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The Effect of Acid-Resistant Adhesive System with Preceding Sandblasting or Silane Addition on the Shear Bond Strength of Indirect Hybrid Blocks

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Aim: The present study investigates the effect of acid-resistant adhesive system with preceding sandblasting or silane addition on the shear bond strength (SBS) of indirect hybrid blocks.
Materials and methods: Forty-five extracted sound human molars were embedded in a rectangular transparent acrylic resin block. Ninety indirect hybrid ceramic discs were obtained by milling the blocks, sectioned into (4mm x 4mm x 1mm) discs, and polished. The discs were randomly divided into six groups -15 specimens each- based on the adhesive agent and surface treatment. BeautiBond Xtreme was applied to groups 1, 3 and 5, and Futurabond was applied to groups 2, 4 and 6. Groups 1, 2, 3 and 4 were treated with 9% hydrofluoric acid. Groups 1 and 2 did not receive a separate silane coupling agent, whereas groups 3 and 4 had a layer of silane coupling agent applied before the bonding agent. Sandblasting was carried out for groups 5 and 6. The SBS test and failure mode analysis was performed for the 6 groups to identify the adhesion quality between the luting cement and the hybrid discs. One-way ANOVA test was used to compare mean values followed by the post-hoc Tukey test to compare between the different groups.
Results: Group 6 stands out with the highest mean of 15.3784 MPa, followed by Group 5 at 12.3524 MPa. In contrast, Group 4 shows the lowest mean at 8.23962 MPa.
Conclusion: This initial comparison suggests that surface treatments using Sandblasting significantly impact shear bond strength.

Keywords: silane, shear bond strength, composite resin, indirect restoration, sandblasting

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Introduction

Integrating CAD-CAM (computer-aided design and computer-aided manufacturing) technology in dentistry has facilitated the production of durable dental restorations that closely resemble natural teeth. This integration not only reduces the manufacturing period but also eliminates technician-related inaccuracies. Furthermore, the continual technological advances in CAD-CAM, coupled with the escalating esthetic demands of patients, have spurred the development of new non-metallic esthetic restorations characterized by diverse esthetic and mechanical features. [1,2,3]

These esthetic dental restorations can be categorized as resin composite and dental ceramics. Dental ceramics exhibit excellent durability, mechanical properties, biocompatibility, discoloration resistance, and superior esthetics compared to composite resins. However, dental ceramics are susceptible to chipping and prone to fracture. In contrast, composite resins minimize abrasion to opposing teeth, require less fabrication time, result in minimal tool damage throughout fabrication, involve a relatively more straightforward finishing and polishing process, and are easier to repair. [4,5,6]

Establishing a robust adhesive bond between dental restorative materials and tooth structure is paramount in ensuring the longevity and clinical efficacy of the restoration. Nevertheless, attaining optimal adhesion between abutment teeth and restorative materials represents a formidable challenge within modern prosthodontics. Extensive literature has firmly established a direct association between suboptimal adhesive connections and a spectrum of mechanical and biological complications. [7,8]

Numerous surface conditioning (SC) techniques have been proposed to alter the surface of dental restorations, aiming to enhance its porosity and consequently improve the chemical and micromechanical adhesion between the tooth substrates and the restorative materials. The impact of diverse SC methods, including hydrofluoric acid etching, aluminum oxide (Al_2O_3) particle sandblasting, tribochemical silica coating, laser irradiation, and silanization, on the adhesive connection between tooth substrates and restorative materials has been examined in the existing literature. [9,10]

The combined utilization of a suitable surface coarsening technique and an appropriate primer/bonding agent has been recognized to significantly enhance the adhesive strength between the resin cement and the restoration surface. Nevertheless, there remains a lack of consensus regarding incorporating silane with universal adhesives as a primer for indirect resin composite blocks. [11,12]

To enhance bond strength, it has been recommended to apply a silane after surface pretreatment. The silane promotes adhesion with silica-based materials by interacting with the hydroxyl groups available in its composition. Additionally, the silane can improve the resin's ability to penetrate microporosities by wetting the treated surface. [13,14] The composition of universal adhesives incorporates a silane coupling agent that may enhance adhesion to silica-based inorganic fillers. However, the efficacy of the integrated silane remains a subject of ongoing investigation. Certain manufacturers of novel universal adhesives posit that a distinct silane primer application is unnecessary for achieving dependable bonding. Nevertheless, empirical evidence suggests that using a separate silane application may influence bond strength, irrespective of the presence of silane in the universal adhesives. Yet, consensus on the optimal silane coupling technique is lacking, thus necessitating continued research in this domain. [15,16]

The current knowledge is limited regarding the impact of using silane and universal adhesives with self-curing resin cement (SC) on the shear bond strength (SBS) of indirect resin composite blocks. Therefore, this study aims to evaluate the effect of acid-resistant adhesive system with preceding sandblasting or silane addition on the SBS of indirect hybrid blocks. The study will test the null hypothesis that different SC methods would not impact the SBS between the restoration and the tooth surfaces. [17,18]

Materials and methods

The sample size for this study was determined based on a continuous response variable derived from matched pairs in a previous study. [19] The current research investigates the impact of universal adhesive system, with or without silane, on the shear bond strength of indirect hybrid ceramic blocks. A dependent t-test was employed to compare the results. The SBS observed ranged from 32.13 ± 11.35 to 41.82 ± 13.98. The sample size was calculated using G Power statistical analysis software (version 3.1.9.6). Regarding an effect size (d) of 0.76, the analysis determined that a sample size of 15 in each group would be adequate to achieve a statistical power (1-β error) of 0.95 (95%) and a significance level (α error) of 0.05 (5%) for a two-sided hypothesis test. The total sample size was calculated at 90 specimens, with 45 specimens in each tested group. The sample size calculation was performed using G*power software. [20]

Materials used in this study are listed in Table 1. An indirect CAD/CAM high-performance polymer is composed of embedding nano-ceramic particles in a very hard polymer matrix (SHOFU Block HC, SHOFU Dental, Kyoto, Japan) and is categorized as a hybrid ceramic blocks. Two different universal adhesive agents were used; BeautiBond Xtreme's universal adhesive with an innovative silane coupling agent, "ARS" (Acid Resistant Silane coupling agent), which makes the chemical composition highly stable without an additional primer. Futurabond adhesive (Futurabond M + dual cure activator) is used with indirect restorations using self-curing or dual-curing methacrylate-based restorative or luting composite. Three different surface treatment protocols were used: 9% hydrofluoric acid, alumina particles (30–50 microns), and a separate silane coupling agent (Bis-Silane, BISCO Dental, USA). The discs were all cemented on the dentine surfaces using self-adhesive dual-cured resin cement.

Table 1: Materials used in the study

Materials	Composition	Manufacture	Lot number
CAD/CAM resin block, SHOFU BLOCK HC	UDMA, TEGDMA, silica powder, fine particulate silica, zirconium silicate, colorant	SHOFU, Inc Corp., Japan	0819920
Porcelain Primer/Bis-Silane™	3-(Trimethoxysilyl) propyl-2-Methyl-2-Propenoic Acid	BISCO, Inc., U.S.A.	2200005 443
Futurabond M+ (FM+) (Light Polymerizing)	Acidic adhesive monomer 10-MDP, Bis-GMA, UDMA, HEMA, ethanol, catalyst, BHT, pyrogenic silicic acid	VOCO GmbH, Cuxhaven, Germany	2128560
Futurabond DC (FDC) (Dual Polymerizing)	Liquid 1: acidic adhesive monomer, HEMA, Bis-GMA, Liquid 2: Ethanol, initiator, catalyst	VOCO GmbH, Cuxhaven, Germany	2128320
BeautiBond Xtreme	Bis-GMA, TEGDMA, phosphonic acid monomer, carboxylic acid monomer, acetone, H_2O, silane coupling agent	SHOFU Inc Corp., Japan	122235
BeautiCem SA	self-adhesive dual cure composite resin cement, composed of: Paste A: UDMA, fluoroboroaluminosilicate glass, silicate glass. Paste B: HEMA, UDMA, BIS-GMA, carboxylic acid monomer, phosphoric acid monomer, zirconium silicate. Inorganic filler contents: 59.6 wt%	SHOFU Inc Corp., Japan	072109

Selection of teeth

In this in vitro study, 45 sounds human molars were collected from the surgery clinic (Faculty of Dentistry, Badr

University). These teeth were extracted due to periodontal diseases. The eligible tooth had to have no caries lesion or cracks and no previous endodontic treatment. To ensure the absence of defects or caries, the sectioned teeth were examined microscopically under (×10) magnification. Teeth were cleaned, disinfected in 0.5% aqueous solution of chloramine-T for 24 hours, then washed under running water. They were kept in sterile saline at 37°C, with 100% humidity to avoid dehydration.

Teeth preparation

The eligible extracted teeth used in the current study were embedded in a rectangular transparent auto-polymerized acrylic resin block (Acrostone, Egypt). Each tooth was invested vertically in the centre of the block during the dough stage of acrylic resin. A flat dentin surface was obtained on both proximal sides using a grinding machine (EmmeviSpA- BadiaPolesine, Italy) with continuous water irrigation, grinding it down to the mid-deep dentin.

Preparation of Discs

Ninety indirect hybrid ceramic discs were obtained by milling the blocks using a CAD/CAM subtractive technology (SHOFU Block HC, SHOFU Dental). The blocks were sectioned into (4mm x 4mm x1 mm) discs (height x width x thickness) using a low-speed isomet saw (Isomet 1000, Buehler Ltd., Lake Bluff, IL, Germany) Figure (1). That was confirmed using a digital caliper, Figure (2). Each disc surface was polished with different sizes of silicon carbide papers (SIA Brand Switzerland), starting with coarse one (600 grit), followed by medium (800 grit), then fine (1000 grit), and lastly, extra fine (1200grit, 2000grit, 2500grit). Fine diamond pastes with particle sizes (3µm, 1µm, and 0.5µm) was used to obtain the final polish respectively using a polishing brush (ENA polishing brushes). The primary rationale for this polishing step was to eliminate any surface irregularities or rough areas that may have resulted from the slicing process. After which, cleaning of the samples was done using an ultrasonic bath for 10 min.

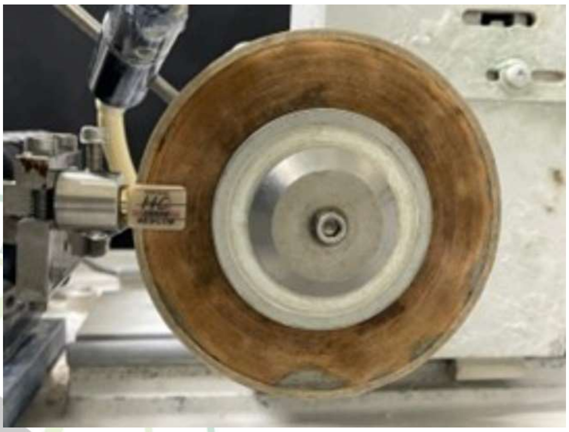

Figure 1: low-speed isomet saw for sectioning the specimens.

Figure 2: digital caliper for measurements.

Discs Grouping

The discs were then randomly divided into six groups according to the adhesive agent used and the surface treatment protocol applied, with 15 specimens each, as follows:

Group 1 (BBX): The disc bonding surface is etched with 9% hydrofluoric acid for 60 seconds, washed, and dried, then BeautiBond Xtreme (with ARS technology) adhesive is applied and cured for 20 seconds (n = 15).

Group 2 (FB): The disc bonding surface is etched with 9% hydrofluoric acid for 60 seconds, washed, and dried, then FuturaBond adhesive is applied and cured for 20 seconds (n = 15).
Group 3 (BBX+S): The disc bonding surface is etched with 9% hydrofluoric acid for 60 seconds, washed, and dried, then a coat of silane coupling agent is applied before the application of BeautiBond Xtreme (with ARS technology) adhesive is applied and cured for 20 seconds (n = 15).
Group 4 (FB+S): The disc bonding surface is etched with 9% hydrofluoric acid for 60 seconds, washed, and dried. Then, a coat of silane coupling agent is applied before the FuturaBond adhesive is applied and cured for 20 seconds (n = 15).
Group 5 (BBX+SB): The disc bonding surface is sandblasted with alumina particles (30 – 50 microns), then BeautiBond Xtreme adhesive is applied and cured for 20 seconds (n = 15).
Group 6 (FB+SB): The disc bonding surface is sandblasted with alumina particles (30 – 50 microns), then FuturaBond adhesive is applied and cured for 20 seconds (n = 15).

Restorative Procedures

Different surface treatment strategies, to improve the bond at the interface between restorative material and resin cement, have been introduced. After removing the teeth from distilled water, a gauze was used to dry the dentin surface to keep it hydrated.

Discs Surface Pretreatment

Groups 1 to 4 were etched with 9% hydrofluoric acid for 60 seconds; specimens were rinsed under running water and ultrasonically cleaned in distilled water for five minutes. For groups 1 and 2, no separate silane coupling agent was applied. In contrast, for groups 3 and 4, a coat of silane coupling agent was applied before the bonding agent, where a drop of the respective silane coupling agent was applied to each sample using a micro brush and smeared into the thin coat. The treated samples were left untouched after silane application in order to allow the reaction between silane and disk surfaces following the manufacturer's instructions. The remaining excess around samples borders were removed using new microbrushes. Then, the sample was air-dried using a triple airway syringe in a mobile dental unit. The samples were checked to ensure the surface was dried entirely (no movement of solution)[21] before proceeding to the coming step. Group 4 and 5: sandblasting was done using an intraoral air-abrasion device (Jeep Air prophy and sandblasting system) filled with 30-50 µm alumina particles from approximately 10 mm at a reduced pressure of 1 or 1.5 bars for 10 seconds.

Application of adhesive

Those specimens received either one of the two used universal adhesives (BeautiBond Xtreme or FuturaBond); regarding the FuturaBond system, a mixing palette with a disposable applicator was used to mix one drop of adhesive with one drop of its Dual Cure Activator for 3 seconds then by the aid micro-brush, this mix was applied to dentin with continuous agitation for 10 seconds. Then, the plastic air tip of dental unit was used to dry adhesive layer for 5 seconds to remove any solvents. The photoactivation procedures were performed with an LED (Light Emitting Diode) device with a light intensity of 1200mW/ cm2 (Elipar™ 10 LED Curing Light), measured by a radiometer device (Hilux Ledmax, serial M4063022 - Benlioglu Dental Inc., Ankara, Turkey) for 20 seconds, and standardized at all stages. The dentin surfaces of the extracted teeth received either of the two used adhesives, the same as the adhesive used on the hybrid disc. It was then cured following the manufacturer's instructions for 20 seconds each using a light curing unit. After removing the mold, each side of the block was light-cured for 10 seconds to ensure complete setting of the materials.

Cementation procedure

All the discs are cemented to the exposed flat dentin surfaces using self-adhesive dual cure resin cement (Beauticem SA, SHOFU Dental, Japan). With the aid of auto-mix dual syringe the self-adhesive resin cement was applied by placing in the mixing tip into the mold and then introducing the resin cement into the dentin surface. A single drop of resin cement was carefully applied to the center of each block, and any excess cement was meticulously removed to prevent contact with the enamel surface. A small condenser was used to adapt the cement, and then the blocks were cemented to the teeth under constant pressure. Photographic evidence was gathered from the bonded specimens, clearly demonstrating that the enamel rim remained free from bonding, with the blocks seated more cervically on the dentin surface. After bonding, cementation, and curing for 20 seconds, the specimens are tested for shear bond strength under a universal testing machine.

Shear bond strength test (SBS):

A universal testing machine was used until failure to perform the SBS test,to measure the bond quality between the composite discs and the luting cement. Firstly, a mounting jig was used for mounting the specimens. After that, a shearing rod was placed then theuniversal testing machine at crosshead speed of 1.0 mm/min, was used to load specimens until failure. Data were recorded using PC software (Nexygen; Lloyd Instruments). Calculation of the SBS was performed by dividing the maximum load at failure (N) by the bonding area (mm^2). The results were recorded in megapascal (MPa). Figure 3 and 4 shows the universal testing machine with the sample in place.

Figure 3: universal testing machine for shear bond strength testing.

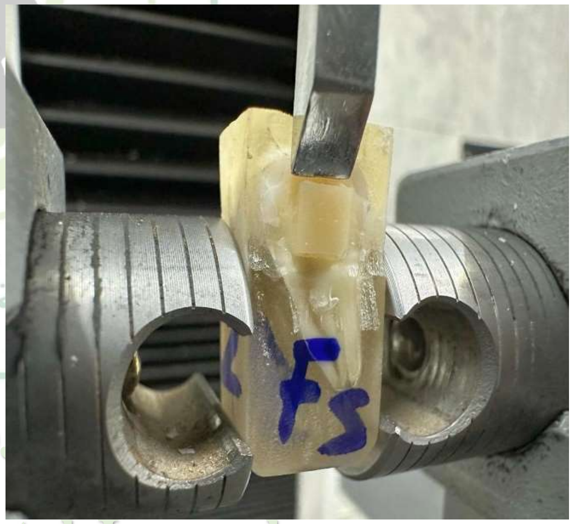

Figure 4: prepared tooth with block cemented and universal testing machine in place

Failure Mode Analysis

A stereomicroscope (20X magnification, SMZ800N, Nikon, Tokyo, Japan) was used to evaluate the composite dentin fracture specimens. Failure modes were classified as an cohesive which means failure occurs within composite,adhesive which is the failure that occurs within the dentin/composite surface and mixed which denotes partial adhesive/cohesive failure. [19]

Statistical Analysis: Continuous data was summarized into mean and standard deviation values. The significance level was set at 5%. One-way ANOVA test was used to compare mean values of different groups followed by the post-hoc Tukey test if there was a significant difference between the groups.

RESULTS

Table 2 provides detailed descriptive statistics for each group, including mean (M), standard error of the mean (SEM), standard deviation (SD), minimum (Min), median (Med), and maximum (Max) values. The groups under investigation are BBX, FB, BBX+S, FB+S, BBX+SB, and FB+SB. A striking feature of this table is the variation in mean shear bond strengths across the groups. Group 6 stands out with the highest mean of 15.3784 MPa, followed by Group 5 at 12.3524 MPa. In contrast, Group 4 shows the lowest mean at 8.23962 MPa, as shown in Figure 5. This initial comparison suggests that abrasion treatments may have a significant positive impact on shear bond strength.

The standard deviations reveal considerable variability within each group. Group 1, for instance, shows the highest variability with an SD of 4.5856, while Group 4 demonstrates the lowest with an SD of 2.25465. This variability could be attributed to inconsistencies in sample preparation, inherent material properties, or variations in the application of treatments. The range of values, as indicated by the minimum and maximum, also varies significantly among groups. Group 6 has the highest mean and maximum value at 20.9011 MPa, suggesting that this treatment can achieve exceptionally high bond strengths in some instances.

Table 2 shows the p-value from a one-way ANOVA test, reported as 0.0001. This highly significant result ($p < 0.05$) indicates strong evidence against the null hypothesis of no difference between groups, suggesting that the observed differences in shear bond strength among the groups are unlikely to be due to chance alone.

Table 2: Mean values of SBS in different groups

	M	SEM	SD	Min	Med	Max
Group 1	10.132	1.52853	4.5856	4.0934	9.06088	18.5641
Group 2	10.2457	1.31442	3.94327	5.89336	9.29656	18.9013
Group 3	8.7306	0.846135	2.39323	5.2243	8.3839	12.6322
Group 4	8.23962	0.79714	2.25465	4.72402	8.61831	11.1709
Group 5	12.3524	0.858923	3.09689	9.41101	11.1433	17.1292
Group 6	15.3784	1.05092	3.78915	7.46368	15.9018	20.9011
P-value	0.0001*					

M; Mean, SEM; Standard Error of Mean, SD; Standard Deviation, Min; Minimum, Med; Median, Max; Maximum, *; Significant Different

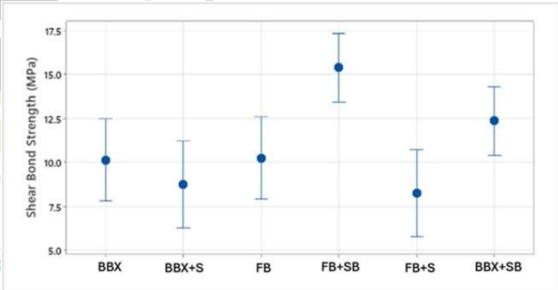

Figure 5: Shear Bond Strength (MPa) Plot of BBX, FB, BBX+S, FB+S, BBX+SB, and FB+SB.

Table 3 builds upon the findings of Table 2 by presenting the results of Tukey's post-hoc test, which is used to determine which specific groups differ significantly. This table is particularly valuable as it groups the treatments based on statistical similarity, denoted by letters A and B. Group 6, with the highest mean of 15.38 MPa, stands alone in group A, indicating that it is significantly different from all other groups except Group 5. On the other hand, Group 5, with a mean of 12.352 MPa, is interesting as it bridges groups A and B, suggesting that its performance is not significantly different from either the high-performing Group 6 or the lower-performing groups.

The remaining four groups -Groups to 4- are all categorized in Group B, indicating that they are not significantly different from each other despite their varying means (ranging from 8.240 to 10.25 MPa). This grouping provides valuable insight, suggesting that these non-abrasion treatments result in statistically similar bond strengths, significantly lower than Group 6. Table 4 shows a number of failure modes in the specimens after the shear bond strength test.

Table 3: SBS results multiple comparisons between groups using Tukey post hoc test

Factor	M	Tukey`s Post Hoc	
Group 6	15.38	A	
Group 5	12.352	A	B
Group 2	10.25		B
Group 1	10.13		B
Group 3	8.731		B
Group 4	8.240		B

The means that do not share the same letter are significantly different.

Table 4: The number of failure modes of specimens after SBS test

Group	Material Type	Failure Type		
		Adhesive	Cohesive cement	Mixed
Group 1	BBX	0	0	6
Group 2	FB	3	3	0
Group 3	BBX+S	1	0	5
Group 4	FB+S	4	0	2
Group 5	BBX+SB	0	1	5
Group 6	FB+SB	0	3	3

Discussion

Alternative indirect aesthetic hybrid restorations, like digital CAD/CAM system technologies, have become common in operative dentistry. Although indirect composites' physical and mechanical properties have improved, and polymerization shrinkage has been reduced, concerns remain about the bond strength when these composites are bonded with resin cement. [22,23,24,25]

Surface composite treatments utilizing chemical or mechanical methods are imperative for indirect composites. [26,27] Various techniques, including microabrasion, etching with hydrofluoric acid, sandblasting, laser, and the administration of silane, have been employed to augment bond strength. [25] Several studies have demonstrated the efficacy of silane in increasing the bond strength of ceramic and indirect hybrid composites with resin cement, facilitating enhanced adhesion to the composite surface.[26,28]

Silane has been shown to enhance chemical adhesion between the glass filler particles and resin matrix. Additionally, it improves the wettability of the substrate surface, which in turn facilitates better penetration of bonding agents into the indirect restoration. This results in enhanced cement penetration inside the resin and reduces the formation of voids. [29] They possess a nonhydrolyzable functional group with a double carbon bond and hydrolyzable alkoxy groups that react with hydroxyl groups on the inorganic surface of silica-based materials, forming oxygen bridges. Hence, they are considered bifunctional. [30,31]

In our present study, two different bonding agents were used, beauty bond Xtreme (Silane containing) and Futura bond M+ (Silane free). The beauty bond Xtreme has the advantage of having in its composition Acid resistance silane (ARS) coupling agent technology. It has been known that one bottle-adhesive system that contained coupling agent undergoes hydrolysis during storage by the effect of the acidic monomers and thus reduce adhesion by means of bond strength to both glass ceramics and resin composite restorations. The latest innovation in the ARS coupling agent of beauty bond Xtreme bonding agent has a protective structure against acidic monomers attack and therefore longterm storage stability could be expected, when the bonding agent is applied this protective structure is removed as the acidic monomers concentration increases by air drying and this in-turn activates ARS coupling agent yielding an optimal bond strength with ceramic restorations preventing its degradation overtime. [32]

Surface treatment by sandblasting is a roughening technique that removes parts of the soft matrix, creating superficial grooves, pits, and depressions with more irregularities. This increases the surface area, which can help distribute stress along the interface of the two bonded substrates, providing more micro-retentive features. [26]

The shear bond strength test was selected due to its reputation as a rapid and uncomplicated method that does not necessitate further specimen processing. [33,34] Moreover, this method replicates the forces typically encountered during mastication and emulates the clinical oral environment with greater fidelity than alternative tests for assessing resin-resin bonding. [35,36]

This study revealed the highest shear bond strength when indirect hybrid blocks were treated using sandblasting for both types of universal adhesives, whether silane-free or silane-containing ones, Futurabond M Plus (silane-free) and BeautiBond Xtreme (silane-containing). Our results agreed with that of Haridy et al[22], when hybrid blocks were mechanically treated using sandblasting followed by acid etching using phosphoric acid for 60 seconds, the highest mSBS with all materials used were obtained after 24 hours. These results were also in agreement with Ahmadizenouz et al[37], who found that roughening indirect restoration's surface creates macro and micro retentive features with filler particles exposed in high bond strength[22,38] and also with that of Abd El Sadek et al[39], Poskus et al[40] and Soares et al[41]. They found higher bond strength when indirect composite was treated with sandblasting and silane, and they attributed that to the aluminum oxide particles (50 um) when using sandblasting, leading to filler particle exposure and facilitating the bonding procedure. Our results also agreed with those of Fornazari et al[30], who found an increased repair bond strength of composite when using AL_2O_3 particles. A similar finding was reported by Michelotti et al[42], revealing higher bond strength values with sandblasting than other surface treatments. This was attributed to increased irregularities and micro retentive cavities when the sandblasting treated the surface.

According to these results, the failure mode is described as follows: Mixed failures were predominant in groups BBX and BBX+S. The adhesive failure was predominant in groups related to FB and FB+S, while cohesive shortcomings were observed in FB+SB and BBX+SB. These findings agreed with the shear bond strength results obtained in this study, in which sandblasted groups showed the highest bond strength values. These findings agreed with studies by Haridy et al[22], Abd El Sadek et al[39], Poskus et al[40], and Soares et al[41], who found that sandblasting gives higher bond strength values.

Our study contradicted that of Yoshihara et al[43], who found that increased surface roughness, under a scanning electron microscope, creates surface and subsurface cracks between resin matrix and the filler particles when using sandblasting, which might decrease bond strength values. Another study, Hori et al[44], which found reduced bond strength values when using sandblasting compared to other treatment procedures, also obtained the same results. This is because sandblasting lead to more prominent surface characteristics that depends upon the resin composite material itself, which may lead to breaking off the clusters and also retain of the smear debris consequently decreasing the bond strength values. [45]

Regarding silane effectiveness, our results revealed no statistically significant difference in shear bond strength with universal adhesives containing silane or not. These results agreed with that of Hashim and

Abd-Alla[35], and Fouad et al[46] they have attributed these results to that most of universal adhesives, encompasses Futurabond M + used in this study has 10-Methacryloyloxydecyl dihydrogen phosphate (10-MDP) in its composition which can bond chemically to zirconium in resin blocks and in turn increase the bond strength values. Similar findings have been reported in other studies. Also, BeautiBond Xtreme used in this study includes pre-hydrolysed silane in its composition and therefore using separate silane was not an advantages in enhancing shear bond strength values.

Our results disagreed with that of Çakir et al[47], who found that using universal adhesives without silane did not improve bond strength values. However, a universal adhesive with silane increased the shear bond strength values. They recognized that presence of silane inside the universal adhesives resulted into its hydrolysis into silanol which in turn forms polysiloxane network on the substrate surface and react chemically with resin composite monomers increasing bond strength. Another explanation is attributed to that presence of silane in bonding agents promote chemical adhesion between resin matrix and filler particles and also increases wettability of substrate surface lead to better infiltration of bonding agents into indirect restorations. [48]

In this study, we investigated using separate silane agents before applying universal adhesives. We found whether the adhesive agents were silane-containing or not provided an advantage in enhancing shear bond strength values. Our results align with those of Hashim and Abd-Alla[35], who discovered that performing additional salinizing steps before applying Scotchbond universal silane adhesive did not enhance sandblast strength values. In contrast, other researchers dictates that to improve bond strength, using of additional silanization step before using a silane-containing universal adhesive was advocated. These contradictory results may be due to methodological differences, as other tests, such as the tensile test, were used to measure bond strength.

This study is subject to a limitation in that it exclusively evaluated a single type of indirect hybrid ceramic restoration substrate and only two universal adhesives containing silane. Consequently, the outcomes may not universally apply to materials with distinct compositions. Furthermore, being in vitro, the study did not account for various factors such as oral fluids, occlusal forces, and thermal variations. Therefore, it is imperative to conduct additional in vivo and in vitro research to thoroughly examine the shear bond strength of bonded hybrid materials. [34]

Conclusion

It is important to treat the fitting surface of indirect composite restorations to enhance their bond strength. The golden standard for indirect hybrid ceramic surface treatments remains the use of aluminum oxide particles with a size of 50 micrometers for sandblasting. Interestingly, the use of silane-containing adhesives did not improve the shear bond strength values.

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Declarations:

Ethical approval and consent to participate: This research has been studied thoroughly and approved by Badr University in Cairo BUC Institutional Ethical Committee with approval number BUC-IACUC-231015-39.

Competing Interest: The authors state that none of their known conflicts of interest could have affected the work that was published in this paper.

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