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Effect of Zirconia Surface Treatments on The Shear Bond Strength of Veneering Porcelain

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Abstract

Aim of the study: The present study aimed to evaluate the effect of surface treatments of zirconia (sandblast with 50µm Al_2O_3, 0.01M NaOH) on the shear bond strength between zirconia substructure and veneering porcelain.

Materials and methods: Twenty-one (21) disk shape zirconia specimens were prepared with dimensions of (10mm) in diameter and (1mm) in height and sintered according to manufacturer instruction. Specimens were divided into three groups (n=7) according to surface treatment method; control group (C), sandblast with 50µm Al_2O_3 (SB), and sodium hydroxide (Na). Porcelain veneer (IPS-emax ceram, vita Germany) was applied on the zirconia specimens (5mm in diameter and 3mm in height) and fired according to manufacturer instruction. All specimens were then evaluated for shear - bond strength in a universal testing machine at 1mm/min cross head speed. The shear - bond strength value was then statistically analyzed with one-way ANOVA and LSD.

Results: The result of the present study showed that 0.01M NaOH has significantly effect on the shear bond strength between zirconia and porcelain than sandblast with 50µm Al_2O_3.

Conclusion: Sandblast with 50µm Al_2O_3 had no effect on the shear bond strength between zirconia substructure and veneering porcelain whereas 0.01M NaOH reduced the shear bond strength between them.

Keywords: zirconia, sandblast, sodium hydroxide, shear bond strength, porcelain veneer.

Introduction

The use of ceramic systems have been increased in dentistry due to demand for high esthetics and biocompatibility requirments (1). Recently, high esthetic zirconia (ZrO_2) was developed as a replacement to metal framework because of its superior esthetic, biocompatibility, and mechanical properties. To achieve optimal esthetic, zirconia substractures are veneered with a ceramic material, adding veneering ceramic in layers result in the final restoration with individual optical properties (2).

However, porcelain veneers are susceptible to fracture. This problem represent the major cause for the failure of zirconia framworks restorations (3).So various surface modification techniques have been suggested to improve the bonding strength between zirconia substructure and veneering porcelain (4). Many manufacturers recommended sandblasting for surface treatment (3), which it increase surface roughness and provide micromechanical undercut (5). In addition, efforts directed to obtain a chemical adhesion that doesn't produce chemical damage in zirconia surface or need any special equipment, as such the use of alkaline solution seem to contribute to bond strength (6).

Materials and method

1. Zirconia specimen's preparation

Zirconia blank was marked with a pencil and sectioned it with a cutting saw to form cubic shape specimens. Each specimen was glued in to a custom mad fitting pin, then it seated in the milling machine. A straight hand piece with a diamond disc operating at high speed (20.000 rpm) was fixed to a movable member of milling machine in way allowing it to free movement along the side of zirconia specimen to change its shape from cubic to cylinder. The same diamond disc was also used to cut the zirconia horizontally to form a disc shape specimen. Larger dimensions were used to compensate for (20%) firing shrinkage. Finally, all zirconia specimens were sintered in zirconia furnace (VITA ZYRCOMAT 6000 MS) at 1450 C° for 80 minutes according to manufacture instruction.

2. Specimens grouping

A total of twenty-one (21) disk shape zirconia specimens with (10) mm in diameter and (1mm) in height were prepared and divided in to three groups according to surface treatment (n=7). Cylindrical shape porcelain with dimension (5mm) in diameter and (3mm) in height were built on zirconia surface according to manufacture instruction.

3. Zirconia surface treatment

For sandblast group (SB), the working surface of zirconia specimens was sandblasted horizontally with 50 µm (Al_2O_3) at an 0.2MPa for 10 seconds and at fixed distance of 10mm between the nozzle and the working surface of the specimen by using sandblasting machine (Bego,Germany) (7), custom made special holder was used to fixed the nozzle and specimens during sandblasting procedure. And for sodium hydroxide group (Na), 0.01-M NaOH solution with pH (12.7) was prepared and generously applied on zirconia surface with brush, it was left for 10 min to dry prior to porcelain buildup.

4. Application of porcelain veneer on zirconia surface

before application of ceramic veneer (Vita VM9, base dentin, 0M1) a thin layer of aqueous mixture (Washbake) layer was applied to the dry clean zirconia surface by using a fine brush, and then fired in zirconia furnace according to manufacturer instruction. In order to obtain the desired dimensions of veneering ceramic (Vita, Germany), a custom- made metal mold was made to allow for application of porcelain at control thickness (5mm diameter and 3mm in height) by layering technique . The ceramic powder VM9 and modeling liquid (VITA modeling liquid, Germany) were mixed to produce the desired creamy consistency of ceramic. Then the ceramic was applied into the mold using a brush, the excess liquid was blotted with a tissue and the procedure continued until the mold completely filled. The first sintering was performed according to manufacture instruction. Because of volumetric shrinkage during firing of porcelain, 2nd layer of dentin (VitaVM9, base dentine 0M1) and enamel porcelain layer (Vita VM9, Enamel ENL) were used in the mold and then vibrated, dried and fired according to the manufacturer instructions. After complete firing, the dimensions of porcelain veneer were checked by Vernia and then it was adjusted by using straight hand piece and diamond bur. Finally, glazing layer was applied and fired according to manufacturer instruction.

5. Preparation of specimens for testing and shear bond strength test

All zirconia specimens bonded onto a type IV stone block (8,9). A custom-made square silicon mold was used for construction of the stone block. The block has a dimension of (20mm × 20mm) in length and width. After that, all the specimens glued with cyanoacrylate resin (UHU Epoxy, Germany) and then fixed on the stone block without application any pressure, it left for 24 hours for drying and complete polymerization.

For shearing test, the specimen was fixed tightly to the lower jaw of testing device. Parallel load was applied to the specimens long axis and as close as possible to the interface. Chisel shape piston was used and at a constant cross head speed 1mm/min until failure has been occured (10), figure (1). The maximum force was record in (N), and the shear - bond strength in (MPa). It was calculated by dividing the load (N) by the surface area of bonded area (mm^2) according to the following formula (11):

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

Results

The study data analyzed via One-way ANOVA and LSD at a confidence level of (95%) and a significant P-Value of ($p<.05$). Figure (2) showed that the highest mean of the shear bond strength value was in group (SB), while the lowest mean of the shear bond strength was for group (Na). In the table (1), one-way ANOVA reveled that there was statistically significant different in the shear bond strength among (C, SB, and Na), LSD in table (2) showed that there was a high significant different between (C) and (Na) and between (SB) and (Na). While there was non- significant different between (C) and (SB).

Discussion

For zirconia surface treatment, many manufacturers recommended sandblasting which might be an irreversible and necessary method of obtaining durable - bond strength in zirconia – ceramic. Air born – particle abrasion with Al_2O_3 is a routine process to clean and roughen zirconia bonding surface (12), it was chosen because of its ability to change the morphology of ceramic surface and increase the surface area to gain micro-mechanical bonding (13).

In the present study, sandblasting for zirconia specimens was done with 50µm of aluminum-oxide as this particles size showed a higher degree of surface roughness with less material removal from the surface when compared with other particle size (14). The result of the present study showed that 50µm (Al_2O_3) provides non-significant different of the mean of shear bond strength when compared with control group.

It's important to consider that sandblasting with Al_2O_3 result in phase transformation of crystalline at the surface changing it from tetragonal to monoclinic (t-m) (2). Proportionally, thicker monoclinic layer may be created on thinner specimens (15).

The result of the present study could be explained that when the surface of the material have a greater amount of monoclinic phase it may lead to microcracking and strength degradation more than those with low monoclinic phase content (16), and also it reduces the mechanical properties and influence the life time of zirconia (17), in addition it may lead to micro- crack in glassy phase of the veneer ceramic at the inter-grain level (as a result of phase change from t to m) and this may reduce bond strength (18,19).

On the other hand, sandblasting consider a double edge sword. Sandblasting affects the reliability and mechanical properties of zirconia because it causes phase transformation from tetragonal to monoclinic phase (t-m) by induce flaw and reshaping and cause surface damage (3).

Zirconia is a completely bioinert material. It provides completely un-polar surface with high corrosion resistance (20). So, Hydroxylation of zirconia surface was proposed to increase the hydroxyl group (-OH) so as to enhance wettability and the reaction between zirconia substructure surface and applied material (21) and also improve shear bond strength between them (22).However, there are few studies had been conducted regarding zirconia surface treatment using different pH solution, so in current study NaOH solution with (12.7 pH) was used to determine shear bond strength (SBS) between zirconia and porcelain veneer.

The finding of current study found that (0.01M, 12.7 pH) NaOH solution provide significantly decrease in the mean of shear bond strength when compare with control group. This finding contributed for two main reason, zirconia reason and porcelain reason:

1 -Zirconia reason: bio inertness and high corrosion resistance of zirconia surface make it lacking chemical adhesion potential or etch ability. Treatment with alkaline solution (NaOH) didn't indicate successful hydroxylation procedure (20). This in agreement with Flores-Ferreyra et al., 2019 (21), a study found that the chemical treatment with NaOH no effect on surface zirconia crystals degradation, and it consequently have no effect on surface roughness.

2 -Porcelain reason: The properties of dental porcelain are dependent on their microstructure, composition, residual stresses and surface finish. The major composition of dental porcelain is silica (SiO_2) and many oxides of (K, Ca, B, Al, Na) (23). When the concentration of alkali ions (Na+) increase, disruption of (-Si-O-Si-) bond occurs, with increase in CTE and reduction in softening temperature and chemical durability. The reduction in chemical durability causes increased susceptibility to chemical attack (23). Another possible explanation was that when alkali solution – exposed to glass surface, it showed a porous surface that consist of silica with hole (24).

Conclusion

Within limitation of this study, the following conclusion were drawn:

1. Treatment the surface with 50 µm Al_2O_3 had no effect on the shear - bond strength between zirconia substructure and veneering porcelain
2. Treatment the surface with 0.01M NaOH solution reduce the shear- bond strength between zirconia substructure and veneering porcelain.

Conflicts of Interest

The authors reported that they have no conflicts of interest.

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Table (1): One- way ANOVA test for shear bond strength between (C, SB, and Na)

	F-test	P-value	Sig
Between group	24.633	0.000	HS

*P<0.001 High significant

Table (2): LSD test between (C, SB, and Na)

Groups		Mean different	Std. Error	P-value	Sig.
C	SB	-.37071	.38096	.340	NS
C	Na	1.94729*	.38096	.000	HS
SB	Na	2.31800*	.38096	.000	HS

Figure (1): Specimens in a universal testing machine

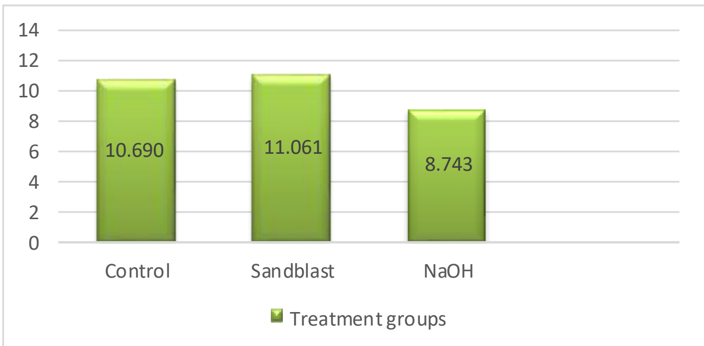

Figure (2): Mean distribution of surface treatments groups