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Repair Bond Strength and Surface Characteristics of Two Ceramic Materials Subjected to Different Laser Surface Treatment Combinations An in vitro study

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Background: (CAD/CAM) ceramic restorations has been widely used in the field of fixed prosthodontic dentistry. CAD/CAM ceramics blocks were reported of having less internal porosity; hence the fracture failure occur at a lower rate than conventional layered ceramics. fracture does not frequently result in restoration failure, but it does cause aesthetic and masticatory problems for the patient. Restorations can be replaced or repaired in situations. Micromechanical and chemical methods of retention can be used to repair ceramic-composite surfaces in order to achieve a solid bond.

Materials and Methods: 70 specimens of two different materials were divided into groups: (Group A) Vita supernity and (Group B) Vita Enamic were used in this in vitro study. 35 specimens with (14x12x3) were made using a slow speed cutting machine from each material. Each group will then be subdivided into five subgroups according to the surface treatment techniques into Subgroup (1): hydrofluoric acid, Subgroup 2 Er:YAG, Subgroup (3) Er,Cr:YSGG, Subgroup (4) EY+ air abrasion Subgroup 5 ECY+air abrasion. According to the manufacturer's recommendation, group B was subjected to crystallization.Each group (n=7) received a surface treatment, SEM were measured then silane coupling agent , bonding aget, composite were applied .lastly thermocycling then shear bond strength was measured.

Results: measurements showed higher shear bond strength in Hf acid surface treatment showed in both Vita Suprnity and Vita Enamic.

Conclusion: Surface treatment affected the shear bond strength of Vita Suprnity and Vita Enamic. HF achieved the highest in Vita Suprnity and in Vita Enamic.

Keywords: CAD/CAM blocks, Laser, Shear bond strength

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Introduction

The internal porosity of Computer-aided design and Computer-aided manufacturing (CAD/CAM) ceramic blocks has been shown to be smaller than that of conventional layered ceramics, which lowers the rate of fracture failure.1-3 CAD/CAM technology has improved the mechanical, aesthetic, and production properties of ceramic materials. Zirconia crystals found in zirconia lithium silicate (ZLS) range 4 in size from 8% to 12%; they might act as a crystal phase to slow the spread of cracks.5 Because it has a feldspathic ceramic matrix and polymer penetrated, the ceramic material known as polymer infiltrate ceramic (PICN) is referred to as a hybrid ceramic. Crack propagation is slowed by the penetration of polymers into ceramic networks.6,7 Used for implants, front and back crowns, veneers, partial crowns, inlays, onlays, and occlusal veneers.

Although dental ceramics fracture seldom leads to restoration failure, it does give the patient cosmetic and masticatory issues. In some cases, restorations can be replaced or repaired. However, because they are painless, inexpensive, and quick, intraoral mending methods are more agreeable for the patient. Dental composite would be used to heal the damaged area in order to increase the restoration's endurance, but a strong bond between the restored material and ceramic is also required.8,9 To increase the bond strength, various procedures are carried out.10 Ceramic-composite surfaces can be repaired using micromechanical and chemical methods of retention to create a strong bond.11 One of the many test methods that can be used to describe bond qualities in general is bond strength testing, which is acquired by loading a test sample until failure in either shear or tension.

The aim of this study was to evaluate repair bond strength and surface characteristics of different ceramic materials subjected to different surface treatment combinations.

Materials and Methods

Vita Suprinity (VS) and Vita Enamic (VE) CAD/CAM blocks were employed in this in vitro study, which involved 70 specimens of two different ceramic materials. A slow speed cutting machine was used to create 35 specimens with a height of 3mm (14x12x3). All specimens were measured using a digital calliper from each substance. The surface treatment methods were used to separate each group into five subgroups including subgroup 1: Hydrofluoric acid, subgroup 2: Er:YAG laser (EY), subgroup 3: ER:Cr;YSGG laser (ECY), subgroup 4: Er:YAG laser + air abrasion (AA), subgroup 5: ER:Cr;YSGG laser + air abrasion (AA). ZLS were crystallised in accordance with the manufacturer's instructions, and other group PICN were meticulously cleaned to remove any residue since any leftovers on the surface could cause bonding issues. After that, polish using the VITA ENAMIC Polishing Set in accordance with the manufacturer's guidelines. Using the pink polishing tools from the kit, pre-polishing was done (7.000-10.000 rpm). The set's grey, diamond-coated polishing tools were used to polish the glass to a high sheen (5.000-8.000 rpm). Surface treatments were given to each group (n=3).

Surface treatment of the samples:

1-Surface treatment hydrofluoric acid etching

Using a 9.5% hydrofluoric acid gel (HF), the surface of the specimens was etched for 60 seconds. After the etching technique, the specimens were cleaned and dried with oil free air flow for 60 seconds.

2- ER:YAG laser

A 2,940 nm EY laser was used to thoroughly vaporise the surface of the specimens Horizontal and vertical movements were done across the specimen with 900 µm diameter spot size EY laser handpiece from

1mm distance to surface (Figure 1). The surface was illuminated with a flow rate of 60% air and 50% water for 20 seconds with an output power of 3 W, a repeat rate of 20 Hz, and a duration of 300 µs pulses.

Figure 1: Surface treatment by laser

3-ErCr:YSGG laser

A 2,780 nm ECY laser was used to thoroughly vaporise the surface of the specimens. Horizontal and vertical movements were done across the specimen with 600 µm diameter spot size ECY laser handpiece from 1mm distance to surface. The surface was illuminated with a flow rate of 60% air and 50% water for 20 seconds with an output power of 3 W, a repeat rate of 20 Hz, and a duration of140 µs pulses.

4- Air abrasion+ Er:YAG laser

Specimens were air abraded with 50 um Al_2O_3 particles for 15 seconds at a pressure of 2 bar perpendicular to the surface at a 10mm working distance by using air abrasion unit. then A 2,940 nm EY laser was used to thoroughly vaporise

5- Air abrasion+ ErCr:YSGG laser

Specimens were air abraded with 50 um Al_2O_3 particles for 15 seconds at a pressure of 2 bar perpendicular to the surface at a 10mm working distance by using an air abrasion unit. then A 2,780 nm ECY laser was used to thoroughly vaporize.

Surface roughness measurement:

A stylus profilometer was used to measure the Ra (average roughness height) in micrometers (µm) for all samples after surface treatment and the data were calculated by three single individual. (Figure 2)

Figure 2: Surface roughness tester

Repair procedure

Oil-free air/water flow was used to wash and dry the specimens. Silane coupling agent was applied to the specimens for 60 seconds and dried in an oil-free air flow for 10 seconds. Following the application of the silane coupling agent, the adhesives were applied according to manufacturer's instructions. After that, a light-emitting diode (LED) curing device was used for polymerization. (Figure 3)

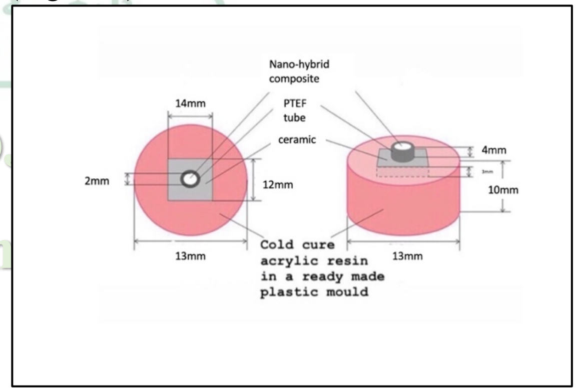

Figure 3: Diagram showing sample with dimension.

Thermocycling

All samples were stored in distilled water at 37°C for 24 hours prior to thermal cycling according to ISO recommendation (international organization for standardization). Then the samples were submitted to 5000 thermocycles in a thermal cycling simulation machine between (5 and 55°C).

Scanning electron microscopy (SEM)

Specimen in each group were obtained using scanning electron microscopy (SEM) analysis at x2000 magnification for surface topography. (Figure 4)

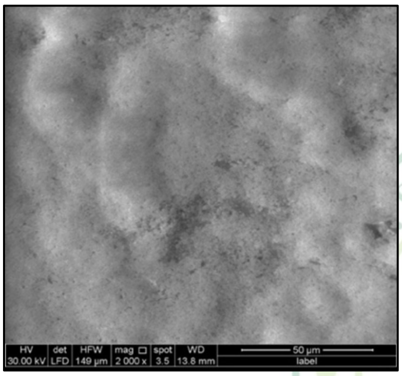

Figure 4: Surface topography by SEM for the specimen A1 III at magnification x2000

Shear bond strength test (SBS test):

SBS test was performed in a universal test machine (Figure 5) at a 1 mm/min crosshead speed. The samples were positioned parallel to the loading direction of the jig of the testing machine (Figure 6). The following formula was used to calculate SBS data: fracture load/bonding surface area (inner diameter) = N/mm2 = MPa.

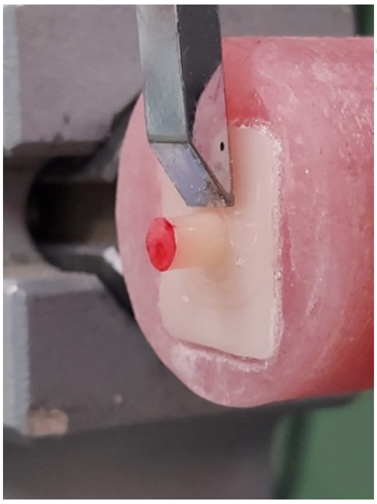

Figure 5: Shear bond strength test

Figure 6: Universal test machine for shear bond strength

Results

Table 1: Mean ± standard deviation (SD) of surface roughness (Ra) and shear bond strength (MPa), for different materials and surface treatments

Material	Surface treatment	Surface roughness	Shear bond strength
Vita Suprinity	HF	9.77 ± 0.47^{A}	19.54 ± 0.92^{A}
	Er:YAG	11.30 ± 0.55^{B}	10.96 ± 2.13^{B}
	Er,Cr:YSGG	13.22 ± 0.12^{B}	13.32 ± 1.41^{B}
	Er:YAG + AA	22.7 ± 0.29^{C}	7.51 ± 0.44^{C}
	Er,Cr:YSGG + AA	25.81 ± 0.20^{C}	8.03 ± 2.86^{C}
Vita Enamic	HF	15.98 ± 0.21^{A}	13.57 ± 1.00^{A}
	Er:YAG	10.45 ± 0.97^{B}	15.83 ± 1.98^{A}
	Er,Cr:YSGG	13.62 ± 0.77^{A}	10.47 ± 1.96^{B}
	Er:YAG + AA	17.91 ± 1.25^{B}	12.17 ± 0.82^{A}
	Er,Cr:YSGG + AA	21.26 ± 0.17^{A}	$9.50 \pm .73^{B}$

Means with different superscript letters within the same vertical column are significantly different *; significant ($p \leq 0.05$) ns; non-significant ($p>0.05$)

Vita Suprnity for surface roughness the highest value was found in Er,Cr:YSGG + AA (19.81±0.20), while the lowest value was found in HF (9.77±0.47) .For Vita enamic the highest value was found in Er,Cr:YSGG + AA (21.26±0.17) while the lowest value was found in E:YAG (10.45±0.97).

And the shear bond strength for Vita Suprnity the highest value was found in HF (19.54±0.92), followed by Er,Cr:YSGG (13.32±1.41) , while the lowest value was found in Er:YAG + AA (7.51±0.44).and Vita Enamic the highest value was found in Er:YAG (15.83±1.98) followed by HF (13.57±1.00),while the lowest value was found in Er,Cr:YSGG + AA

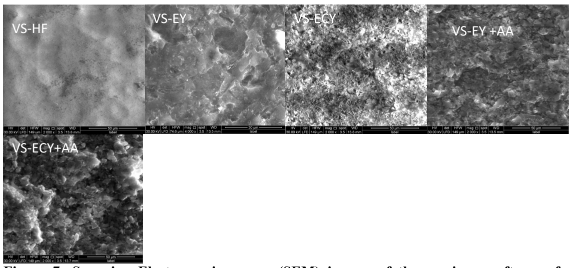

Figure 7: Scanning Electron microscope (SEM) images of the specimens after surface procedures for Vita Suprinity.

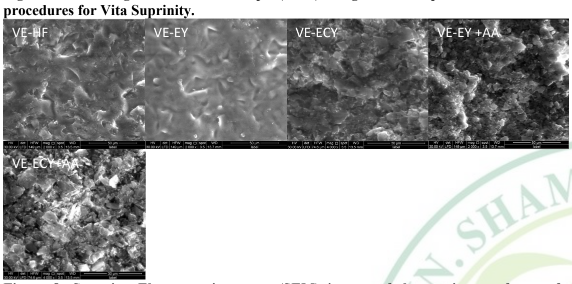

Figure 8: Scanning Electron microscope (SEM) images of the specimens after surface procedures for Vita Enamic.

Discussion

Findings of the present investigation refuted the null hypothesis by showing that various surface treatment techniques have an impact on shear bond strength. The shear bond strength values were all increased by the surface treatment techniques.

Although, there are no guidelines provided for figuring just how much chipping has occurred. Repairs should be prioritised over replacements because they are less expensive and less necessary. With a three-year success rate of up to 89%, employing surface treatments to fix broken ceramics in crowns is a viable alternative in the correct circumstances. During a three-year observation period in their prospective clinical trial, Spitznagel et al.12 recorded four (5%) chipped fractures of CAD/CAM polymer infiltrate ceramic restorations. Both inlays and partial coverage restorations were used in the study, however with PICN, only the partial coverage restorations exhibited chipping cracks; none of the inlay restorations did. It might be conceivable to fix chipped CAD/CAM ceramics intraorally using conventional dental resin composite in order to prolong the life of restorations and avoid needless structural harm to the tooth structure caused by removing the chipped restoration. Resin composite is the ideal material for mending ceramic restorations since it is less expensive and simpler to use than alternative methods. The properties of resin composites have improved over time. Along with ceramic repair.13

The results of the present study are consistent with those of B Altan et al 14 analysis, which found that Vita Suprinity blocks had the highest bond strength values following the HF acid etching method. These results support those of Ataol et al.15 and Sato et al.16, who discovered that the HF acid etching group from Vita Suprinity displayed the strongest bond strength. These results could be explained by the fact that Vita Suprinity's glassy matris was eliminated by HF acid etching, which enhanced micromechanical retention. 19 that described how Vita Suprinity's glass matrix is dissolved and micromechanical retention is improved by HF acid etching.

An alternative to traditional surface-treatment techniques is laser irradiation. The main outcome of laser energy is the conversion of light energy into heat, and the most significant interaction between the laser and substrate is the laser energy's absorption by the substrate. 20 A further finding by Kirmali et al.17 was that Er:YAG laser irradiation produced rougher surfaces than Nd:YAG laser irradiation.18 According to Ozdemir et al. 18, specimens treated with the Er:YAG laser had stronger bond strengths than specimens treated with the Nd:YAG laser. These results suggest that using the Er:YAG laser will strengthen the bonds. Lower bond strength of laser groups19demonstrated that laser irradiation could not create enough micro-depth. Sandblasting plus laser irradiation group showed lower bond strength values. This result may be associated with decrease in surface roughness when laser irradiation was applied after sandblasting. Considerably close to our study, Akyıl et al.9 found lower bond strength values in sandblasting plus laser group compared to sandblasting group. ER:YAG can be an alternative method to Acid etching for Vita Enamic but in our present study Er:Cr;YSGG showed lower bond strength and for Vita Suprnity.

Conclusion

On the basis of the results and conditions of this study, the following conclusions can be drawn:

- Surface treatment affected the shear bond strength of Vita Suprinity and Vita Enamic. HF achieved the highest mean bond strength value in Vita Suprinity
- Surface treatment and choice of adhesive are essential for bonding between Vita Suprinity and Vita Enamic and composite

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