Original Article

Investigation The Function Of Surface Conditioning Parameters And Different Adhesive Resin Types For The Chairside Repair Protocols Of Translucent Zirconia (5y) Dental Restorations

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Abstract

(1) Purpose: to determine the shear bond strength (SBS) of a repair composite to a monolithic zirconia veneer (5Y) after applying various resin bonding materials and pretreatments to the zirconia surface. (2) Methods: A total of 54 zirconia discs (1.7 × 7 mm × 7 mm) were manufactured and classified into three primary groups based on their surface treatments: control (A), sandblasting with 50 µm Al_2O_3 particles at a distance of 10 mm under 4 atm (B), and stone bur roughening (C). Each of the three main groups was subdivided into three subgroups based on the adhesive material applied following surface treatment. All samples were evaluated for SBS following cementation, following resin-composite repair and before shear bond strength testing (SBS). All hydrothermal aging of the specimens was carried out in an autoclave set to 134 c. The resin-substrate contact was loaded at a shear rate of one millimeter per minute. Three-way ANOVA and Tukey's tests were used to assess the data (MPa) ($p \leq 0.05$) (3) The SBS values of the surface-treated samples were statistically different ($p \leq 0.001$) regardless of the adhesive type. There was a statistically significant difference in the SBS values of the surface-treated samples. The highest mean SBS value (15.423.86) was found in Group stone bur, followed by Group B sandblasting (9.431.92) and Group A no surface test (7.011.02). Resin bond samples recorded the highest mean values regardless of the type of surface treatment and the values had a statistically significant difference (p 0.001). The resin bond recorded the highest values (16.14 3.43), followed by adhesive cement samples (8.71 ± 3.35), and finally, the zircon primer samples (7.11 5.56). The paired differences by t_test paired samples reported a significant statistical difference between resin bond samples and the other two adhesive samples (p 0.000) (4) Conclusions: The roughness of the stone bur and the resin bond samples increased the shear bond strength of the repair composite resin to zirconia. When monolithic zirconia restorations fail, sandblasting with resin bond or adhesive resin cement may be better than zirconia primer.

Keywords: monolithic zirconia; resin bond; stone bur roughening; shear bond strength; surface treatment; zirconia

1. Introduction

Due to the friability of ceramic material, fracturing or chipping is a common clinical failure in fixed and implant-borne prostheses. This can result in both aesthetic and functional complications for the patient, and hence must be addressed immediately. When a shattered prosthesis is adaptive and cosmetically acceptable, direct repairs have been used to restore functionality, aesthetics, and comfort [1].

This translucent (monolithic) zirconia has been widely used for crowns, as well as anterior and posterior monolithic fixed prostheses such as dental veneers and ultrathin veneers, and has long been considered a desirable material [2].

In comparison to bi-layered restorations, monolithic zirconia restorations have greater mechanical properties and fracture strength because of their homogeneous structure [3,4].

Most commonly, ceramic restorations consisting of tetragonal zirconia polycrystals stabilized with yttrium, chip most frequently (Y-TZP). Another issue with these restorations is that when the core is exposed, the adhesive that holds the core to the porcelain veneer separates, a phenomenon known as delamination [5–7].

While replacing these restorations is costly and time-consuming, the repair process may entail the removal, fabrication, and insertion of a provisional restoration or subsequent repair and/or rebinding, depending on the amount of the fracture. To prevent total replacement in medically or prosthetically difficult situations, clinicians have the option of performing a repair operation via direct and chairside repair approaches [1,8].

On the other hand, Y-TZP ceramic, on the other hand, is inert, has low surface energy and wettability, and resists standard hydrofluoric acid etching. Additionally, silane coupling agents do not work with zirconia [9].

A comprehensive review (2021) divided pretreatment procedures into three categories: (1) mechanical: studies including air abrasion, lasers, ceramic coatings, or chemical etching; (2) chemical: studies involving coupling agents such as adhesive resins, silanes, or primers; and (3) mechanicochemical: studies involving both mechanical and chemical conditioning methods. The control groups were made up of zirconia substrates that had not been surface prepped [10].

For intraoral repair, numerous surface conditioning strategies have been proposed. Zirconia is etch-resistant because it doesn’t include any silica phases. So, these ceramics have to be roughened in order to retain the resin micromechanically. Airborne particle abrasion, with or without silica coating, followed by silanization or primer application has been found to be the best method for conditioning zirconia ceramic surfaces [11–13]. No defined approach exists for treating the zirconia surface prior to repairing it with composite resin, even when a variety of treatments are combined with bonding processes.

There are a variety of methods that can be used to repair damaged materials, depending on their characteristics. These include the use of a universal adhesive [14], airborne-particle abrasion with 50–110 µm Al_2O_3 [15], or the use of tribochemical silica airborne-particles (CoJet) , roughening with a diamond-rotary instrument [16], or acid-etching with phosphoric acid [17].

When polishing monolithic zirconia, diamond rotary burs with coarse- and fine-grit diamond grits are typically used at high speeds [9].

Due to the lack of success in increasing adhesion to zirconia using sandblasting alone, chemical surface conditioners with silane (silanization) and/or phosphate monomers must be used after air abrasion to provide long-term stability [18–20]. Silane is a chemical that serves two purposes: it establishes bonds with the restorative material’s silica and the organic matrix of the resin cement [21]. These metal oxides make strong connections with phosphate monomers such as 10 (MDP) (e.g., ZrO_2 and Al_2O_3) [22].

The chemical compositions of resin cements vary widely: phosphoric acid esters, 10-MDP, HEMA, glycerol phosphate dimethacrylate (GPDM), 4-META, bis-GMA, or triethylene glycol dimethacrylate (TEGDMA). The lack of manufacturer information also makes it difficult to determine the component composition or proportion. As a result, they classified their goods as self-adhesive, methylene diamine cement, and Bis-GMA cement (without 10-MDP or were not self-adhesive). The cement was very heterogeneous within the same group due to component proportions and viscosity, preventing micromechanical interpenetration [22,23]. No one can agree on how fast cement ages artificially. thus, further research is needed to find the best resin cement mix [11].

Despite the existence of numerous aging mechanisms, the effects of aging on Y-TZP ceramics are still being explored and documented in the literature [24,25]. Simulated aging of Y-TZP ceramics is frequently accomplished using a steam autoclave set to 120 °C to 140 °C [29,30]. Hydrothermal aging, as demonstrated by the t-to-m phase shift, accelerated LTD and had a detrimental effect on the flexural strength of Y-TZP ceramics, according to a recent systematic review [12,13].

The importance of employing certain zirconia stone burs has been well proven in the literature [28]. There is still a lot of confusion about how stone burs affect final roughness in relation to the application of various surface treatments. An investigation of whether or not the use of diamond and stone burs on zirconia impacts composite resin restoration was the goal of this study. Zirconia surface grinding has no effect on the final roughness or the production of bacterial biofilms, according to the null hypothesis.

Research on intraoral repair strategies for attaching composite resin to zirconia has been scarce [29]. The aim of this study was to test three hypotheses: (1) determine if the varied surface treatments had an effect on the shear bond strength between a veneering composite resin and zirconia frameworks in this laboratory research, (2) the mechanical preparation of the zirconia framework had no effect on the shear bond strength and repair composite, (3) and the three chemical adhesive applications had no variation in shear bond strength.

2. Materials and Methods

2.1. The Investigation Permission

Permission for this in vitro investigation was given by the ethics committee of the Faculty of Dental Medicine, Al-Azhar University, Assiut branch, which is constituted and operates according to ICH GCP guidelines and applicable local and institutional regulations and guidelines that govern IRB operation. The committee met on 7 April 2021, under # AUAREC20200407-18.

The study took place in the laboratory of Faculty of Dentistry, Al-Azhar University, Assiut branch.

2.2. Zirconia Specimen Preparation

Fifty-four cylindrical-shaped specimens 1.7 × 7.0 × 7.0 mm were prepared out of presintered zirconia blocks (translucent zirconia Wieland Dental + Technik GmbH & Co. KG, Pforzheim, Germany) using a sectioning saw (Isomet 1000; Buehler Ltd.) under water cooling.

Specimens were then placed in a sintering furnace (Nabertherm) and sintered according to the manufacturer’s instructions, Table 2.

A total of 54 specimens (1.7 × 0.7 × 0.7 mm) were obtained for the shear bond strength test by cutting pre-sintered Y-TZP zirconia ceramic (translucent zirconia, Ivoclar Vivadent, Schaan, Liechtenstein) and were initially embedded in plastic molds (Scandiquick, Scandia, Hagen, Germany) with auto-polymerized polymethylmethacrylate using an acrylic resin (Duralay, Reliance, Illinois). Each specimen’s bonding surface was polished for 3 min at 400 rpm with 600- and 1200-grit silicon carbide abrasive sheets under wet circumstances. The specimens were ultrasonically cleaned in distilled water for 30 s and dried with oil-free air (Thornton; Inpec Eletrônica Ltd.a). According to the manufacturer’s specifications, the specimens were sintered in a specialized oven (VITA Zyrcomat 6000 MS, Vita Zahnfabrik, Bad Säckingen, Germany) using a standard sintering program for Zenostar T (heating rate of 600 °C/h; temperature 1 of 900 °C with a holding time of 0.5 h; heating rate of 200 °C/h; and temperature 2 of 1450 °C with a holding time of 2 h). All of the specimens (n = 54) were hydrothermally aged for 8 h at 134 C and 300 kPa in an autoclave (M9 UltraClave; Midmark Corp) [17].

Table 1. The article design**.**

Material Study Samples	Types of Surface Treatments	Types Adhesive ttt	Code	
Monolithic zirconia (n = 54)	No surface ttt Control group)A)	1. Resin bond	A1	Esthetic composite
		2. Zirconia primer	A2	
		3. Resin cement	A3	
	Sandblasting with alumina (110 µm) (B)	1. Resin bond	B1	
		2. Zirconia primer	B2	
		3. Resin cement	B3	
	Diamond bur roughening (C)	1. Resin bond	C1	
		2. Zirconia primer	C2	
		3. Resin cement	C3	

Table 2. The brands, chemical compositions, manufacturers, and batch numbers of the main materials used in this study**.**

Brand	Chemical Composition	Manufacturer	Batch Number
Monolithic zirconia (Zenostar T)	ZrO_2 + HfO_2 + Y_2O_3 (_99%) Y_2O_3 (>4.5-_6.0%), HfO_2 (_5%) Al_2O_3 + other oxides (_1%)	Wieland Dental + Technik GmbH & Co. KG, Pforzheim, Germany	48595436
TheraCem Dual cure self-adhesive resin cement	Base Portland Cement 20–50%, Ytterbium w/Barium Glass 30–50%, Proprietary 1–10%, Ytterbium Fluoride 1–5%, BisGMA 1–5%, Proprietary < 1% Catalyst 2-Hydroxyethyl Methacrylate HEMA 1–5%, 10-Methacryloyloxydecyl Dihydrogen Phosphate MDP 10–30%, Tert-butyl Perbenzoate 1–5%	Bisco, Inc. Schaumburg, IL60193 USA	D-46311

Resin bond All Bond Universal	BisGMA 30–50%, Ethanol 30–50%, 2-Hydroxyethyl Methacrylate HEMA 10–30% and 10-Methacryloyloxydecyl Dihydrogen Phosphate MDP 5–10%	Bisco, Inc. Schaumburg, IL60193 USA	B-7204
Zirconia primer Z-PRIME plus	BisGMA 5–10%, Ethanol 75–85%, 2-Hydroxyethyl Methacrylate HEMA 5–10%, 10-Methacryloyloxydecyl Dihydrogen Phosphate MDP 1–5% and Triethylamine < 1%	Bisco, Inc. Schaumburg, IL60193 USA	B-6003s
Alumina particles 50 mm Al_2O_3 particles	Silica coated alumina, particle size: 50 mm	3 m	
Diamond bur	fine red TF (53–63 μm)	MANI, INC. Japan	
Resin composite Polofil NHT (light-curing nano-hybrid filling)		VOCO Cuxhaven. Germany	

2.3. Scanning Electron Microscopic Examination

Scanning electron microscopy (JSM-6610LV; Jeol USA Inc.) was used to examine the surface morphology of one hydrothermally aged Y-TZP ceramic specimen according to the kind of surface treatment (no surface ttt, sandblasting, and stone bur). The specimens were further examined for fractography and surface features using a scanning electron microscope (SEM; JEOL, JSM-6360LV, 3-1-2 Musashino, Akishima, Tokyo 196-8558, JAPAN) (Figure 3). Each specimen was gold-coated using a sputter coater (Fine coat ion sputter, JFC-1100, JEOL Ltd., Tokyo, Japan), and the surfaces to be investigated were kept parallel to the SEM's base. An experienced SEM technician inspected the specimens and took photos at a magnification of 2000.

The surface morphology of surface prepared ceramic specimen according to the type of surface treatment (no surface treatment, sandblasting, and stone bur) was analyzed with scanning electron microscopy (JSM-6610LV; Jeol USA Inc.) at ×2000 magnification.

2.4. Surface Treatment of Zirconia

Hydrothermally aged specimens were divided into 3 main groups (n = 18) according to the surface treatment performed: Group A served as control and specimens did not receive any surface treatment, and Group B, where the surface of sintered specimens was air abraded (sandblasted) with 50 μm Al_2O_3 particles for 15 s in a circular motion and under 2-bar pressure. A finishing diamond stone was used to make the surface of the sintered specimens smooth. The stone was used in a single-direction sweep. The prepared surface, which was to be bonded to all specimens, was cleaned for 20 s with an air-water spray.

2.5. Application of Resin Adhesives

Specimens of each main group were divided into 3 subgroups (n = 6) according to the adhesive resin types:

2.5.1. Subgroup 1

Discs of zirconia specimens were treated by application of universal single bond (All Bond Universal Bisco, Inc.) by bond brush for 20 s then air-dried by gentle oil-free air for 5 s; adhesive was light-cured for 10 s with light curing unit (LED cordless 10 W APOZA Enterprise Co., Ltd. Taiwan) at 2000 mW/cm^2 light intensity according to manufacturer's instructions.

2.5.2. Subgroup 2

Discs of zirconia specimens were treated by application of zircon primer (Z prime plus Bisco, Inc.) by bond brush for 20 s then air-dried by gentle oil-free air for 5 s, without curing according to manufacturer's instructions.

2.5.3. Subgroup 3

Discs of zirconia specimens were treated by application of dual cure self-adhesive resin cement (TheraCem Bisco, Inc.) from auto-mix syringe, which has spread by bond brush to minimal thickness, the excess cement was then removed by dry cotton pellet, then resin cement was light cured for 10 s with light curing unit (LED cordless 10 W APOZA Enterprise Co., Ltd. Taiwan) at 2000 mW/cm^2 light intensity according to manufacturer's instructions.

2.6. Macro-Shear Bond Test

For the macro-shear bond test (MSB), specimens were put in the jig of the Universal Testing Machine (Instron, UK), and shear force was applied to the adhesive interface until failure occurred using a shearing blade. At a crosshead speed of 1 mm/min, the load was applied to the adhesive contact as close to the substrate surface as feasible, and the stress-strain curve was studied using the software program. By dividing the maximum load (N) by the resin cements' bonding surface area, the maximum load was converted to megapascal (MPa).

Figure 1shows the steps of sample preparation, translucent zirconia disc, after surface ttt and adhesive type application, and repair composite building then loaded to Instron device for shear testing.

Fig.1.steps of sample preparation, translucent zirconia disc, after surface ttt and adhesive type application, repair composite building then loaded to Instron device for shear testing

2.7. Data Analysis

Using SPSS®, all of the data was computed, and mean and standard deviations of shear bond strength were calculated for each of the nine test groups. The data was then submitted to an analysis of variance (one-way ANOVA) and a 5% post hoc Tukey's test for multiple comparisons across groups (Ver. 26.0, SPSS, Chicago, IL, USA). The $p < 0.05$ significance level was chosen.

3. Results

After exploring the data, to test the normal distribution of the data by Kolmogorov-Smirnov & Shapiro-Wilk at a significance level $p < 0.05$ and by the Q-Q plots, the data was normally distributed, then by descriptive statistics, the mean and standard deviation for all groups and subgroups was reported in Table 3; by Three-Way ANOVA the variability between the groups was tested,then the multiple comparison between groups and subgroups was analyzed by post-hoc Scheffie test, and after the confirmation the equality of data was analyzed by Levene's Test of Equality of Error Variances.

As a result of the normality test, it was observed that the data were distributed normally ($p = 0.114$). Regardless of the adhesive type used, SBS values of the surface-treated samples were statistically different ($p < 0.001$) (Table 3). Group C stone bur was determined as the group with the highest mean SBS value (15.42 ± 3.86) followed by Group B sandblasting (9.43 ± 1.92) and Group A no surface ttt (7.01 ± 1.02).

Table 3. The means, st deviations and significance between adhesive groups related to surface pretreatments groups.

	Groups	**Mean**	**Std. Deviation**	**Significance between Groups.**
resin bond	A = NO surface ttt	12.56	1.70	
	B = sandblasting	16.48	1.69	
	C = stone bur	19.38	2.48	
	Total	16.14	3.43	0.00
zirconia primer	A = NO surface ttt	1.81	0.15	
	B = sandblasting	5.47	1.26	
	C = stone bur	14.05	3.35	
	Total	7.11	5.62	0.00
Adhesive resin cement	A = NO surface ttt	6.67	1.87	
	B = sandblasting	6.63	1.11	
	C = stone bur	12.83	1.72	
	Total	8.71	3.35	0.01

Regarding the adhesive type of application after surface pretreatment, the resin bond samples recorded the highest mean values regardless of the type of surface treatment and the values had a statistically significant difference ($p < 0.001$); the resin bond recorded

(16.14 ± 3.43), followed by adhesive cement samples (8.71 ± 3.35), then, finally the zircon primer samples (7.11 ± 5.56). The paired differences by t-test paired samples reported statically significant differences between resin bond samples and the other two adhesive samples ($p < 0.000$), but there was no statically significance between the samples of zircon primer and adhesive resin cement ($p < 0.56$). Tables 4 and 5.

Table 4. Paired Samples Test.

		Paired Differences							
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**		**t**	**df**	**Sig. (2-Tailed)**
					Lower	**Upper**			
Pair 1	resin bond–zirconia primer	9.02	3.28	0.77	7.39	10.66	11.65	17	0.000
Pair 2	resin bond–adhesive resin cement	7.42	2.50	0.58	6.18	8.67	12.59	17	0.000
Pair 3	zirconia primer–adhesive resin cement	−1.60	3.30	0.77	−3.24	0.04	−2.05	17	0.056

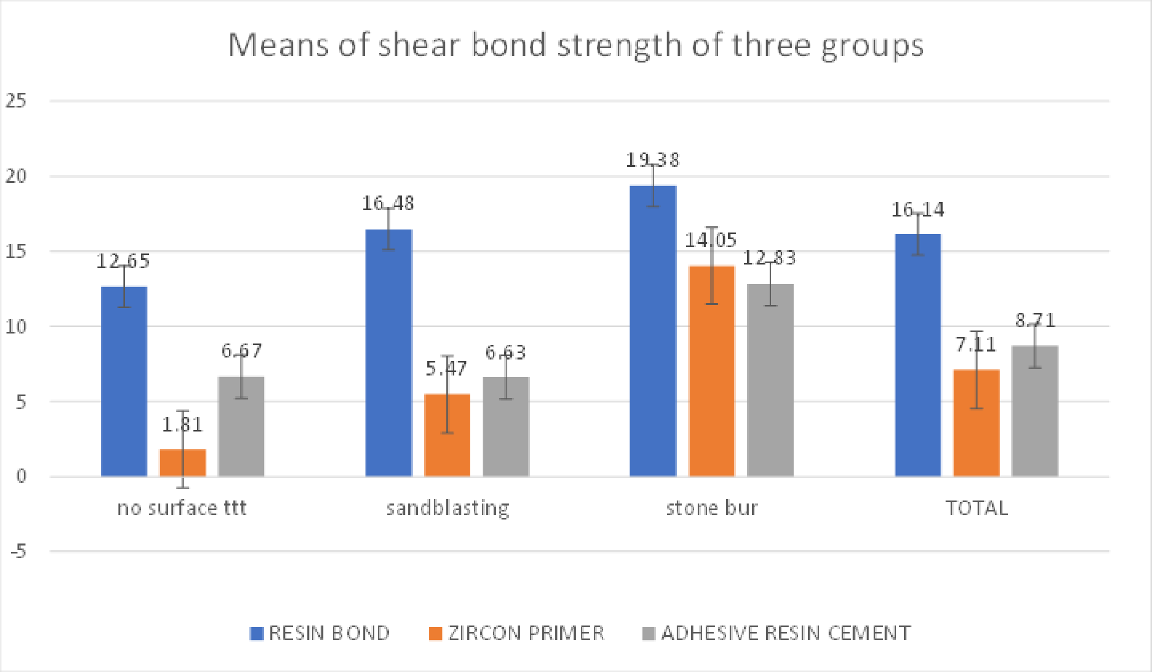

Figure 2. Bar chart showing statistically significant differences between all groups related to surface ttt and regardless of adhesive type application.

Table 5. Tests of Between-Subjects Effects.

Source	**Dependent Variable**	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Intercept	resin bond	4689.961	1	4689.961	1176.518	0.000
	zirconia primer	910.933	1	910.933	211.859	0.000
	Adhesive resin cement	1366.948	1	1366.948	529.631	0.000
groups	resin bond	140.714	2	70.357	17.650	0.000
	zirconia primer	473.626	2	236.813	55.076	0.000
	Adhesive resin cement	152.569	2	76.284	29.557	0.000

Scanning Electron Microscope

The qualitative analysis of bacterial colonization on the Y-TZP surfaces was performed by scanning electron microscopy (SEM). Three specimens (one from each of the following groups: A (no surface ttt), B (sandblasting), and C (stone bur roughening) were analyzed

Microstructures of the specimen surface post grinding were studied using SEM. The surface of the control group, Group A, was completely free of any sintering crystals.

Group B's sandblasting revealed a rough surface as a result of grinding mechanically. The sintered ceramic grinding bur had a rough surface which may be because of its uneven shape. According to the results of Group C, the use of diamond grit has improved both grinding efficiency and roughness. This sample had fewer scratches and a smoother surface than samples from Groups A and B, as seen in Figure 3.

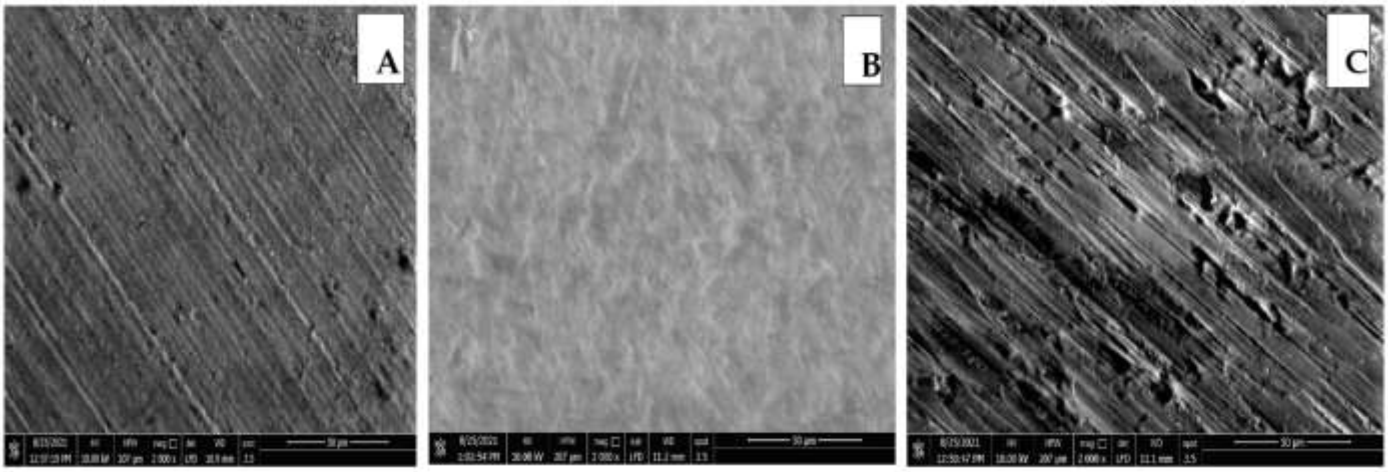

Figure 3. From left to right, the first micrograph by scanning electron microscopy of Group (**A**), no surface ttt, the second shown group (**B**) sandblasting by 50 um silica, and finally Group (**C**) created by stone bur.

Failure types were the predominantly adhesive type and fewer samples showed mixed type where cohesive fracture in the veneering ceramic was not observed that was accompanied with resin composite left adhered to zirconia discs. (Table 6)

Table 6. Failure mode after shear bond testing.

GROUP	Total No,	Adhesive	Cohesive	Mixed
A1	6	6	0	0
A2	6	6	0	0
A3	6	6	0	0
B1	6	2	0	4
B2	6	6	0	0
B3	6	6	0	0
C1	6	4	0	2
C2	6	6	0	0
C3	6	4	0	2

4. Discussion

The goal of a repair is to establish a strong and stable bond between the repaired and the broken sections. The quality of the interface produced during the repair determines how long it will last. The usage of resin composite permits the failure to be promptly, effectively, and cost-effectively repaired. With a few additional expenditures, this procedure can be done chairside in a single session [30].

The purpose of this investigation was to examine how sandblasting and a coarse stone grinding bur affected the surface of monolithic zirconia veneer. Following surface preparation, three types of adhesive resin bonds, zircon primer, and adhesive resin cement were applied. The two null hypotheses could be rejected based on the findings of this investigation, which demonstrated that surface treatment methods and types of adhesive application on zirconia surface had a substantial effect on the repair shear bond strength.

Zirconia and composite cement bond strength have been tested using various methods because there is no universal standard. Aside from its ease of use and reduced rate of specimen preparation failures, the macroshear test was the most widely used. Zirconia repair materials can be tested for their bond strength using the shear bond test, which was employed in this study [16].

All the test specimens in the current study were autoclave aged to replicate oral circumstances, as the aging of the specimens influences the bonding of the studied repair materials to the Zirconia [17,18]. Steam autoclaving at 120 °C to 140 °C and 0.2 MPa for 20 h has been used to simulate the aging of Y-TZP ceramics [13].

The investigations all concur that the zirconia surface should be prepared before applying the resin cement, as all of the pretreatments improved bond strength and improved the control group's values [15].

Regardless of the adhesive type used, SBS values of the surface-treated samples were statistically different ($p < 0.001$) (Table 3). Group C stone bur was determined as the group with the highest mean SBS value (15.42 ± 3.86) followed by Group B sandblasting (9.43 ± 1.92) and Group A no surface ttt (7.01 ± 1.02)

The control group, which was not treated to any surface roughening, had the lowest SBS values, demonstrating that surface roughening is required for more reliable resin/ceramic bonding [18].

The most effective way to prevent endangering 5Y-TZP is to choose a procedure that introduces the fewest possible surface flaws. As a result, a grinding tool that allows for fine movement control (i.e., handpieces connected to slow speed motors—contra angle attachment), a tiny tool grit size (50 m), and lar number of coolants appear to be a good strategy [20,21]. The higher values of stone bur samples compared to other groups could be attributable to an increase in roughness, morphology, and wettability of the treated surface, as seen in the SEM image (Figure 3), which is consistent with much research. Various factors such as particle size, wear time, load pressure, tool efficiency, and grinding temperature have been linked to the polymorphic transformation of tetragonal zirconia to the monoclinic phase in literature (t-m) [19–21].

Surface treatments such as grinding and polishing usually enhance roughness [25]. Compared to the control group, Groups C and B saw an increase in roughness; Group C demonstrated statistically significant changes ($p \leq 0.000$). Some studies indicated that after grinding with a fine-grit bur or sandblasting, the roughness of the surface remained the same or decreased. The milling trace may have been erased, causing this [19].

In the control group, SEM analysis revealed a normal crystal structure, whereas in the experimental groups, residues of the grinding bur were discovered. The grinding surface in Group B was smoother.

In terms of sandblasting characteristics, particle size and pressure vary between investigations, however; recent research suggests that 1.5–2 bar pressure and a particle size of 50 m produce a surface roughness that is sufficient to boost retention when compared to untreated surfaces [27,31]. Yang et al. [32] also found that SB with 50 µm Al_2O_3 is a good long-term zirconia cementation technique. As a result, in the current investigation, Al_2O_3 with a size of 50 µm was chosen.

According to this study, sandblasting with alumina particles resulted in a significant increase in shear bond strength compared to the control group. This could be because of an increase in surface energy, wettability, and roughness, as well as the formation of hydroxyl groups that aid in bonding with the primer/universal adhesive/cement [15,20–21].

The results of this study show that stone bur roughening samples had higher values than sandblasting samples regardless of the adhesive material used, which is consistent with a study that found that air abrasion with Al_2O_3 should be used with caution for pre-treating zirconia with higher yttria content (>5 mol percent) as it may have negative effects on strength. There was a widespread consensus that airborne particle abrasion using Al_2O_3 and a diamond rotary device for resin ceramics was effective, according to quantitative and qualitative assessments of the research included in older meta-analyses [33].

It is possible to resurface zirconia by sandblasting, although this method is not effective in improving adhesion to zirconia alone and must be supplemented with a chemical surface conditioner to ensure that it remains stable over time [18,34,35]. This is in accordance with previous systematic reviews' conclusions [22,36].

Adhesives have begun to contain chemical boosters named universals to ease the adhesion process and make clinicians' lives easier. The objective was to complete the preparation for restoration without adding another component. The bulk of these universal adhesives, which incorporate varied concentrations of 10-MDP, have been the subjects of the most research in the last five years. The use of a universal adhesive containing 10-MDP was found to improve adhesion to zirconia after sandblasting [14,38,37–38] and was even suggested as a replacement for mechanical conditioning and primer application [20,23–25].

Regarding the lowest values showed by zircon primer (BisGMA 5–10%, ethanol 75–85%, MDP 1–5%) (7.11 ± 5.56) compared to resin bond (BisGMA 30–50%, ethanol 30–50%, MDP 5–10%) (16.14 ± 3.43) and adhesive resin cement (BisGMA 1–5%,MDP 10–30%) (8.71 ± 3.35) regardless to the type of surface treatment, based on this perspective, the variations in the bond strength of ceramic primers may be due to solvent evaporation. The coupling potential of silanes is influenced by the evaporation of the solvent in this sense. Silane wetting may benefit from a little amount of solvent, although adhesion may be compromised if the solvent does not evaporate completely. OH-rich regions may remain hydrogen-bonded to water, alcohol, acetone, and acetic acid if the drying process is not complete. It's possible that this will reduce the number of bond sites available for silane reactions and put the production of siloxane bonds at risk. Thus, a heat treatment was recommended to remove the solvent and volatile byproducts of the silane reactivation and complete the condensation reactions with both the silane coating and the substrate. At most, the silane layer received 60 s of reaction time followed by 5 s of drying in all of the study groups. Longer reaction times may speed up the condensation reaction, but more research is needed in this area. This is in opposition to the study [16,39_41] reported that the repair by zircon primer application produced the highest strength values 13.79 + 1.32 MPa; this may have been due to the differences in ceramic types, adhesion protocol, and sample design.

In relation to the MDP rate, MDP is currently the most extensively used, and primers lacking 10-MDP have been shown to have lower binding strength values [29,42]. Other research, on the other hand, found that using primers containing 10-MDP after sandblasting did not increase adhesion and was inconsistent over time, but they were better than primers that did not contain this molecule [43]. However, it is unclear whether using a primer with silane and 10-MDP is more advantageous than using silane alone [44,45]. It's unclear what the inclusion of a primer containing 10-MDP has in relation to this. A rise in adhesion has been documented in many investigations [46,47]. In contrast, due to the saturation of this molecule, another study found the opposite in cement with 10-MDP [47]; regardless of other parameters, the resin bond with 5–10% MDP had a greater value than self-adhesive resin cement with 10–30% MDP in our current investigation [26].

Based on the finding of this study, the groups A1, B1, and C1 had the highest values of shear bond strength: the combination between the stone bur roughness and resin bond even with the control group A1,as the most rough surface in this study with resin bond after the hydrothermal aging; this may be due to the high stable amount of BisGMA 30–50% after aging compared to other adhesives used, such as no volatile ethanol as zircon primer and had a high degree of polymer conversion (DC) after curing due to a less viscous consistency than self-adhesive resin cement; this is consistent with a number of studies [4,22,25,27,31].

The type of failures, which showed that adhesive failures were more common on the zirconia surface table, further confirmed these findings [5]. Adhesive failure was shown to be the most common mode of failure in the current study's specimens after SEM inspection. This finding is consistent with a study, which found that adhesive failure of ceramic restorations (84 percent) was the most common mode of failure across all groups evaluated. The deboning of the repaired composite to the cores using vertical wedging stresses, which is characteristic in shear bond testing, could explain these results [16].

The study was unique in that it focused on the impact of employing common equipment found in any clinic, such as the stone bur and intraoral sandblaster. The findings showed that stone bur increases roughness and morphology, as well as bond strength. The highest values were obtained by combining resin bond with a stone bur, followed by self-adhesive resin cement, which was also discovered in this investigation.

The principal limitation of this in vitro study was the use of circular disc-shaped specimens rather than crowns. A steady vertical strain was applied to the specimens until they failed. Internal temperature and moisture changes affect the mechanical properties of restorations. The long-term bond strength of monolithic Zr restoration procedures will need to be studied under heat conditions equivalent to the oral cavity. In vitro testing that correctly simulates and predicts the clinical context is unlikely. Due to the aforementioned limitations, the results of this study should be regarded with caution.

5. Conclusions

Within the confines of this study's limitations and on the basis of the findings, the following conclusions may be drawn:

1. After mechanical treatment with an MDP-containing universal adhesive and an adhesive resin cement, a high bonding strength to both materials was established using a stone bur or airborne particle abrasion.
2. The composition and viscosity of resin cements are highly variable. The resin bonds containing 10-MDP adhered to zirconia the best.
3. Precautions should be taken when using zircon primer, and it should not be used alone.
4. The best adhesive results were obtained using mechanicochemical surface pretreatments.

The repair's lifespan is contingent upon the quality of the interface created and the clinician's understanding and management of adhesive procedures.

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