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Effect of Surface Treatment of Translucent and Conventional Zirconia on the Surface Roughness

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Abstract: ***Statement of problem**: Although conventional zirconia had demonstrated a very acceptable clinical performance but still have some limitation. Its low translucency adversely affects the final aesthetic outcome. On one hand, porcelain layering could solve the problem, on the other, it creates another drawback in the form of the possibility of delamination of the porcelain veneer. **Purpose**: The aim of this study was to evaluate the effect of surface treatment of translucent zirconia, in comparison to conventional zirconia on the surface roughness. **Material and Methods**: A total of twenty zirconia plates (n=20) were assigned into two equal groups (n=10). Group (A) constructed from translucent plates (n=10) were air blasted with 50µm aluminum oxide particles, and group (B) was assigned to the conventional plates (n=10) and air blasted with 110µm aluminum oxide under the same conditions. The surface roughness test was performed using an optical profilometer. **Results**: The values of surface roughness recorded with the translucent plates were higher than those recorded with the conventional zirconia specimens with non - significant differences. **Conclusions**: Both conventional and translucent zirconia's surface roughness increased after alumina blasting. Alumina air abrasion of translucent zirconia could achieve a sufficient bond strength comparable to that of conventional zirconia.*

Keywords: Translucent Zirconia, Alumina air abrasion, Resin cement, Shear bond strength

1. Introduction

Ceramic dental restorative systems have become increasingly popular and in high demand by both the patient and the clinician, due to their natural appearance, aesthetics and biocompatibility. More specifically, zirconia had become one of the most important and prime alternatives to the ceramometallic restorations due to their high strength and good aesthetic properties.

Unlike traditional ceramics, bonding to zirconia is very challenging as a result of its difficult chemical etching nature due to lack of glassy matrix and high crystalline nature. Surface treatment of zirconia is a mandatory step to obtain strong durable bond with dental cements. There is no universally agreed method for achieving a bondable zirconia surface. However, the most reliable protocol is mechanical surface treatment through using alumina air abrasion. This creates a rougher surface which raises the zirconia surface area and improves surface energy, allowing better wetting by luting agent and creating a mechanical bond. (1)

It is too difficult to create a chemical bond between cements and zirconia due to its polycrystalline nature and lack of chemical structure that could chemically bond with dental cement. However, other studies showed that zirconia and adhesive resin cement that contained methacryloyloxy - decyl dihydrogen phosphate primer (MDP) bonded better and suggested that a chemical bond may have formed between the two materials. Furthermore, many studies showed that micromechanical and chemical surface treatments could achieve the most durable bond strength in traditional zirconia. (2)

One of the main drawbacks of conventional zirconia is; its relative compromised translucency, its layering with ceramic have been advocated to improve aesthetics. However, delamination has been reported by many researches. (3)

Translucent zirconia and multishaded zirconia have been developed to improve the final aesthetic outcome and have been advocated to be used as monolithic restorations. Nowadays, translucent zirconia becomes highly recommended as a fixed prosthesis as it enables better color appearance with shade degradation, eliminates the problems of porcelain layering, time waste and increased amount of tooth preparation. Traditional translucent zirconia made from partially stabilized zirconia has a higher fraction of cubic phase than conventional zirconia. (4)

Microstructural changes including porosities, additives, flaws, grain sizes, their boundaries, crystalline phase, and thickness have been used to create multishaded zirconia. Because light scattering at the alumina/zirconia interface is amplified, additives like alumina reduce translucency. Alumina should thus be avoided or its concentration should be decreased in order to increase translucency. Reduced translucency is caused by flaws like oxygen gaps outside of the polycrystal space lattice. (5)

In addition to reduction of alumina oxide (Al_2O_3) mass up to 0.05%, there has been an increase in yttria oxide (Y_2O_3) mass to 6.9% and the grain size <0.5. Hence, it is a promising material due to its excellent aesthetic properties and high strength about 1000mpa. Little information is available about the adhesion capabilities of translucent zirconia to adhesive resin cement. Investigating the bonding strength of translucent zirconia to adhesive resin cement might be beneficial in order to create long - lasting successful restorations with higher degrees of aesthetics. [(1)]

Therefore, the aim of this study was to determine how translucent zirconia's surface treatment affects the bonding strength compared to conventional zirconia.

2. Methodology

A total of 20 zirconia plates were assigned into two equal groups. Group (A) were constructed from translucent zirconia **(n=10)** and air blasted with 50µm aluminum oxide particles, and group (B) were constructed from conventional zirconia **(n=10)** and air blasted with 110µm aluminum oxide under the same conditions Conventional and translucent presintered zirconia blanks (ZOLID, Amanngerbach, England) were sectioned horizontally using diamond discs with water coolant in a sawing machine Isomet saw 4000 (Buehler Ltd, Lake Bluff, Illinois, USA) into bars and then into square plates, followed by sintering according to the manufacturer's instructions at 1450 °C, 7 hours. The final dimensions of zirconia were 10x10x2 mm^3 for each plate after sintering with shrinkage percentage of 0.4. The thickness of each specimen was verified using a digitalcaliper. Hence, zirconia specimens were then ultrasonically cleaned in ethanol for 20 minutes.

For standardizing the distance parameter an especially designed wooden holder has been used. The specimens were fixed inside it and, then inserted into an airblasting unit (Renfert BasicQuattro, Germany), where they were subjected to the same conditions of 2.5 bar of pressure for 15s at a 10mm distance and ultrasonically cleaned using distilled water in an ultrasonic bath (Sonorex RK100H, Bandelin, Germany) for 10 min and air - dried for 60 seconds.

Measurement of the specimen surface roughness of conventional and translucent zirconia specimens was obtained for all groups to perform morphological analysis. The arithmetic average roughness (Ra) of the zirconia surfaces were evaluated using an optical profilometer.

The surface topography of the zirconia plates was scanned before the bonding procedure using a scanning electron microscope (Inspect S, produced by FEI Company, Holland la 25 kV) at × 1000 and × 3000 magnifications attached with EDX Unit (Energy Dispersive X - ray Analyses), for the elemental analysis or chemical characterization of the sample.

3. Results

Descriptive data showing mean values and standard deviation of average roughness test, results measured in micro - meters (µm) as a function of material group following surface treatment.

The mean ± SD values of roughness average recorded for group (A) (0.251974±0.004962 µm) meanwhile the mean ± SD value recorded for group (B) was (0.251341±0.003445 µm). The difference in roughness average mean value between both groups was statistically non - significant as indicated by the t - test (t=0.445, P=0.6593 > 0.05) as shown in table (1) and figure (1).

Table 1: Comparison of average roughness test results (Mean ±SD) between both material groups after surface treatment in microns

Variables		Mean	SD	95% CI		Range	
				Lower	Upper	Mini.	Maxi.
Material group	Translucent	0.251974	0.004962	0.249682	0.002292	0.23	0.2582
	Conventional	0.251341	0.003445	0.249749	0.001591	0.2398	0.2574
t - test	t - value	0.445					
	P value	0.6593 ns					

Regarding the topographical features on the surface, it was noted that Al_2O_3 air abrasion revealed slightly increased surface roughness in the translucent zirconia plates than in the conventional ones when subjected to different sizes of alumina particles. The digital microscopic image of the conventional specimen showed a relatively uniform pattern of micro irregularities, shallow valleys, and broad peaks with an uneven pattern of micro irregularities histogram image figure (1), and the translucent ones showed a relatively uniform pattern of micro irregularities with deeper valleys and more pointed peaks figure (1) than those shown in the conventional microscopic images under the same conditions of pressure and time of exposure.

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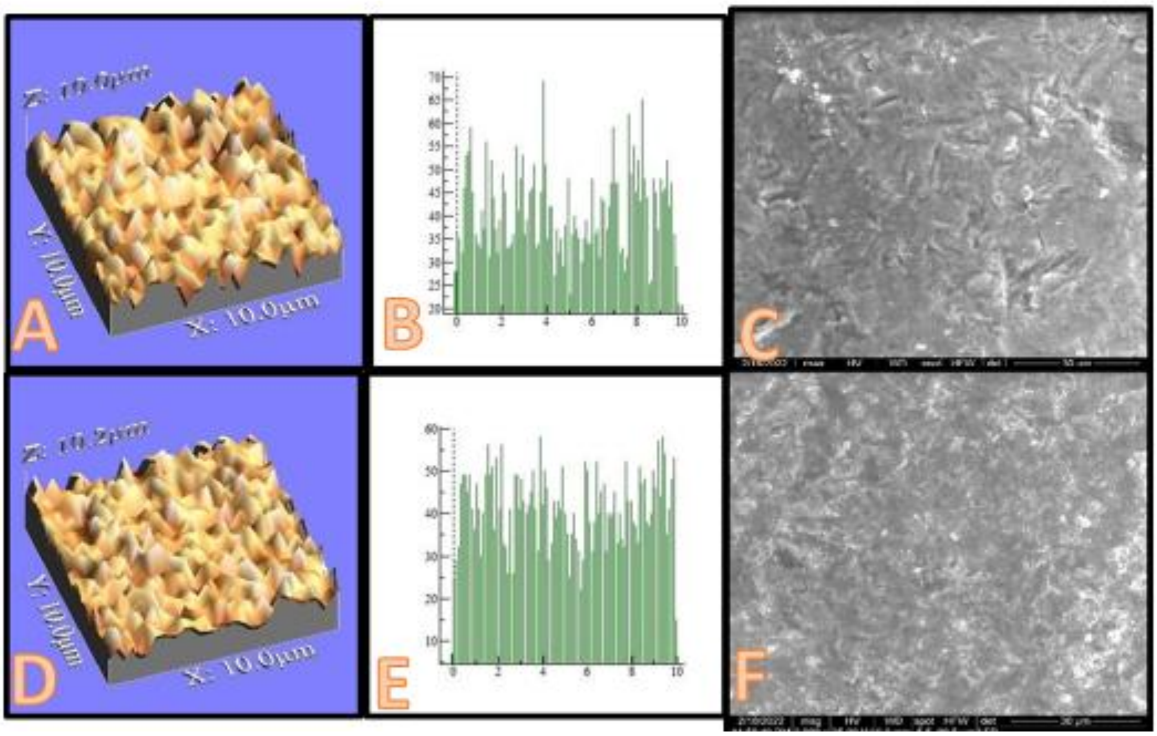

Figure (1) (a) 3D digital microscopic image of the airblasted conventional zirconia plate **(b)** Histogram of the image showed uneven patern of microirrigularities **(c)** Representative SEM image x3000 magnification of treated conventional zirconia plate (gp B)

Figure (1) (d) 3D digital microscopic image of the airblasted translucent zirconia plates **(e)** Histogram of the image showed uneven pattern of micro irrigularities. **(f)** Representative SEM image x3000 magnification of treated translucent zirconia plate (gp A).

Results of SEM and EDX Analysis after Alumina Blasting Procedure:

Scanning Electron Microscope with energy dispersive X - ray spectroscopy (SEM/EDX) of the specimens before bonding and cementing procedures figure (2) showed the tested conventional zirconia specimen and EDX analysis figure (2) revealed a higher percentage of zirconium oxide concentration (ZrO_2) than the values that were revealed in the translucent zirconia specimen SEM figure (2) and EDX analysis figure (2) which, showed a higher percentage of other oxides than, the conventional specimen.

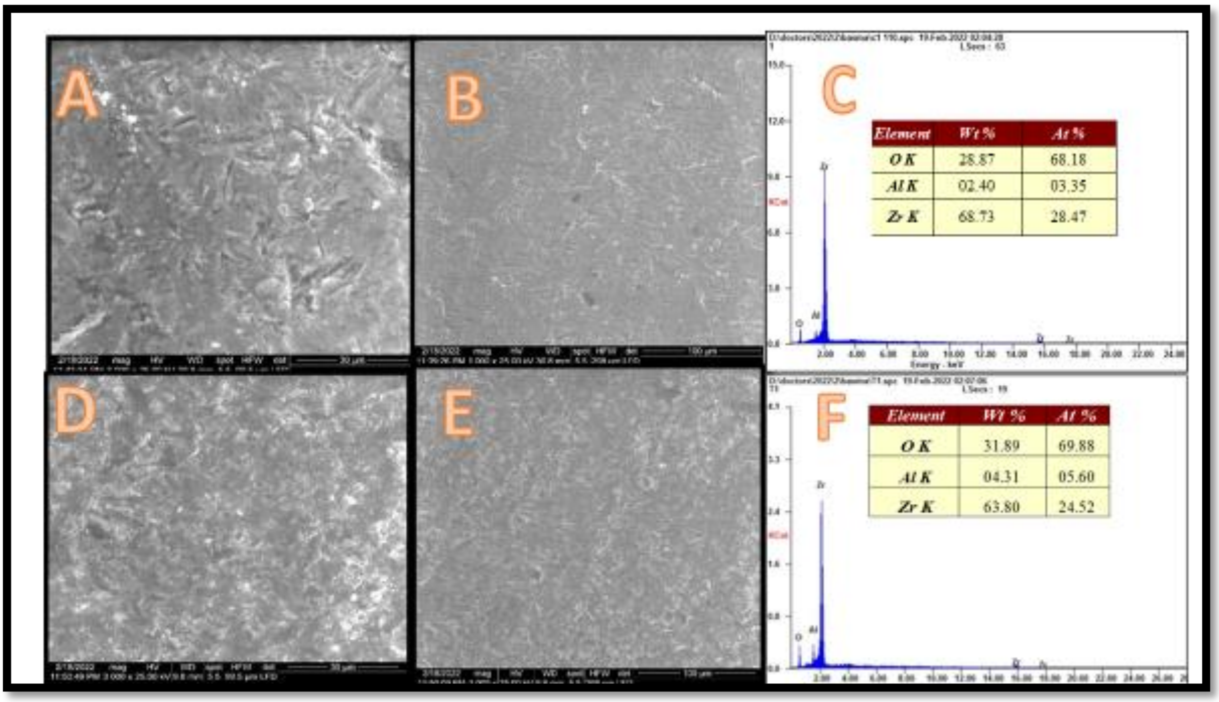

Figure (2) (a) Representative SEM image x3000magnifications of alumina blasted conventional zirconia. **(b)** Representative SEM image x1000 magnifications of alumina blasted conventional zirconia. **(c)** Elemental analysis of treated conventional zirconia withAl2O3 110μm.

Figure (2) (d) Representative SEM image x3000 magnifications of alumina blasted translucent zirconia. **(e)** Representive SEM image x1000 magnifications of alumina blasted translucent zirconia. **(f)** Elemental analysis of treated translucent zirconia with Al2O3 50μm.

4. Discussion

The current study sought to assess the impact of air abrasion with Al_2O_3 particles on surface roughness and morphology of translucent and conventional zirconia.

Zirconium oxide - based all - ceramic materials provide many benefits, including high flexural strength (> 1000 MPa) and attractive optical characteristics. The stabilizer most frequently employed in zirconia formulation is yttria (Y_2O_3). Compared to full cubic zirconia stabilization with higher yttria content (Y_2O_3> 8 mol%), partially stabilized zirconia (PSZ) was obtained by adding Y_2O_3 at a lower concentration (4 to 6 mol%). To increase zirconia's translucency, a full cubic stabilized monolithic zirconia (FSZ) has been produced. Reduced alumina content, relatively small grains, and the presence of optically isotropic cubic zirconia particles to reduce grain boundary light scattering have been used to create Y - TZP monolithic materials, which have higher translucency and less low - temperature degradation than conventional zirconia. [(6) (7)]

A popular surface preparation technique is aluminum oxide (Al_2O_3) particle air abrasion. This method's abrasive step eliminates the ceramic surface's contaminated layers, expands the area that is available for bonding, and enhances the flow of resin cement over the ceramic surface. [(6)]

After a pilot study was performed to test 50μm and 110μm alumina particles on both types of zirconia, the results showed that the conventional plates achieved higher bond strength when treated with 110 μm Al_2O_3, while the translucent one showed higher results with 50 μm Al_2O_3. For the translucent zirconia when the alumina particles were excessively big, rough zirconia surfaces were produced, and pits and grooves tended to become too wide and flat, which was harmful to cement microinterlocking. As a result, it's critical to pick the right particle size for successful bonding. In the current investigation, 50 μm alumina particle size was used, which was suggested or used in most studies to provide dependable binding strength to resin cement. [(8) (9)]

Concerning surface roughness, the results of the present study revealed that the highest value (0.2528) μm for the translucent group while, the lowest value was (0.2317) μm while, the highest value was recorded for the conventional group was (0.2574) μm and lowest value was (0.23) μm which, is not significant statistically and these results were in accordance with the findings of ([(1) (2) (10)] and in contrast to the finding of ([(11) (12)] this could be attributed to the difference in other parameters of pressure and time of specimen exposure.

EDX analysis after the alumina blasting procedure revealed peaks of zirconium oxides in both conventional and translucent plates with a much higher ratio for the traditional zirconia contrary to other oxides and alumina particles ratio which were higher in the translucent plates elemental analysis which may be the cause of the non - significant increase of surface roughness.

5. Conclusion

Both conventional and translucent zirconia's surface roughness increased after alumina blasting. Between various zirconia materials, no discernible changes were discovered.

However, controlled clinical trials are necessary to confirm the long - term bond durability before clinical recommendations can be given.

References

[1] Ruales-Carrera, Edwin, Paulo F. Cesar, Bruno Henriques, Márcio C. Fredel Mutlu Özcan, and Claudia AM Volpato. "Adhesion behavior of conventional and high-translucent zirconia: Effect of surface conditioning methods and aging using an experimental methodology. "Journal of Esthetic and Restorative Dentistry 31, no.4 (2019): 388 - 397.

[2] Yoshida, K. (2020). Influence of alumina air - abrasion for highly translucent partially stabilized zirconia on flexural strength, surface properties, and bond strength of resin cement. Journal of Applied Oral Science, 28.

[3] Inokoshi, M., Shimizu, H., Nozaki, K., Takagaki, T., Yoshihara, K., Nagaoka, N., Zhang, F., Vleugels, J., Van Meerbeek, B., & Minakuchi, S. (2018). Crystallographic and morphological analysis of sandblasted highly translucent dental zirconia. Dental Materials, 34 (3), 508–518.

[4] Shimizu, H., Inokoshi, M., Takagaki, T., Uo, M., & Minakuchi, S. (2018). Bonding efficacy of 4 - META/MMA - TBB resin to surface - treated highly translucent dental zirconia. Journal of Adhesive Dentistry, 20 (5), 453–459.

[5] Tabatabaian, F. (2019). Color Aspect of Monolithic Zirconia Restorations : A Review.28, 276– 287.

[6] Demir, N., Subasşi, M. G., & Ozturk, A. N. (2012). Surface roughness and morphologic changes of zirconia following different surface treatments. Photomedicine and Laser Surgery, 30 (6), 339–345.

[7] Elsaka, S. E. (2019). Optical and Mechanical Properties of Newly Developed Monolithic Multilayer Zirconia. Journal of Prosthodontics, 28 (1), e279–e284.

[8] Zhang, X. et al. (2021) ‘Effects of air - abrasion pressure on mechanical and bonding properties of translucent zirconia’. Clinical Oral Investigations, pp.19.

[9] Comino - Garayoa, R., Peláez, J., Tobar, C., Rodríguez, V., & Suárez, M. J. (2021). Adhesion to zirconia: A systematic review of surface pretreatments and resin cements. Materials, 14 (11).

[10] Schmid - Schwap, M., Graf, A., Preinerstorfer, A., Watts, D. C., Piehslinger, E., & Schedle, A. (2011). Microleakage after thermocycling of cemented crowns – A meta - analysis. Dental Materials, 27 (9), 855–869.

[11] Paper, C., Piva, A. D., Campos, F., & Bottino, M. A. (2011). Effect of sandblasting protocols on shear bond between zirconia/self - adhesive cement. December.

[12] Xiong, Y. et al. (2021) 'Effect of Airborne - Particle Abrasion Protocols and MDP - based Primer on the Bond Strength of Highly Translucent Zirconia Performed optical microscope and SEM observations', J Adhes Dent, 23 (5), pp.437–446. doi: 10.3290/j. jad. b2000249.