification.

Heat application was performed by placing the brackets in a furnace with a preadjusted temperature at 450°C for 1 hour for burning the remaining composite on the brackets bases, and then the brackets were put in an ultrasonic bath with alcohol for cleaning any remaining composite and also checked by the naked eye and stereomicroscope at ×10 magnification.

The buccal enamel surface of each tooth was etched with 37% phosphoric acid gel for 30 seconds, thoroughly rinsed in water and dried for 20 seconds. Ortho Solo Sealant (Ormco) was applied to the etched area, light cured for 10 seconds. Then the silane (ESPE Sil; 3M ESPE) was applied to the conditioned bracket base and allowed to dry for 5 minutes. Next, each bracket was bonded on the tooth surface using Blugloo composite resin (Ormco). The excess resin was carefully removed, and the adhesive resin was light cured for 40 seconds.

The bonded teeth were stored in distilled deionized water for 24 hours at room temperature. Then they were thermocycled for 5000 times between 5°C ± 2°C and 55°C ± 2°C with a transfer time of 5 seconds and a dwell time of 20 seconds in each bath.

After thermocycling, each tooth was mounted in self-cure acrylic resin discs. To ensure that all the specimens were inserted in an upright position to the cemento-enamel junction, a 0.021 × 0.025-inch stainless steel wire was soldered in a cross shape with the vertical wire segment attached to a Ney-type surveyor and the horizontal segment secured to the bracket on the specimen with elastomeric ligature. The assembly was used to lower the specimens to the level of the cemento-enamel junction in individual molds milled in a brass block attached to the platform of the surveyor. The molds were subsequently filled with self-cure acrylic resin to form individual discs (Fig. 1).

The shear bond test was performed using a universal testing machine (Com-Ten Industries, Pinellas Park, FL): a chisel secured to

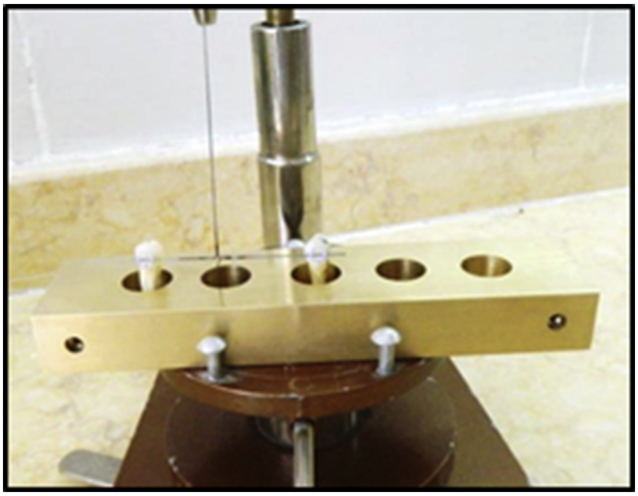

Fig. 1. Digital image showing the surveyor with the tooth ligated to the cross-shaped wire and the brass block in place.