Research Article

The Influence of Repeated Cementation of an Old and New Glass Ceramic Lithium Disilicate Veneers on Shear Bond Strength to the Tooth Structure (*In Vitro Study*)

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Abstract

Objective: Debonding of dental veneers represents the most common problems faced the patient and the dentist. The aim of this study was to compare the bond strength of repeated bonding Glass ceramic Lithium Disilicate (LD) veneers and new veneers to the tooth structure.

Methods: Twenty veneers from (IPS e.max CAD (LD), Ivoclar Vivadent) block (5mm length, 3mm width and 2mm thickness) were prepared. They bonded to twenty of prepared labial surfaces of bovine teeth by using Variolink resin cement (Ivoclar vivadent) as a sample group of twenty samples. They randomly divided into two subgroups of 10 samples named as A1 and B1 and tested under the universal testing machine to measure shear bond strength (SBS). The ten deboned veneers of A1 rebonded on the related tooth structure after conservative cleaning of both veneers and teeth structure and assigned as group A2. While for the subgroup B1, new ten veneers bonded on the same teeth structure and assigned as group B2. The (SBS) tested for groups A2 and B2 and compared with each other and with the previous sample groups. All debonded samples evaluated under a stereomicroscope to assess the mode of failure.

Results: There is no statistical difference between all groups and the mode of failure was mostly adhesive failure between the resin and tooth structure.

Conclusions: There are no statistically differences in bond strength between re-bonding of debonded veneer compared with of bonding of the new veneer.

Keywords: *IPS e.max CAD Lithium Disilicate, Veneer, Shear bond strength, Stereomicroscope.*

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Introduction

Porcelain dental veneer restorations were introduced in the early 1980s as a conservative and reliable esthetic restorative service[1,2,3]. These types of restorations can be used to modify tooth color and shape, close diastemata, and improve minor alignment problems. The material used in this type of restoration mainly is LD, which is the partially crystallized type of glass-ceramic[4]. This monolithic material improved the flexural strength (360 MPa to 400 MPa). Two levels of translucency can be obtained. The high translucency (HT) material contains fewer and larger crystals of lithium metasilicate in the pre-crystallized state, while the low translucency (LT) material contains a higher density of smaller crystals phase[5]. The success rate of porcelain veneer restorations is dependent on the preparation of the tooth enamel, good occlusal relationships, and the ability of the porcelain to be etched and adhesively bonded to tooth structure by resin cement and adhesive system[3,6]. Moreover, successful adhesion depends on the proper treatment of the internal surfaces of the restoration as well as the dentinal surface[7].

For the internal surface of indirect restoration to increase the adhesion by using acid-etching with phosphoric acid, acidulated phosphate fluoride, or hydrofluoric (HF) acid. The internal surfaces of indirect restorations can also be abraded with aluminum oxide, using an intraoral sandblasting device[8]. Also, silane-coupling agents are used as adhesion promoters[9]. The surface becomes chemically reactive to the resin by means of silane coupling agents[10]. When a porcelain veneer completely separated from the tooth structure in an adhesive failure mode and is still intact, an assessment is necessary to determine whether there is resin cement remaining on the tooth surface or the internal surface of the veneer. In cases where adhesive bond failures with porcelain veneer restorations occur, resin cement is usually retained on the internal surface of the porcelain veneer and the tooth, A conservative method for removing resin cement from the internal surface of the veneer is an essential step in the method of rebonding the restoration. Many references available to remove the luting resin composite from the internal surface of the intact veneer have recommended by using a casting burnout oven or porcelain ovens[11]. While for the tooth structure Research investigating suggests using a 50 Mm of aluminum oxide (Al2O3) air abrasion[12]. That all represent the conservative meaning of complete cleaning of the tooth structure and internal veneer surface as well before rebonding of the veneer to the tooth.

The clinical procedure of porcelain veneer like any other clinical procedures has its problems and complications. The most common complication of this procedure is debonding of the veneer from the tooth structure, and because of its costly procedure for the patient; there are two ways for resolving of this problem, either rebonding of the old veneer or construction of the new one. The decision between them is very important. As Such, the aim of this study is to evaluate the effect of rebonded of previous debonded veneer on its SBS after complete cleaning of both veneer and tooth structure by conservative meaning.

Patients and methods

Twenty standardized veneers of IPS e.max CAD LD glass-ceramic were prepared as a rectangular block with dimensions of (5mm in length, 3mm in width and 2mm in thickness) by CAD/CAM (Cerec ACIII, Sirona).

Twenty crowns of bovine teeth were sectioned to a cubic shape of dimensions (8mm in length and width with full thickness buccolingual of the tooth).

The enamel surface of the teeth was roughened by using 600-grit silicon carbide (SiC) paper[13]. The tooth specimen fixed in the acrylic block for easy handling and adjustment inside the universal testing machine. The twenty veneers block were prepared by etched their fitting surfaces using hydrofluoric acid (Maquira, Portugal) for 60 seconds and dried thoroughly by oil-free air. Monobond plus (ivoclar, vivadent) was applied for 60 seconds and dried according to manufacturer instruction, then fixed on the etched and bonded

labial surfaces of twenty teeth by using 37% phosphoric acid (super etch) and bonding (Prime&Bond universal). Method of fixation was done by applying a variolink resin cement (ivoclar, vivadent) on the fitting surface of the veneer and positioned on the middle surface of the tooth structure by application of a constant load of 2kg by using dental survey[13] and light cured according to the manufacturer instructions, then thermocycled. These twenty samples were divided randomly into two subgroups ten, each named as A1 and B1.

Sample grouping

The twenty bonded group sample were divided randomly into two subgroups of (N=10/group, A1 and B1) that prepared on the same situations and tested under the universal testing machine, as shown in figure 1. After debonding, the first ten debonded veneers rebonded on the related teeth specimens after conservative cleaning of both veneers and teeth (A2). While the other ten samples, the veneers were discarded and new ten veneers constructed with the same material, method and bonded on the ten remaining teeth specimens after conservative cleaning of the teeth (B2). The sample was tested under the universal testing machine as well:

A1 n=10 sample group

B1: n=10 sample group

A2: n= ten experimental groups: Old veneers fixed on old related teeth after cleaning of both the veneers and teeth specimens

B2: n=10 experimental group: newly constructed veneers fixed on remaining old teeth after a complete cleaning of the teeth specimens.

Shear bond strength testing

Direct Shear Strength Universal Testing Machine used to measure a SBS testing of the twenty samples at a crosshead speed of 1 mm/min, as shown in figure 1. The bond strength was calculated in Megapascals (MPa) for each specimen using this equation[14]:

Shear Strength [MPa]=maximuim force (Newton)/area [mm]²

Max f = took it from data recorded, Area =area of the veneer

Surface treatment

After debonding, the twenty teeth specimens cleaned from previous cement and bonding by using air polisher with 50 µm of aluminum oxide AL2O3 to be ready for rebonding. The first 10 (A1) debonded veneers rebonded on the related ten teeth specimens group (A2) (using same protocol of the previous cementation with the same cement) after complete cleaning of the fitting surface of the veneers by heating in the ceramic oven to burn out the remnant of the cement at 454C/850F held for 10 minutes, and sandblasted by using 50 µm of AL2O3, then checked under stereomicroscope at magnification of 40 to be sure are completely cleaned[14]. While for another ten teeth specimens, a new ten veneers were fixed on them as a group (B2) (following the same previous protocol of cementation). The rebonded samples (A2 and B2) tested under the universal testing machine to check the SBS as the previous method and compared the results. Figure 2 shows the differences in surface treatment.

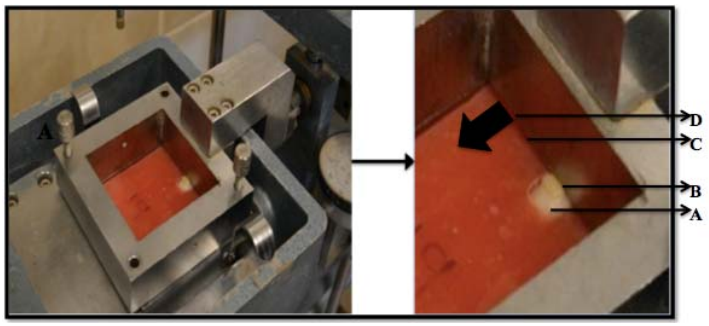

Figure 1: Direct Shear Strength by Universal Testing Machine and specimen ready for testing, A: Tooth structure, B: Veneer, C: Debonding border, D: Direction of force.

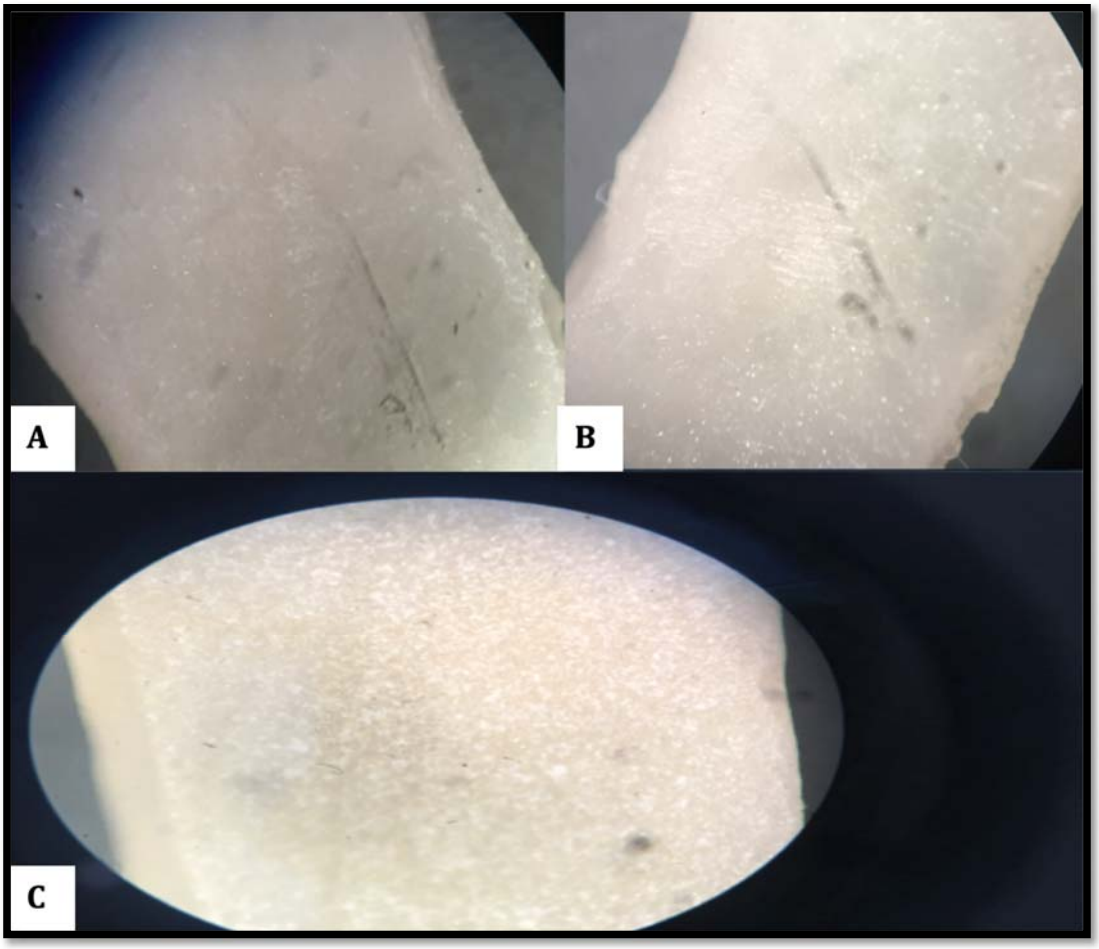

Figure 2: Differences in surface treatment under microscope, (A) Naked sample of veneer (clean surface without any scraching or roughness). (B) sample of veneer after acid etched by hydroflouric acid (There is some white points and lines refers to the effect of roughnes by acid etch). (C) sample of veneer after sand blasted (There is many white points on the surface refers to the roughnes by AL2O3 sand blast).

Analysis of failure mode

After SBS testing, each debonded sample was evaluated under a stereomicroscope and determined the type of bond failure, either adhesive or cohesive. Adhesive failure means complete separation between (tooth and resin cement), (resin cement and veneer), while cohesive failure occurs either within the tooth, resin and veneer.

Statistical analysis

Shapiro-Wilk test was used to test the normality of Quantitative variables (Shear bond tests 1 and 2) and the p value for all groups were > 0.05 (i.e. they all were normally distributed).

The quantitative continuous variables are described by mean and SD (standard deviation). The statistical significance of the difference in mean between two groups was assessed using independent sample t-test, the paired t-test was used for comparing the shear bond test of the same group on two occasions.

Chi-square and Fisher exact tests were used to compare the categorical data (modes of failure) between every two groups of data. P values of 0.05 were used as a cut off point for the significance of statistical tests.

Results

Shear bond strength testing

The results predicted that the SBS results in MPa (mean+SD) for the specimen groups were (A1) 12.00±5.59, (A2) 14.02±4.72, (B1) 11.43±5.07 and (B2) 12.38±3.68 as depicted in table 1 and figure 3. Independent t-test between groups (A1 vs. B1) and (A2 vs. B2) indicated that there were no significant differences as p values were 0.81 and 0.40. A paired t-test between groups (A1 vs. A2) and (B1 vs. B2) indicated that there was also no significant difference as p values were 0.26 and 0.64. Group A2 (rebounded of old veneer) specimens had the highest mean SBS: however, this was not significantly different at p >0.05 from other groups (A1, B1 and B2).

Table 1: Mean ± SD of all groups.

Groups N=10	Mean ± SD (MPa)
A1	12.00± 5.59
B1	11.43± 5.07
A2	14.02 ± 4.72
B2	12.39 ± 3.68

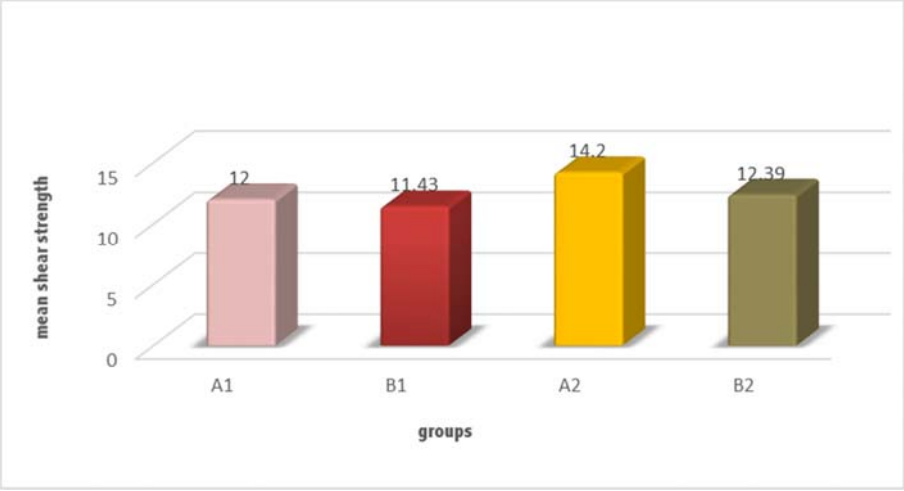

Figure 3: Mean shear strength in each group.

Table 2: Mode of failures in all groups.

Groups N=10	Mode of Failure				
	Adhesive (cement from the tooth)	Adhesive (cement from veneer)	Cohesive on (tooth)	Cohesive on (veneer)	Cohesive on (cement)
A1	90%	0	0	0	10%
B1	70%	0	0	0	30%
A2	70%	0	20	0	10%
B2	50%	0	30	0	20%

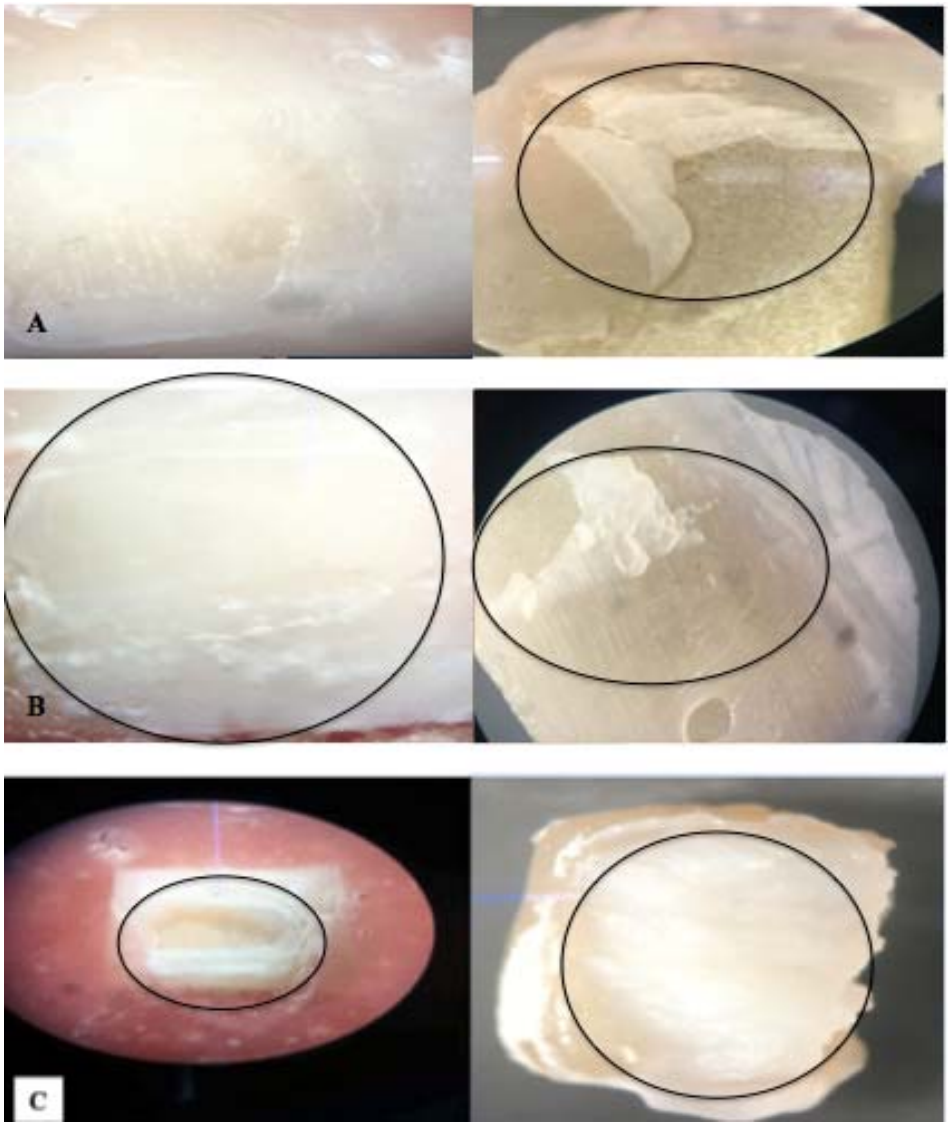

Figure 4: Mode of failure under stereomicroscope, (A) adhesive failure cement from the tooth structure. (B) Cohesive failure inside the cement. (C) Cohesive failure in the tooth structure.

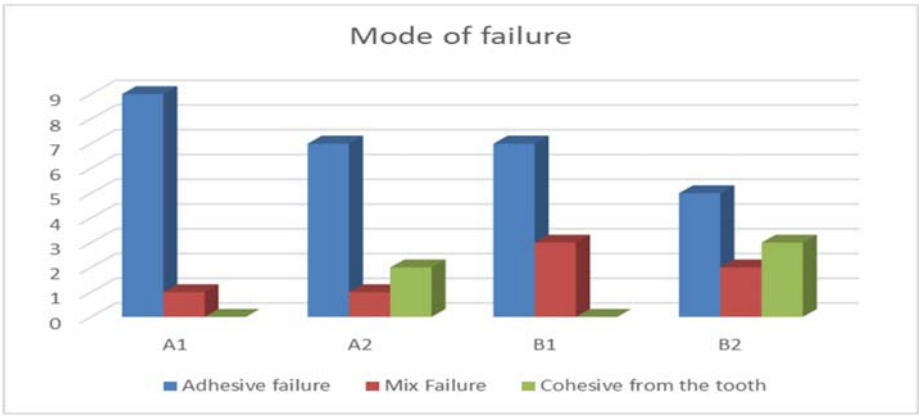

Figure 5: Mode of failure, there is no statistically significant difference between A1, A2, B1, B2 with p value=0.22 between A1 and B1. There is no statistically significant difference between A1, A2 p= 0.32. There is no statistically significant difference between B1, B2 p= 0.17. There is no statistically significant difference between A2, B2 p= 0.64.

Discussion

The idea for testing the shear strength is that the shear failure represents the most common defect relates to dental veneer. When the patient came back with falling or debonding veneer completely, it is difficult to decide whether to rebound the old veneer or constructing a new one.

The material used for the veneer construction is glass ceramic and LD are one of these materials. LD is translucent enough that it can be used for the highest etchable area. LD glass ceramics are also content alumino-silicate glasses that contain fluoroapatite crystals rather than leucite that gives this material high strength and fracture toughness, which reaches it, is a strength to 400 MPa[15]. This material is etchable material because it is glassy content, which enhances it is bond strength to the tooth structure even with the minimum thickness[16]. There are different method available for the veneer construction, Machinable method by (CAD/CAM) system was applied in this study to provide restoration with much higher fracture resistance than other systems and have shown interesting clinical results for anterior veneer with short time[17]. The thickness of the glass ceramic LD was 2 mm for easily adapted with the crosshead of the shearing testing machine while debonding. Since it was known that in previously published articles, the temperature recommendations for the resin cement burnout were determined for use with feldspathic porcelains (Tg range of 518C/950F to 945C/ 1733F), these temperatures would have closely resembled or exceeded the burn out temperature for the LD porcelain, and decided to initially expose the resin-bonded porcelain specimen to 315C/600F for 30 minutes[18]. This temperature did not affect any carbonization of the luting composite cement. So, another trial decided to run for 10 minutes at 398C/750F, and although the luting composite did exhibit a carbonized, aluminum oxide (Al2O3) air abrasion was not able to easily remove the carbonized luting composite cement, and the use of rotary instrumentation to remove residual cement was considered potentially damaging[13]. The current study has determined that the best results for complete carbonization of the resin composite cement were achieved at a temperature of 454C/850F held for 10 minutes, and with this method, the residual resin cement was very easily removed by using 50 Mm Al2O3 air blast. This temperature was below the LD porcelain Tg of 645 ± 10, so deformational damage to the veneer was not anticipated.

In situations where sufficient enamel structure remains for successful adhesive bonding, an attempt to rebond an intact debonded porcelain veneer restoration may be an appropriate option for the treatment plan. The results of this study determined that the non-invasive clinical procedures could be used to accurately remove resin composite cement from the internal surface of an adhesively debonded LD porcelain veneer restoration and to rebound the veneer restoration to the cleaned previously prepared and bonded and reconditioned of the enamel tooth surface. According to the result, the mean SBS values of the sample and experimental (rebonded) specimen groups were not significantly different. The mean SBS value range of 11.43 to 14.02 MPa. These values do not consist of other research values of LD to human enamel, which is range from 23.64 to 24.76 MPa for the same luting cement[19]. This differences in the value reach to that by using bovine teeth in this research, which has differences to human teeth. In regards to research[20] which evaluate of bovine enamel and dentin are appropriate substitutes for the respective human hard tooth tissues to test shear bond strength (SBS) and fracture analysis and according to its result was revealed a highly significant difference between shear and tensile bond strengths of human and bovine enamel; SBS of standardized orthodontic brackets on human and bovine enamel was tested with the result that bond strength on bovine enamel was approximately 40% lower than on human enamel[21]. However, regression prediction equations supported the use of bovine teeth as a reliable substitute to human counterparts in bonding studies of orthodontic adhesion[22]. Since bovine enamel and dentin develop more rapidly during tooth formation, bovine enamel has larger crystal grains and more lattice defects than human enamel[21].

According to the result, the reading of the first time was between 11.43 to 12 MPa while for the second time (debonded of rebounded groups) was 12.38 to 14.02 Mpa; the second reading was greater than the first reading however there is the non-significant

difference between the two results. The reason for this result was that first: the old veneer that used for rebonded treated by heat and sandblast for complete cleaning of old remnant cement in addition conditioned with hydrofluoric acid. So, in the second time, there were chemical and mechanical ways that increased the bond strength of dental ceramic, as shown in (figure 2). The study stated that the bond strength was higher in groups with HF + Sandblasting compared with groups with HF alone or sandblasted alone[23]. The second reason was that the bonded enamel surface might have a remnant of resin tag inside the enamel prism that not appears under the microscope that would favor rebonding, as suggested in previous research[13].

In sample groups (A1 and B1), there were no significant differences between them (p-value was 0.26) that prove the working condition in these groups was standardized in the same situation. Although there were nonsignificant differences in SBS between the first bonding and second bonding at p values were that 0.81 between A1 and A2 and 0.4 between B1 and B2 that is >0.05 that the bond strength not differs if the veneer debonded completely from the tooth surface and rebonded again. In relates to study[13] which discovered the SBS of rebounded leucite-reinforced ceramic to the tooth structure by complete cleaning of the fitting surface of dental veneer by burnout casting and sandblasting, the result was that also nonsignificant differences in SBS between the control and rebounded groups.

Regarding the mode of failure, the present research simulated a ‘‘clean" adhesive failure of a porcelain veneer between the acid-etched and bonding resin-coated tooth surface and the resin composite cement inside the veneer specimen. That appears higher in group A1 which includes 90% of adhesive debonded from cement to the tooth structure; the rebounded veneer specimens did have a lower incidence of adhesive failure at the tooth interface compared to the bonded sample group of veneer specimens. However, it is nonsignificant differences between all the groups. This may not be problematic clinically since if the rebounded porcelain veneer would subsequently fail again in an adhesive mode, it could be rebounded for the second time; however, at this point, it may be advisable to shift to other, conservative restorative options. These results are in agreement with previous research results that when there is an incidence of adhesive debonding[19]. For the group A2 and B2 which include rebounding of old veneers and a new veneer, there is an incidence of cohesive failure on the tooth structure, however the incidence of adhesive failure was higher on group A2 70% and cohesive failure on the tooth was 20% while for the group B2 incidence of adhesive failure was 50% and cohesive failure on the tooth was 30%. Description for these results is that sandblasting of old veneers and reconditioning of the tooth structure may increase the bond strength a may cause a fracture of the tooth structure. However the incidence of the adhesive failure was higher also in the rebonding groups. A laboratory study published in 1980 discovered that when a composite restoration breaks cleanly at the enamel–composite interface, the best procedure for rebounding to that surface is by simply etching the debonded tooth enamel surface with 37% phosphoric acid to avoid rotary instrumentation removal of rebondable resin tags remaining on the enamel surface. Furthermore, other research investigating Al2O3 air abrasion as an enamel surface treatment prior to acid etching for rebounding metallic orthodontic brackets did not result in significantly higher SBS compared to acid etching alone[24]. Although these studies used different resin composite materials than our current study, acid-etching procedures, the bonding resins that used, and the enamel substrate can be considered similar.

The limitations of this study are that there was a large standard deviation that reached half of the mean; this may relate to the small sample size. It would also prefer to check the fatigue test of the ceramic material as it has large effects on the success rate of the restoration. Moreover, due to a shortage in instruments facility, the machine of the shear test was large in comparison with the present sample, and it was better to check the shearing force by using a smaller machine like instrone machine. As a recommendation for the upcoming

research to find new fixing materials to increase the bond strength of dental ceramic restoration to decrease the patient's anxiety and cost ,while completely debonding of veneers from the tooth has been occurring, and for the next research it may be interested in finding a new surface treatment for the veneer to increase its bond strength.

Conclusions

Within the limitations of this in-vitro comparative study, there are no differences in shear bond strength of LD veneer bonded to the tooth structure and bond strength of the same veneer after detached from the tooth structure or bonded new veneer. While the debonding failure mode, the adhesive failure (cement from the tooth) present about a large percentage in whole groups.

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