SEM ANALYSIS OF ZIRCONIA-DENTAL MATERIAL

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Abstract:

In dentistry, zirconia is used as a framework for dental prostheses and has been traditionally covered with porcelain to provide excellent aesthetics. The purpose of this study is to evaluate the effects of surface polishing on the properties of zirconium dioxide (Zirconia), the Tizian material, from Schutz Dental. The microstructural tests were carried out using an electron scanning electron microscope, VegaTescan. The images show a more pronounced action of the felt and Al_2O_3 powder on the material compared to mechanical polishing by sandpapers. From the analysis of the distribution of the chemical elements we can see a good homogeneity, which leads to the maintenance of the chemical, physical and mechanical properties in all the areas of this material.

Keywords: roughness, zirconia, Al_2O_3 powder

INTRODUCTION

The popularity and clinical use of dental zirconia has increased due to its superior physical properties, high aesthetic potential, biocompatibility and chemical stability. In dentistry, zirconia is primarily used as framework for fixed dental prostheses and has been traditionally covered with porcelain to provide good aesthetics. [1]

Zirconia is a polycrystalline ceramic that can be found in three crystallographic forms depending on temperature: monoclinic, tetragonal and cubic [2]. Dental zirconia is stabilized by metal oxides, such as yttria (Y_2O_3) to allow tetragon formation at room temperature [3]. Requests may cause microfissures that generate stretching tensions and thus induce the transition from the tetragonal phase to the monoclinic phase, producing an increase in localized volume [4].

Several studies have shown that 25 µm diamond paste polishing increases zirconia resistance, while rough grinding will decrease its strength. However, some studies show that finishing the surface with fine or coarse diamond stones decreases the strength of zirconium [5, 6]. The adverse effects of surface grinding are assumed to be caused by the heat produced by friction, [7] which exceeds the inverse transformation of temperature, causing a phase change from monoclinic to tetragonal, which may weaken zirconia [8]. In addition, increased surface roughness have a negative impact on the biological integration with development of bacterial biofilms [9-12].

AIM OF THE STUDY

The purpose of this study is to evaluate the effects of surface polishing on the properties of dental zirconia.

MATERIALS AND METHODS

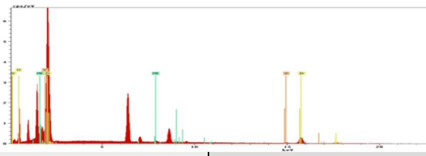
The most used method in zirconium structure manufacturing is the CAD / CAM milling from a solid block. Zirconium blocks are obtained of dried zirconium powder, isostatically pressed and incompletely sintered. After milling, zirconium is completely sintered in an oven at 1350-1500^0C to obtain the final shape, strength and physical properties.

Three samples of 0.5 cm diameter were cut from a fixed prothesis framework (Tizian material, from Schutz Dental) and embedded in polymeric resin. These samples were subject to the mechanical polishing with sandpapers 600,1200 grit and felt with 0.3 μm alumina powder.

Figure 1 *The main Zirconia sample*

The quantitative presence of the chemical elements in the material is shown in Table 1. The chemical composition is given in mass and atomic percentages. Also, Table 1 presents the error of the EDS detector specific to each identified chemical element.

Table 1. *Chemical composition of dental Zirconia*



Element	**YEAR**	**Net**	**[wt.%]**	**[norm. wt.%]**	**[norm. at.%]**	**Error %**
Zirconium	40	6632	48.16	48.16	14.95	0.43
Oxygen	8	11164	47.41	47.41	83.89	1.52
Yttria	39	761	2.88	2.88	0.92	0.15
Hafnium	72	1704	1.55	1.55	0.25	0.08
		Sum:	99.99	100	100	

The presence of the elements Y and Hf is due to the zirconium and they do not negatively influence the corrosion resistance or the hardness of the dental material.

The microstructural tests were carried out using an electron scanning electron microscope (SEM) by VegaTescan, the LMH II model (fig. 2).

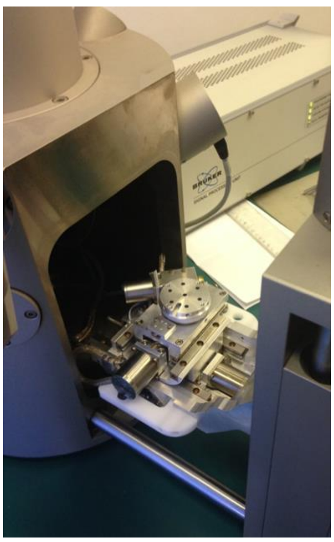


Figure 2. *Electron scanning microscope*

RESULTS AND DISCUSSIONS

The experimental results obtained by scanning electron microscopy are presented for the analysis of the effects of surface polishing techniques.

The 3D) images of the dental zirconia surface condition after mechanical polishing with sandpapers 600, 1200 grit and felt with 0.3 μm alumina solution.

The images (micrometric and submicrometric scale) show the state of the surface without ultrasonic cleaning or methods for removing scrap materials used for grinding.

The images in Figure 3 show a surface with a uniform orientation of the surface asperities, located in the dimensions of 2-3 μm between them and with submicronic heights (300-500 nm, Fig. 3 c) and d)).

Figure 4 shows the distribution of the Zr, O, Y and Hf elements of which Y and Hf are accompanying elements on the surface of a zirconia dental element.

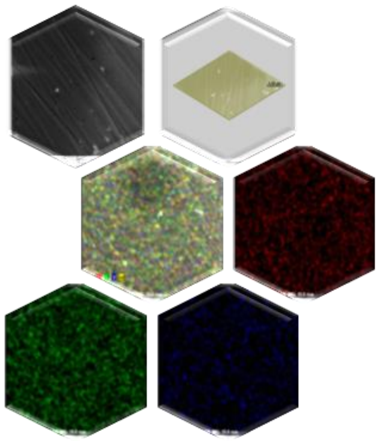


Figure 4. *The distribution of Zr, O, Y and Hf elements*

From the analysis of the distribution of the component elements we can see a good homogeneity of the chemical elements in the alloy, which leads to the maintenance of the chemical, physical and mechanical properties in all the areas of this material.

Figure 5 shows the surface of dental zirconia, 2D (a and b) and 3D (c and d) images polished to sandpaper 1200 grit a) and c) 1000:1 respectively b) and d) 5000:1. A lower surface roughness is observed compared to the 600 grit polished sample. A surface structure was made at a micron level.

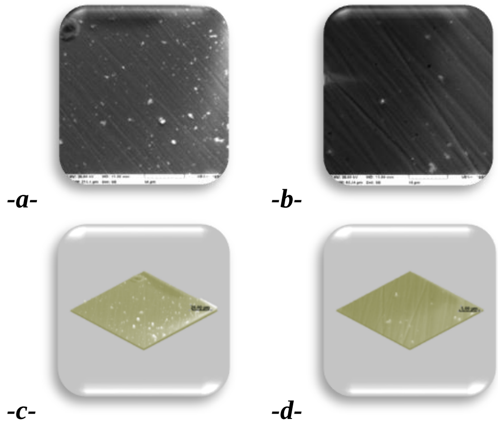


Figure 3. *Zirconia dental material, 2D (a and b) and 3D (c and d) images polished to 600 grit a) and c) 1000*:1 *respectively b) and d) 5000*:1

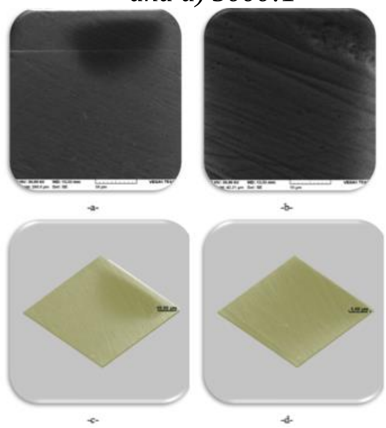


Figure 5. *Dental Zirconia, 2D (a and b) and 3D (c and d) images polished to 1200 grit a) and c) 1000*:1 *respectively b) and d) 5000*:1

The distances between the processed material areas are at submicron level (300-500 nm) and the surface roughness is below 300 nm. The surface of the material behaves similarly to the previous process.

The 3D appearance of the surface shows the homogeneity of the material.

The distribution of the main chemical elements is presented in fig.6.

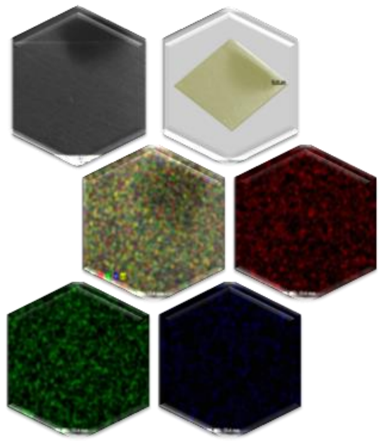


Figure 6. *The distribution of Zr, O, Y and Hf elements*

From the distribution of the main components (Zr and O) and accompanying elements (Y and Hf) shown in fig.6, the chemical homogeneity of the material is observed.

The images from figure 7, show a more pronounced action of the felt with alumina powder on the material compared to mechanical polishing by sandpapers.

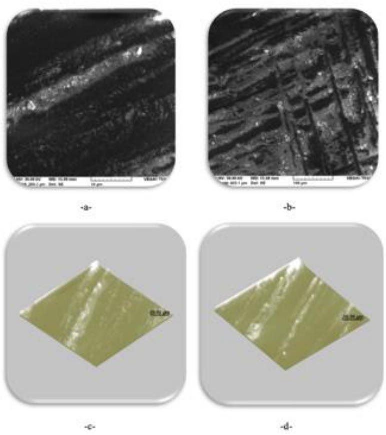


Figure 7. *Dental Zirconia, 2D (a and b) and 3D (c and d) images polished to felt a) and c) 1000*:1 *respectively b) and d) 5000*:1

The general distribution of the elements (fig.8) indicates an accentuated oxidation of the areas from which the material was detached.

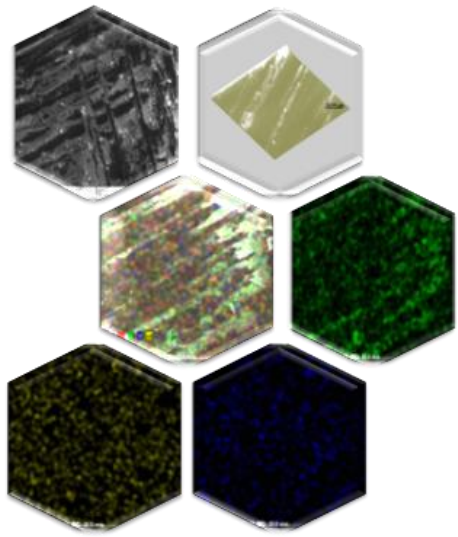


Figure 8. *The distribution of Zr, O, Y and Hf elements*

CONCLUSION

It has been shown that surface grinding significantly affects the state of the surface of the zirconium samples.

The images show a more pronounced action of the felt + Al powder2O3 on the material compared to mechanical machining by grinding. It has been noticed that mechanical polishing to the sandpaper 1200 grit exhibits the smooth surface.

The chemical analysis of the material identified elements of oxygen (to one energy) and zirconium (at three energies) as well as the accompanying elements yttria and hafnium.

From the analysis of the distribution of the component elements we can see a good homogeneity of the chemical elements in the alloy, which leads to the maintenance of the chemical, physical and mechanical properties in all the areas of this material.

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