ECRONICON OPEN ACCESS

EC DENTAL SCIENCE
Research Article

Analysis of Zirconia Ceramic Surfaces with Different Surface Treatments by SEM

Zuhal Gorus[1] and Devrim Deniz Üner[2]*

[1]*Department of Prosthodontics, Harran University, Faculty of Dentistry, Sanliurfa, Turkey*

[2]*Department of Periodontology, Harran University, Faculty of Dentistry, Sanliurfa, Turkey*

***Corresponding Author:** Devrim Deniz Üner, Department of Prosthodontics, Harran University, Faculty of Dentistry, Sanliurfa, Turkey.

Received: May 17, 2019; **Published:** June 25, 2019

Abstract

Objective: The aim of this study is to evaluate the surface morphology of 3Y-TZP zircon ceramic crowns with different surface treatments through SEM scanning.

Materials and Methods: 15 samples from 3Y-TZP zirconia blocks were prepared. After polishing all the samples, they were randomly divided into 5 groups; control group, 2.5W Er:YAG laser irradiated group, 3.5 W Er:YAG laser irradiated group, CoJet group, and Al2O3-sandblasted group. Then, SEM images of each group were prepared and analyzed.

Results: SEM images of the research groups revealed no significant difference between the control group and the laser groups. Uneven and irregular surface textures were observed in the Al2O3-sandblasted group. In the CoJet group, these irregular surfaces were observed to have fewer gaps.

Keywords: *SEM; Laser; Sandblasting; 3Y-TZP; Cojet*

Introduction

The use of all-ceramic restorations has increased in recent years due to their fine esthetic appearances and lack of metal. In dentistry, zirconia, one of the high-resistance ceramic materials, is used as a core material in fixed prosthetics, in posts, and in implant and upper implant structures [1,2].

Being a polymorphic material, it exhibits a crystalline structure more than a crystal does, depending on temperature and pressure conditions. It has three forms [monoclinic (M), cubic (C) and tetragonal (T)]. Pure zirconia is in M phase at room temperature, and it stays stable until the temperature is 1170°C. The most frequently used zirconia in dentistry is the 3Y-TZP ceramic type. Transformation strengthening induced by stress is the only characteristic of 3Y-TZP ceramics, which grants them excellent mechanical features compared to other ceramics [3,4].

In order for a good connection to be on the restoration interface, roughening should be performed on the surface with a set of methods, among which we can count tribochemical silica coating (CoJet), sandblasting with Al_2O_3 and laser applications [5,6].

Studies performed in recent years have shown that sandblasting procedures do not have any negative effect and can be safely used on zircon ceramic restoration surfaces. Sandblasting increases the roughness of the surface, and in turn, the surface energy and wetting capacity of the restoration [7,8].

Er:YAG lasers are also known as hard tissue lasers. Er:YAG lasers have high affinity against the maximum absorption and hydroxyapatite under water during dental procedures, and they require the use of additional water and air spray for cooling during dental processes. Laser energy is absorbed by hydroxyl radicals within apatite crystal and water within the crystalline structure of the tooth [8]. The vaporization of water in the mineral structure creates a dramatic increase in volume and causes materials around it to move away. Decay removals and tooth preparations can be easily performed by using these lasers. Er:YAG lasers can be used in roughness procedures during the surface preparation of restorations [9,10].

Objective of the Study

The objective of this study is to analyze different methods, applied on zircon ceramic surfaces, through SEM.

Materials and Methods

The ceramic samples used in the study were obtained using 10 x 7 x 7 mm sized 3Y-TZP zirconia blocks. Zirconia blocks were cut under water cooling using a diamond disk (0.3 mm thick) specific to zirconia ceramic on a sample cutting device whose rotational speed was programmed to be 150 revolutions. Following the cutting process, 15 samples were obtained.

Afterward, the samples were sintered in a sintering furnace specific to 3Y-TZP blocks as recommended by the producer. Following the sintering stage, the samples were witnessed to have undergone an approximately 20% dimensional change, with their final sizes calculated as 7 x 7 x 5. In order to provide standardization on all the surfaces before performing surface treatments, the surfaces of the ceramic samples were polished under water for 15 seconds using SiC series abrasive discs (with 120, 220, 600 and 1200 grit ranges, Ballerup, Denmark) on an automatic polishing machine with 150 revolutions per minute. 15 obtained samples were divided into five sub-groups among themselves based on the surface treatments to be applied.

Group 1: No surface treatments were applied (control group) (Figure 1).

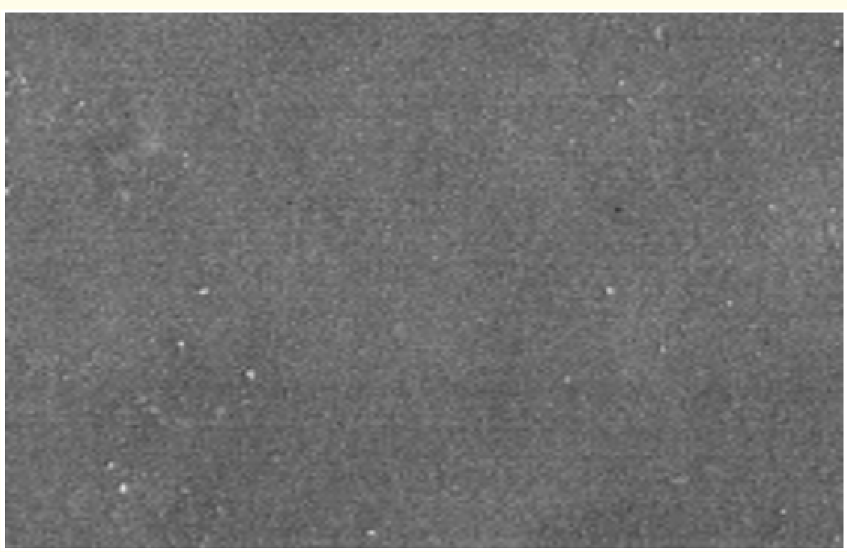

Figure 1: *Control group.*

Group 2: Er:YAG laser with a wavelength of 2940 nm, 2.5 W/250 mJ energy, and a frequency of 10 Hz, (Fotona Laser AT Fidelis Plus III, Slovenia), was applied for 20 seconds to the ceramic surfaces prepared in the second group (Figure 2).

Figure 2: *Surface image on Cojet group.*

Group 3: The ceramic surfaces in the third group were sandblasted with Korox 50 (Bego, Germany) for 20 seconds from a distance of 10 mm with a 2.5 bar pressure in Ata dental laboratory in Gaziantep, Turkey. Afterward, they were cleaned ultrasonically in ethanol solution for 20 minutes and air-dried (Figure 3).

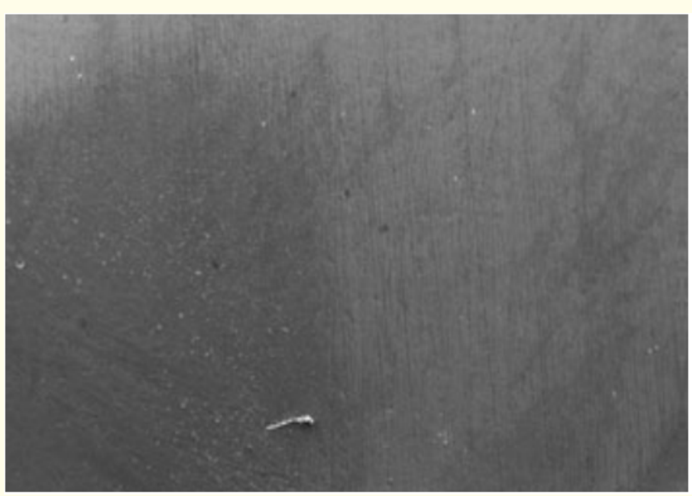

Figure 3: *Image that be formed with Er: YAG laser on surface.*

Group 4: Silica-coated Al_2O_3 particles 30 µm in diameter (CoJet, 3P ESME, Seefeld, Germany) were applied to the prepared ceramic surfaces for 10 seconds with a 2.5 bar pressure. The main point to take into consideration during this application was to ensure a 10 mm distance between the intraoral sandblasting equipment and the samples. After the silica-coated ceramic surfaces were coated with Al_2O_3 particles, a silane system was applied to the ceramic surfaces with a brush (ESME Sil, 3P ESME, Seefeld, Germany), left to dry for 60 seconds, and then air-dried (Figure 4).

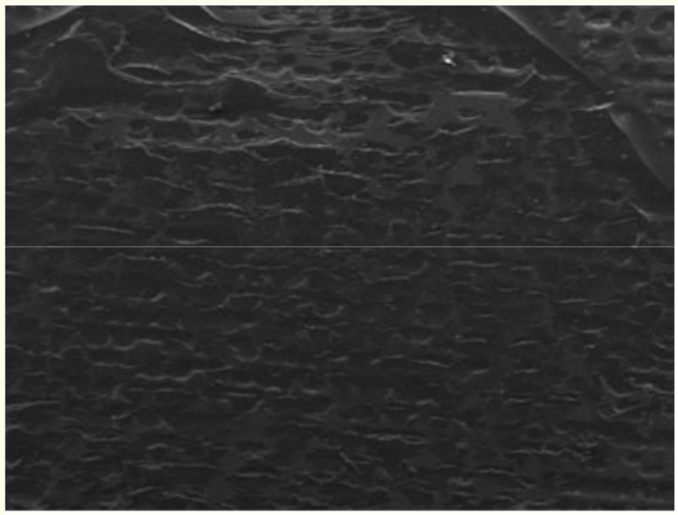

Figure 4: *Image of the surface that be formed by Korox 50 blasting.*

Group 5: Er:YAG laser with a wavelength of 2940 nm, 3.5 W/350 mJ energy, and a frequency of 10 Hz, (Fotona Laser AT Fidelis Plus III, Slovenia), was applied for 20 seconds to the prepared ceramic surfaces.

The test samples to be examined for SEM analysis were analyzed in Fırat University Electron Microscope Laboratory (FÜEM Lab) after being left idle in dry air for one night and then being coated with 100-Â-thick gold with a vacuum.

Results

Following SEM analysis, a highly flat surface structure was observed in the control group since no treatments were applied to the surfaces of these samples. No significant differences were observed between the control group and the laser group. While the images of the laser group were similar to those of the control group, little marks left on the surface by the laser tip were observed in the former. Group 3 was seen to contain rough and irregular surfaces. A less rough surface structure was observed in Group 4, though it had similar surface structures to those of the Group 3 samples.

Discussion

All-ceramic materials have become an alternative to metal ceramic restorations thanks to their esthetic characteristics similar to natural tooth structure, chemical stabilities, and biological compatibilities. The need for esthetic restorations in our day has enabled these systems to develop more. Zirconia, one of such systems, is used in dentistry in three methods (Y-TZP, ZTA, and Mg PSZ), and Y-TZP is the most frequently used ceramic type [11,12].

The latest studies have reported that the long-term success levels of zirconia-based all-ceramic restorations depend on the preparation techniques of inner ceramic surfaces before cementation, characteristics of the attaching cement, and the durability and the strength of the attachment between the cement and the ceramic [13-16]. To this respect, changes in the surface morphology of zirconia ceramic samples, to which different surface treatments were applied, were analyzed with SEM in our study.

Some researchers have stated that roughening the inner surfaces of ceramic restorations increase the surface area and enable the wetting capability of ceramic surfaces of resin-based materials to increase [5-7,9].

Some studies have reported that the sandblasting method creates rougher surfaces, while Er:YAG laser leaves little marks on the surface [1,3,4] and it can be used on ceramic surfaces to create a micromechanical support. Besides, it has been reported that regardless of the particle height, there will always be some levels of roughness on the surface [12,14], which is in parallel with the results of our study. In our study, surface changes occurred in the CoJet group, but these surfaces still had less rough structures than those of the Korox 50 group.

Some researchers have expressed that laser applications cause microcracks on the surface [8,13,15]. No microcracks were observed in our study, but laser tips left some little marks on the surface.

A few researchers have deemed it possible to create changes on the surface by increasing the laser power [9,10,15]. However; we are of the opinion that high-power laser radiation can cause undesired morphological changes on the surface.

Conclusion

1- The sandblasting method applied to the ceramic surface provides more roughness on the surface than Er:YAG laser applications. This method may provide an increase in the attachment strength of zirconia crowns by forming micro-retentive grooves.

2- Er:YAG laser application creates scratches on the surface, which are insignificant.

Disclosure

All authors listed have contributed sufficiently to the study to be included as authors, To the best of our knowledge, no conflict of interest, financial or other, exists.

Bibliography

1. Madfa AA., *et al*. "Use of Zirconia in Dentistry: An Overview". *The Open Biomaterials Journal* 5.1 (2014): 1-7.
2. Manicone PF., *et al*. "An overview of zirconia ceramics: Basic properties and clinical applications". *Journal of Dentistry* 35.11 (2007): 819-826.
3. Kara O., *et al*. "Effect of Various Lasers on the Bond Strength of Two Zirconia Ceramics". *Photomedicine and Laser Surgery* 33.2 (2015): 69-76.
4. Atsu SS., *et al*. "Effect of zirconium-oxide ceramic surface treatments on the bond strength to adhesive resin". *Journal of Prosthetic Dentistry* 95.6 (2006): 430-436.
5. Della Bona A., *et al*. "Effect of surface treatments on the bond strength of a zirconia-reinforced ceramic to composite resin". *Brazilian Oral Research* 21.1 (2007): 10-15.
6. Harding AB., *et al*. "The Effect of Surface Treatment of the Interfacial Surface on Fatigue-Related Microtensile Bond Strength of Milled Zirconia to Veneering Porcelain". *Journal of Prosthodontics* 21.5 (2012): 346-352.

7. Raucci-Neto W., *et al*. "Influence of Er: YAG laser frequency on dentin caries removal capacity". *Microscopy Research and Technique* 74.3 (2011): 281-286.

8. Cavalcanti AN., *et al*. "Evaluation of the Surface Roughness and Morphologic Features of Y-TZP Ceramics after Different Surface Treatments". *Photomedicine and Laser Surgery* 27.3 (2009): 473-479.

9. Turp V., *et al*. "Evaluation of air-particle abrasion of Y-TZP with different particles using microstructural analysis". *Australian Dental Journal* 58.2 (2013): 183-191.

10. Van As G. "Erbium lasers in dentistry". *Dental Clinics of North America* 48.4 (2004): 1017-1059.

11. Kim HJ., *et al*. "Effect of zirconia surface treatments on the shear bond strength of veneering ceramic". *Journal of Prosthetic Dentistry* 105.5 (2011): 315-322.

12. Rosentritt M., *et al*. "Influence of substructure design and spacer settings on the in vitro performance of molar zirconia crowns". *Journal of Dentistry* 37.12 (2009): 978-983.

13. Çağlar İ and Yanıkoğlu N. "The Effect of Sandblasting, Er: YAG Laser, and Heat Treatment on the Mechanical Properties of Different Zirconia Cores". *Photomedicine and Laser Surgery* 34.1 (2016): 17-26.

14. Gomes AL., *et al*. "Influence of sandblasting granulometry and resin cement composition on microtensile bond strength to zirconia ceramic for dental prosthetic frameworks". *Journal of Dentistry* 41.1 (2013): 31-41.

15. Kirmali O., *et al*. "Shear Bond Strength of Veneering Ceramic to Zirconia Core After Different Surface Treatments". *Photomedicine and Laser Surgery* 31.6 (2013): 261-268.

16. Koçak DA and Türker YDDŞB. "DHekimliğinde Zirkonyum". Atatürk Üniversitesi Diş Hekim Fakültesi Derg (2014).

Volume 18 Issue 7 July 2019