Evaluation of Shear Bond Strength Between Zirconia Core and E. Maxpress with Veneering Porcelain by Different Surface Treatment

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Abstract

This in vitro study was conducted to evaluate the effect of different surface treatment (sandblasting with 50µm of Al2O3, etching with 5% of hydrofluoric acid and a combination of 50 µm of Al2O3and 5% of hydrofluoric acid) on the shear bond strength of veneering ceramic to zirconia and e.max press substructures .

Eighty rectangular specimens (9mm length ×4mm width×4mm height) were fabricated and divided into two major groups(zirconia and e.max press), Forty specimens for each group. Then, each group was subdivided into four subgroups according to surface treatment (control group, sandblasting by 50µm of Al2O3,etching with 5% of hydrofluoric acid and a combination of 50 µm of Al2O3 and 5% of hydrofluoric acid),10samples for each group. then, they veneered with their corresponding veneering ceramic material (Vita VM9 ,E.max ceram) according to manufacturer's instructions.

The results of shear bond strength test revealed that the highest mean was for a combination treatment groups followed by sandblasting groups then etching with acid groups and finally untreated groups. One-way ANOVA test showed there is highly significant difference among each subgroups. While, LSD test for zirconia subgroups showed, there is no-significant difference between acid etching (ZHF) and untreated (ZC) groups. Also, LSD test for e.max press subgroups showed there was non-significant difference between acid etching (EHF) and sandblasting (ESB) groups. student's t-test between two major groups showed, higher significant difference among untreated groups and sandblasting groups. While, there was significant difference among acid etching groups and a combination treatment groups for each major group.

A combination of two surface treatments represented an effective method on the bond strength due to the cumulative effect of these treatments

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Key Word: Zirconia ,E,max press ,Surface treatments ,Shear Bond Strength.

Introduction

For more than 40 years, metal ceramic restorations (MCRs) have been widely used in the fabrication of fixed partial dentures (FPDs) and still represent the gold standard nowadays. [1]Despite the success of porcelain fused to metal restorations , the need for better aesthetics ,inertness and biocompatibility remains and is the

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driving force for the development of all-ceramic core materials.

All-ceramic restorations have become suitable alternatives to metal restorations in recent decades because of their excellent biocompatible properties and high aesthetic performance, which is attributed to the veneering porcelain bonded on the ceramic substrate.(2) Currently, two of the most popular ceramic restorative materials are lithium disilicate and zirconia, both materials can be used for either a monolithic restoration or as a core material with veneered porcelain.

In the early 1990s, The introduction of zirconia as a dental material has generated considerable interest in the dental community. zirconia is widely used to build restorations because of its good chemical properties, dimensional stability, high mechanical strength, toughness and young's modulus similar to that of stainless steel alloy.(3)

On the other hand, the evolution of lithium disilicate as a restorative material dates back to1998, when it was introduced to dentistry as IPS Empress 2 (Ivoclar Vivadent). It was the second generation of heat-pressed ceramic and contained lithium disilicate material as the main crystalline phase with a higher translucency and lower mechanical strength than zirconia.

However, common complications that have been reported for both materials include cracking, chipping, and the fracture of the veneering porcelain material.(4)Delamination and chipping of the veneer are two common failure modes of ceramic/veneer prosthesis and have a high incidence rate of 6%–25% over 2–5 years, which is significantly higher than that of metal/ veneer restorations. Delamination failures in all-ceramic restorations either originate from the veneer and propagate to the interface or originate from the ceramic/veneer inter-face. Voids and flaws inevitably exist at the interface, and crack may initiate from these voids and flaws due to stress concentration under a certain loading. In vitro studies have reported that ceramic/veneer interface has lower bond strength and fracture toughness compared with metal/veneer interface. Therefore, sometimes delamination between ceramic and veneer is partly related to the poor bond strength and toughness of the interface, and zirconia/veneer interface is an important and weak link in the all-ceramic system.(2)

Thus, various surface treatments (e.g. sandblasting, acid etching, glazing, heat treatment, and application of liner onto coping materials) have been recommended to enhance the bonding efficiency between veneering ceramic and coping material. However, none of these treatments have been determined to produce the highest bond strength. Airborne particle abrasion or sandblasting, is an important treatment procedure for achieving strong adhesion of veneering ceramics, works by increasing surface roughness and providing undercuts.

While, acid reacts with the glassy matrix that contains silica and forms hexafluorosilicates. As a result, the surface of the ceramic becomes rough, which is advantageous for micromechanical retention on the ceramic surface. In addition, combination of surface treatments such as sandblasting with alumina-oxide particles and acid etching may substantially increase the surface area for micromechanical retention. This will subsequently increase the bond strength.(5).

Material and method

Eighty rectangular specimens (9 mm length ×4 mm width×4 mm height).[3] Were prepared from two different type of coping materials(n= 40): i) Zirconia(Z), ii) e.max press (E) . for Zirconia group, A block of partially sintered Y-TZP (Vita, Zahnfabrik) was marked with pencil for drawing rectangular shapes on the block , a saw was used for cutting the block into (40) rectangular piece. Then, the specimens were sintered in the furnace (Vita vacumat 6000M) according to manufacturer's instructions at (1450°C in 80min). For e.max press group, lost wax technique have been used. Then, IPS e.max® Press (Ivoclar Vivadent AG, Liechtenstein) ingots were softened at 920°C and were automatically pressed into the mold in a furnace (EP 3010, Ivoclar Vivadent, Liechtenstein). After pressing and cooling to room temperature, the investments were divested from the specimens with polishing glass beads. The specimens from each coping material group were randomly divided into 4 subgroups according to surface treatment with 10 specimens in each subgroup (n = 10). a) no treatment or control ,b) sandblasted with 50 µm alumina (Al_2O_3) particles at 0.2 MPa for 10 seconds and at the 10 mm distance from the nozzle to the specimen, c) etched with 5% hydrofluoric acid (HF) (IPS Ceramic Etching Gel, Ivoclar Vivadent AG, Liechtenstein) for 20 seconds, and d) A combination group were sandblasted with 50 µm alumina (Al_2O_3) particles at 0.2MPa for 10 seconds and at the 10 mm distance from the nozzle to the specimen. Then, the specimens etched with5% hydrofluoric acid for 20 seconds. Finally, all specimens were cleaned in an ultrasonic bath containing alcohol and distilled water for 10 minutes and air-dried. After surface treatment of the specimens were completely finished , one specimen was selected randomly from each group for SEM stage, Firstly, the specimens attached to the aluminum holder in a plasma gold-coating device for painting their surface with pure gold. Then, inserted to the Scanning Electronic Microscope (Inspect –S50, Holland) to determine the morphology of their surface after surface treatment by scanning at different magnifications. A custom-made clear acrylic mold was fabricated with a dimensions of (14 mm length, 5 mm width, 5 mm height) for application of veneering ceramic Fig:(1) .for zirconia (VM9, Base dentin (2M2),Germany) and for e.max press (IPS e.max Ceram,Ivoclar Vivadent AG, Liechtenstein) in this study were manipulated as recommended by the manufacturer. The final thickness of veneering ceramic was (3 mm).

The veneering ceramic surface was ground flat and parallel to the coping surface by hand piece to obtain the desirable dimensions of (9mm length for substructure and 3mm thickness of veneering ceramic) as shown in Figure :(2).

A universal testing machine (instron, Laryee WDW- 50, China) was used for the shear bond strength test at across head speed 0.5 mm/min Fig:(3). A shear load was applied until failure occurred. The maximum force that caused failure was recorded by newton, and shear bond strength was calculated by dividing the load (N) by the surface area of bonded area (mm^2) according to following formula:

Shear bond strength (MPa) = force in (N)/ bonding area in (mm^2).

The surface bonding area was calculated as follows:

Surface area = length × width

$$4mm \times 4mm = 16\ mm^2$$

Failures Modes:

Failures fractures were inspected by using Dino-Lite microscope of (20x) .Failure modes were classified into three modes. [6]

1. Adhesive failure: occurred at interface between zirconia core and veneer ceramic.
2. Cohesive failure: occurred with in veneer ceramic.
3. Mixed failure: cohesive and adhesive failure.

Results

Shear bond strength results revealed that the highest mean of (SBS) was for a combination treatment groups followed by sandblasting groups then etching with acid groups and finally untreated group for both major group (Table 1) (Table2). One-way ANOVA test for zirconia group showed that there is highly significant difference among their subgroups (Table 3). LSD test for zirconia subgroups showed that there is significant difference among (ZC) group with (ZSB) group and (ZSB) group with both (ZHF and ZCOMB) groups. While, there is highly significant difference between (ZC) group with (ZCOMB) group, and (ZHF) group with (ZCOMB) group. In addition, LSD test results showed there is non-significant difference between (ZC) group and (ZHF) group (Table 4). Also, One-way ANOVA test for e.max press group showed that there is highly significant difference among their subgroups (Table 5), and LSD test for e.max press subgroups showed that there is significant difference among (EC)group with (ESB) and (EHF) groups. Also ,(ESB) group with (ECOMB) group and (EHF) group with (ECOMB) group. But, higher significant difference was found between(EC) group and (ECOMB) group. In addition, LSD test results showed there is non-significant difference between (ESB) group and (EHF) group (Table 6). Comparison between two major groups by using student's t-test showed, higher significant difference among untreated groups and sandblasting groups for each major group, and a significant difference among acid etching groups and a combination treatment groups for each major group (Table 7).

Scanning Electronic Microscope (SEM):

The scanning electron microscope (SEM) results for the control specimens of both zirconia and e.max press revealed there is smooth and no morphological changes for their surfaces Fig:(4-A),(4-E). While, the SEM analysis revealed that 50 µm of airborne particles produce a rougher surface with irregular shape voids for zirconia specimens Fig:(4-B),micro-retentive grooves and visible roughness were found for e.max press specimens Fig:(4-F) .

The SEM findings of the acid etched zirconia specimens revealed no changes for their super structures, as no micro-grooves were created due to the low amount of glass phase when compared to the SEM image of control group. Fig:(4-C).But, The finding of SEM for e.max press specimens showed there is a visible irregularity and porosities Fig:(4-G).

The SEM analysis for both zirconia and e.max press specimens sand blasted with 50 µm of Al_2O_3 and etched by 5% of hydrofluoric acid showed that etching with hydrofluoric acid was effective for cleaning the numerous micro-grooves and porosities that created by (50 µm) of aluminum oxide particles. Fig:(4-D),(4-H).

Discussions

Bonding means connecting and establishing stable adhesive contact between two materials. For all-ceramic restorations, the core-veneer interface is the weakest part and plays a significant role in the success of these kinds of restorations.[7] Thus, to achieve an adequate bonding and stable interfacial bonding at core-veneer interfaces, various surface conditioning methods are used nowadays. These methods are grinding ,sandblasting with aluminum-oxide (Al_2O_3), tribochemical silica coating, hydrofluoric acid etching (HF) and laser irradiation.[8] In this study, The shear bonding strength test (SBS) have been used which mean the maximum stress that a material can withstand before failure in a shear mode of loading. SBS test was selected because of its importance in the study of interference between two materials, its simplicity such as, the ease of specimens preparation , simple test protocol and the ability to rank different products according to bond strength values.[3] It is calculated by dividing the maximum applied force by the bonded cross-sectional area.

Effect of sandblasting by 50µm of Al_2O_3:

Effect of sandblasting on zirconia specimens (ZSB) group

Airborne particles abrasion or sandblasting with aluminum- oxide (Al_2O_3) is an important treatment procedure for achieving strong adhesion of veneering ceramic, works by increasing surface roughness and providing undercuts. [9].the results of the present study, revealed 50 µm of sandblasting particles with zirconia specimens (ZSB) group produce a significant increase in the mean of shear bond strength when compared with control group (ZC) with no treatment . This in agreement with study of Kareem and Al-Azzawi [6], a study stated that 50 µm of sandblast particles after grinding is more effective on zirconia specimens and increase SBS values, due to the sandblasting with 50 µm after grinding provide moderate surface roughness and porous. The results came in agreement with Ramos-Tonello et al.,[10] a study, evaluated the effect of 50µm of sandblast particles on zirconia roughness, phase transformation and Y-TZP/veneer shear bond strength pre and post-sintering. The results of their study showed there was a significant difference and greater strength for treated groups when compared with untreated groups. The results of the present study also in agreement with de Mello et al.,[11] since their study explained that sandblasting with aluminum-oxide is the most commonly used treatment on the surface of zirconia and it shown to be an effective method to increase SBS values. However, the findings of the present study are in disagreement with the finding of Tarib et al.,[5], a study suggested there is no significant effect of 50 µm of alumina-oxide on the shear bond strength of zirconia with veneering ceramic as compared with control group, they claimed that sandblasting can create surface micro cracks that can initiates bigger crack, These cracks later cause fracture of the material. Also, the results of the present study disagree with study of Yilmaz-Savas et al.,[8] , their study demonstrated that 50µm of sandblast particles with zirconia specimens did not enhance the bond strength between zirconia core and veneering ceramic.

Effect of sandblasting on e.max press specimens (ESB) group

Airborne particles abrasion with aluminum-oxide has been mentioned as a standard laboratory procedure for heat-pressed ceramic [12]. According to the results of the present study, there was a significant effect of these particles on the mean of shear bond strength when compared with control group (EC) which was untreated with any surface treatment. This is in agreement with the findings of Borges et al.,[13] that showed the effect of 50 µm of sandblast particles on the microstructure of Ips Empress 2, their study represented that airborne particles changed the morphological surface of Ips Empress2 by increasing the number of pits per unit area and increase their surface roughness when compared with control group . Also, the result of the present study agrees with those of Maruo et al., [14]. A study showed that 50µm of aluminum oxide with lithium-disilicate produced a microstructure that promoted mechanical retention to lithium-disilicate glass ceramic, and there was increase in the bond strength when compared with control group. However, the finding of present study disagreed with Tarib et al., [5], a study suggested that 50µm of aluminum oxide have a lowest mean of shear bond strength when compared with untreated group. In addition, the results of present study disagree with Hasan and Abood [15], a study claimed that 50µm of aluminum oxide on lithium disilicate had no-significant difference on SBS values when compared with control group.

Effect of etching by 5% concentration of hydrofluoric acid:

Effect of etching by 5% concentration of hydrofluoric acid on zirconia specimens (ZHF)

The results of present study found that 5% concentration of hydrofluoric acid for 20 seconds does not produce a significant difference in the mean of shear bond strength when compared with control group. This demonstrated that HF did not effect on the microstructure of zirconia surface and does not produce deep pores or grooves to enhance retention with veneering ceramic. Also, it could be explained that zirconia structure differs from conventional silica-based material like porcelain, thus, it is resistant to conventional etching technique by hydrofluoric acid. [16] The results of the current study also comes in agreement with a study done by Tarib et al.,[5] and in agreement with results of Smielak and Klimek [17] a study concluded that application of 9.5% and 5% of hydrofluoric acid to zirconia surface does not produce any morphological changes in its structure and does not increase surface roughness.

Effect of hydrofluoric acid etching on e.max press specimens (EHF)

Hydrofluoric acid treatment is a commonly used on silica- based ceramic to react with, and remove the glassy matrix that contain silica. This leaves the crystalline phase exposed, generating surface roughness because of the formation of numerous porosities and grooves due to the acid action on the matrix and the crystal structure; initiating the extreme bonding. [15, 18] The results of present study showed a significant increase in the mean of SBS values when 5% concentration of hydrofluoric acid have been applied on lithium disilicate surface for 20 seconds in comparison to control group. This results in agreement with Tarib et al.,[5], a study demonstrated that 5% concentration of hydrofluoric acid for 20 seconds on lithium disilicate can produce significant increase in the mean of SBS when compared with control group . Also, the results of present study agrees with the results of Borges et al.; Ramakrishnaiah et al.; Zogheib et al.,[13, 19, 20]. They found in their studies, application of hydrofluoric acid for 20 seconds on lithium disilicate surface could provide desirable porous surface, increase surface roughness, and consider an effective method to produce suitable bond strength for lithium disilicate. On the other hand, the results of present study showed there is no-significant difference in the mean of shear bond strength between (ESB) and (EHF) groups. This demonstrated that, sandblasting with aluminum-oxide particles have the same effect of hydrofluoric acid etching done with bonding of lithium disilicate ceramic ,this results are in agreement with the study of Hasan and Abood [15], But this result disagree with the study of Maruo et al.; Salvio et al.,[14, 21],they claimed that etching with hydrofluoric acid resulted in a higher bond strength than sand blasting technique.

Effect of combination sandblasting procedure and hydrofluoric acid etching:

Effect of combination sandblasting procedure and hydrofluoric acid etching on zirconia specimens (ZCOMB) group

The results of the present study demonstrated a higher mean of shear bond strength and a higher significant increase for zirconia specimens when treated with a combination of 50µm of aluminum-oxide particles and 5% concentration of hydrofluoric acid (ZCOMB)group as compared with untreated zirconia group (ZC). This comes in consistent with study done by de Mello et al., [11] a study concluded, that associations between two or more treatments showed a significant effect on the bond strength of Y-TZP due the cumulative effect of the treatments. In addition, this result comes in agreement with the findings of Tarib et al., [5].

Effect of combination sandblasting procedure and hydrofluoric acid etching on e.max press specimens (E COMB) group

The results of the current study showed there is a higher significant difference of a combination treatment (ECOMB) group when compared with control group (EC). This comes with outcomes of Tarib et al.,[5] a study demonstrated that the combination of 50µm of aluminum-oxide particles and 5% concentration of hydrofluoric acid was more effective on SBS when compared with treated and untreated groups. Also , the results agreed with those of Kansu et al., [22] , a study found that a combination of 50µm aluminum-oxide particles and 9.6% of hydrofluoric acid with Empress2 ceramic was the most successful statistical result obtained, micro-pitting of the surface was created by sandblasting, whereas the second phase to remove the glass matrix and lithium orthophosphate of the surface was performed using HF acid . But, this results disagree with those of Ribeiro et al.,[23], a study claimed that a combination of 50µm of aluminum-oxide particles and 10% of hydrofluoric acid with lithium disilicate did not improve the shear bond strength values when compared to use hydrofluoric acid alone .

Mode of Failure

According to the results of interfacial fractures as shown in tables (8),(9) that was analyzed with a Dino-Lite microscope of an original magnification of 20x for the current study, a mixed mode failures (adhesive /cohesive) was prevalence in most of treated groups. In the subgroup (ZC), adhesive failure was predominantly that means the bonding strength at the interface was at a relatively low level,[24,25].also for subgroup (ZHF) ,adhesive failure was predominantly higher than cohesive failure. This indicated that hydrofluoric acid etching does not sufficiently enhance the boding strength and lead to delamination of veneering ceramic from the underlying substructure due to the weak bonding between the two ceramic materials.(26)while for the subgroup (ZSB), the mixed failure was the predominantly occurred .The adhesive failure was not observed than cohesive failure, this may be interpreted to that the connection force at zirconia /ceramic interface was higher than the cohesion force between the intrinsic molecules of the veneering ceramic .On the other hand, Airborne particles abrasion found to decrease the percentage of interfacial failure pattern , because it is able to induce transformation of tetragonal to monoclinic phase without developing higher temperatures or creating sever damage.(27) In the subgroup (ZCOMB), the mixed failure was the predominantly because a combination of sandblasting process and acid etching were greatly influence on the bonding strength of core /veneer interface .That was clear from the SBS values for this subgroup.

In the e-max press ceramic subgroups showed a mixed failure primarily occurred in most of treated groups with a cohesive failure, that was observed but at low percentage. In the subgroup (ESB),a higher incidence of mixed mode failures and there is no adhesive failures to be observed when compared with un treated (EC) group. This demonstrated that airborne particles abrasion produced amicrostructures which promoted mechanical retention to the lithium-disilicate glass surface and increase bonding strength. (14) While a mixed failures were prevalence in both (EHF) and (ECOMB) groups, that demonstrated that etching with hydrofluoric acid alone pronouncedly increase the bond strength of lithium-disilicate, independent of any combined of surface treatment such as (airborne particles) .Therefore, adhesive failure was not observed in both of them, indicating that HF acid etching in both cases alone or combined is an aggressive etching agent on silica based ceramic surface, react with the glassy or crystalline components and produced an irregular porous surface that increase the surface area and increase the bonding strength of lithium-disilicate and veneering ceramic. (14, 21)

Conclusions

Based on the findings and limitations of this in vitro study, the following conclusions are drawn:

1- Using of different surface treatments with zirconia and lithium disilicate were more effective on the values of shear bond strength.
2- A combination of two surface treatments represented an effective method on the bond strength of both materials due to the cumulative effect of these treatments .
3- Airborne particles of 50 µm showed appositive effect for conditioning of the zirconia and lithium disilicate surfaces.
4- Hydrofluoric acid alone was not effective in altering the zirconia surface morphology.
5- Using of different surface treatment has a significant effect by decreasing the adhesive failure of most experimental groups.

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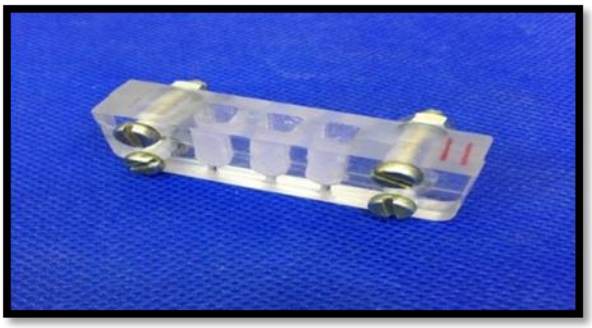
Figure (1): Custom made mold for buildup.

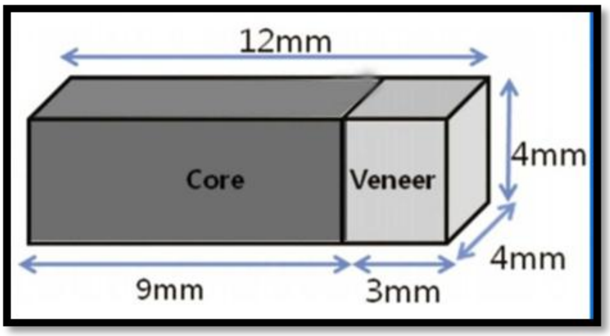

Figure (2): Final dimensions of samples


Figure (3): universal testing machine

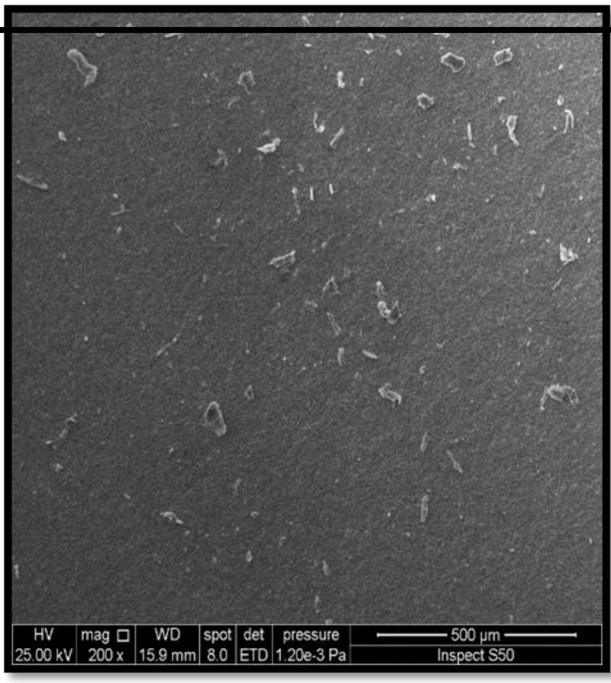

Figure (4-A):SEM for zirconia specimens without surface treatment.

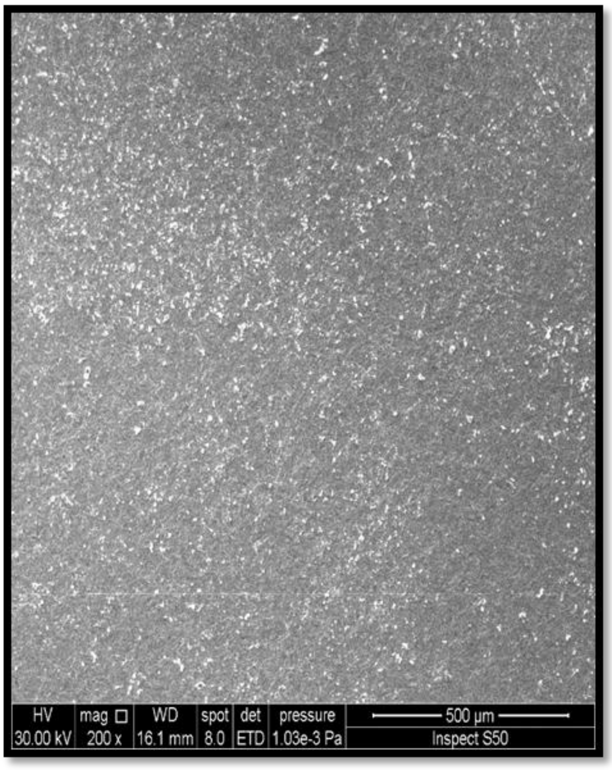

Figure (4-B): SEM for zirconia specimens treated with 50µm of aluminum-oxide.

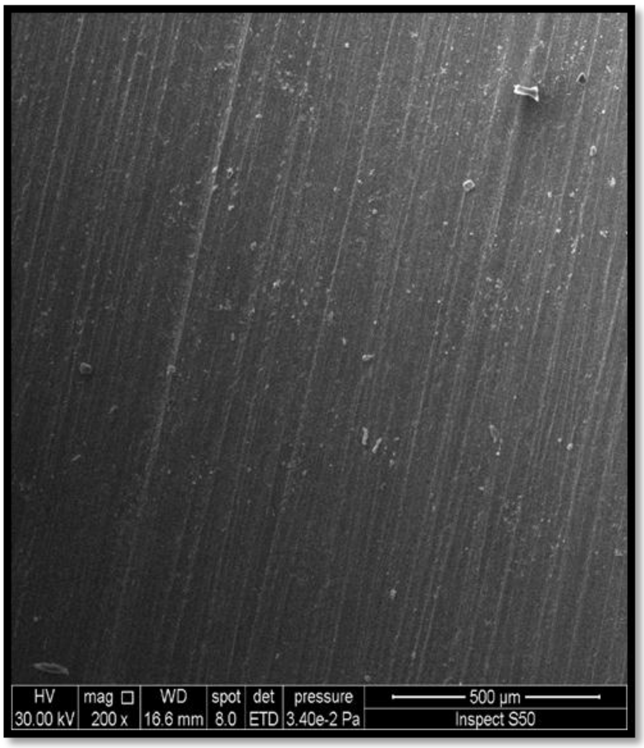

Figure (4-C): SEM for zirconia specimens treated with 5%of hydrofluoric acid .

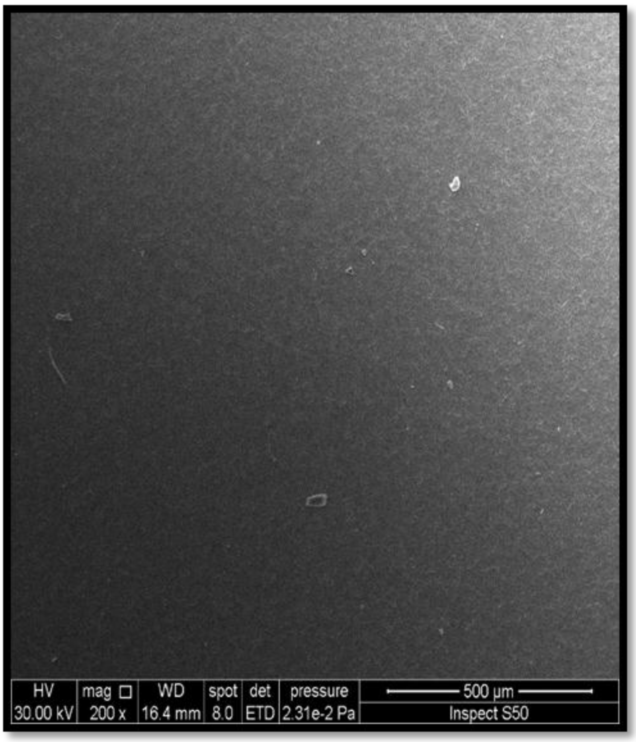

Figure (4-D): SEM for zirconia specimens treated with a combination of 50µm of aluminum-oxide and 5%of hydrofluoric acid .

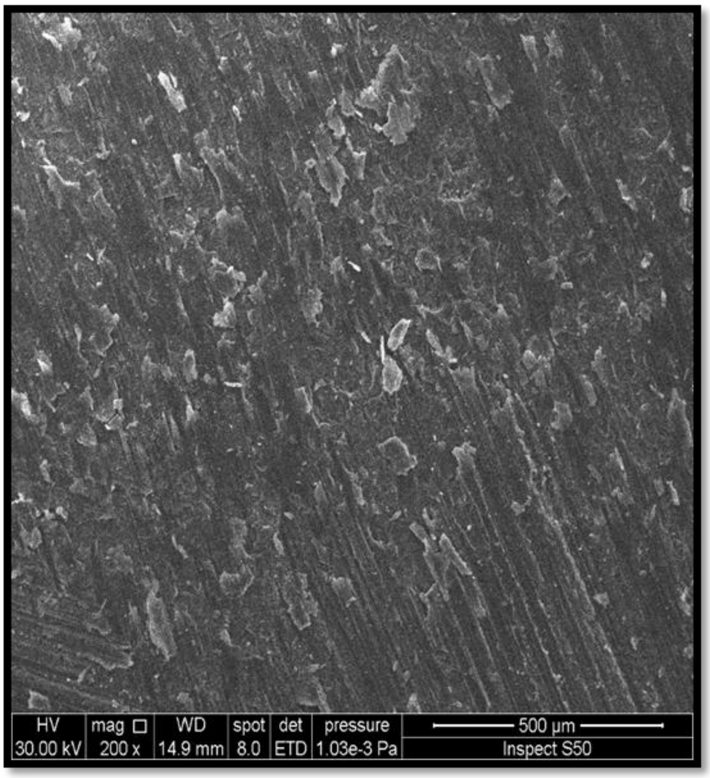

Figure (4-E): SEM for e.max press specimens without surface treatment.

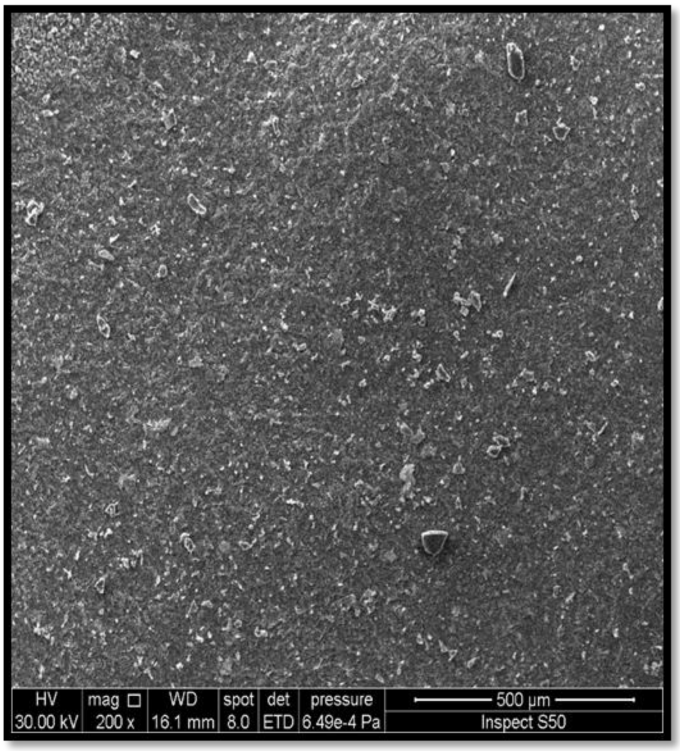

Figure (4-F): SEM for e.max press specimens treated with 50µm of aluminum-oxide

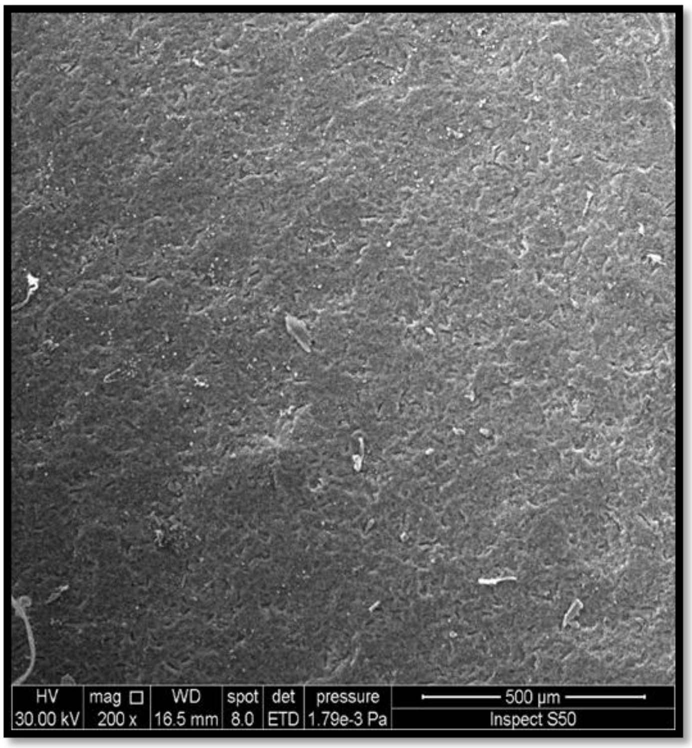

Figure (4-G): SEM for e.max press specimens treated with 5%of hydrofluoric acid .

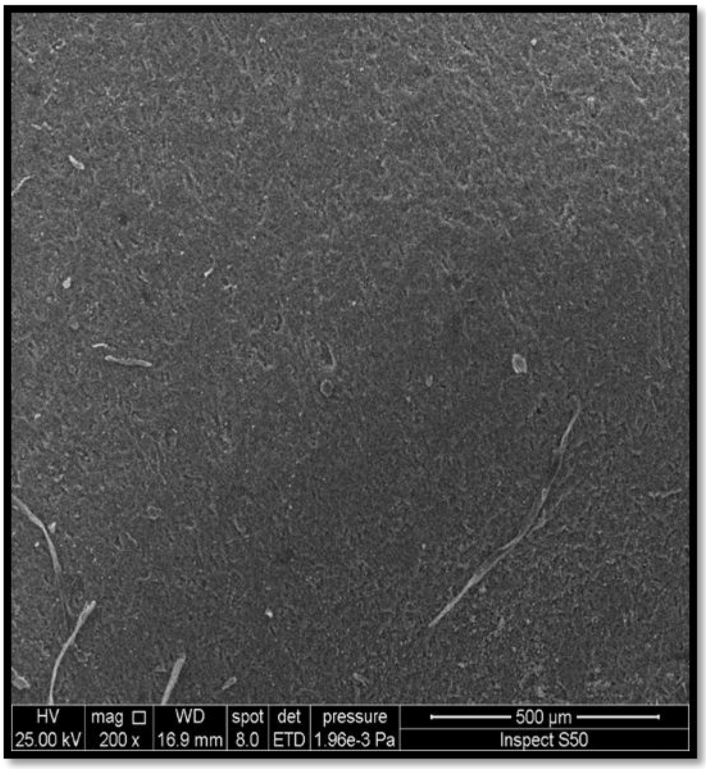

Figure (4-H): SEM for e.max press specimens treated with a combination of 50µm of aluminum-oxide and 5% of hydrofluoric acid.

Table (1): Descriptive Statistics of Shear Bond Strength of Zirconia Ceramic Groups (ZC, ZSB , ZHF and ZCOMB) in Mpa.

Std. Deviation	Std. Error	Mean	Maximum	Minimum	N	Groups
2.16005	0.68307	20.1080	23.75	17.21	10	ZC
2.44564	0.77338	23.2726	26.88	20.00	10	ZSB
1.72830	0.54654	20.4037	22.75	18.13	10	ZHF
2.04641	0.64713	26.3323	30.38	23.75	10	ZCOMB

Table (2): Descriptive Statistics of Shear Bond Strength of zirconia Ceramic Groups (EC, ESB , EHF and ECOMB) in Mpa.

Std. Deviation	Std. Error	Mean	Maximum	Minimum	N	Groups
2.46018	0.77798	12.9909	16.75	10.00	10	EC
1.61272	0.50999	16.3895	18.63	14.00	10	ESB
2.69104	0.85098	15.1539	18.69	11.00	10	EHF
3.56796	1.12829	18.5585	23.63	15.38	10	ECOMB

Table (3): One- Way ANOVA test for shear bond strength among Zirconia ceramic subgroups.

Sig	P-value	F	Zirconia Groups
HS	0.000	19.000	Among Groups

Table (4):LSD test among zirconia groups of shear bond strength.

Sig	P-value	Std. Error	Mean Difference	Groups	
S	0.002	0.94398	-3.16460-*	ZSB	ZC
NS	0.756	0.94394	-.29570	ZHF	
HS	0.000	0.94393	-6.22430-*	ZCOMB	
S	0.004	0.94391	2.86890*	ZHF	ZSB
S	0.003	0.94392	-3.05970-*	ZCOMB	
HS	0.000	0.94395	-5.92860-*	ZCOMB	ZHF

Table (5): One- Way ANOVA test for Shear Bond Strength among E.max press ceramic subgroups

Sig	P-value	F	Emax press Groups
HS	0.000	7.575	Among Groups

*P<0.001(High significant).

Table (6): LSD test among e.max press groups of shear bond strength.

Sig	P-value	Std. Error	Mean Difference	Groups	
S	0.007	1.19636	-3.39860-*	ESB	EC
S	0.048	1.19606	-2.16300	EHF	
HS	0.000	1.19632	-5.56760-*	ECOMB	
NS	0.309	1.19631	1.23560	EHF	ESB
S	0.049	1.19633	-2.16900	ECOMB	
S	0.007	1.19634	-3.40460-*	ECOMB	EHF

*P<0.05(Significant).

Table (7): The comparison between the shear bond strength of zirconia ceramic and e.max press ceramic groups.

Sig	P-value	t	Groups
HS	0.000	9.431	ZC & EC
HS	0.000	6.311	ZSB & ESB
S	0.001	5.226	ZHF & EHF
S	0.002	4.754	Zcomb & Ecomb

Table (8): types of Failure in Zirconia Ceramic Subgroups .

Mixed	Cohesive	Adhesive	Zirconia Subgroups
20%	20%	60%	ZC
70%	20%	_	ZSB
30%	10%	60%	ZHF
70%	_	_	Z COMB

Table (9):Types of Failure in E.max Press Ceramic Subgroups.

Mixed	Cohesive	Adhesive	E.max Subgroups
30%	30%	40%	EC
80%	20%	_	ESB
80%	10%	_	EHF
90%	_	_	ECOMB