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Effect of finishing process on the surface quality of Co-Cr-Mo dental alloys

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Abstract: Preparatory procedures for the material have a significant influence on the surface stereometry of the material. This study investigated the effect of the electropolishing process on the surface quality of metallic prosthetic constructions based on Co-Cr-Mo alloys. It has been found that the process of electropolishing prevents to excessive development of the surface of a material and consequently improves surface quality.

Key words – biomedical engineering, surface roughness, casting alloy, quality

1. Introduction

Biomedical engineering is an interdisciplinary field of knowledge whose main goal is the constant development of medical techniques. An important problem frequently considered as negligible is the quality control of each component in the manufacturing process of prosthetic work and influence of its properties on fitting to the patient's mouth (BIAŁAS A. 2008; PANEK H., BARZYK M., NAWROT P., NAPADŁEK P., ŚPIKOWSKA-SZOSTAK J. 2009, HĘDZELEK W., URBANEK M., WASIAK W. 1998/1999, JOSEPH D. BRONZINO 2000). Regardless of the type of product (elements of prosthetic restorations) the primary factors in achieving a high quality are: technical aspects, material selection and quality of service (DRAGO C., PETERSON T. 2014, KOCHANEK-LEŚNIEWSKA A., CIECHOWICZ B., WOJDA M., MICHALIK R. 2012., POLAK A.2015). During the production of the final product a number of inconsistencies may occurring the production process; from bad design due to the use of improper methods during the manufacturing process, to the use of different methods of finishing treatment (mechanical or chemical treatment) (KEDICI S. P., AKSUT A. A., KILIÇARSLAN M. A., BAYRAMOGLU G., GOKDEMIR K. 1998, KHAMIS E., SEDDIK M., 1995, LIN M. H-Y., BOWERS B., WOLAN J.T., CAI Z., BUMGARDNER. 2008, MAKOWSKA J. D. WALCZYŃSKA A. 1990).

The aim of this study is to demonstrate the relationship between the use of the electropolishing process and the quality of the surface layer of prosthetic construction.

2. Experimental

For research the dental alloy - Collado CC has been used. This type of alloy has chemical composition $Co_{59,0}Cr_{25,5}Mo_{5,5}W_{5,0}$and a low content of elements such as Ga (3.2%) Nb, Fe, B (less then 1%) is an alloy without Ni and designed to perform metal structural work (i.e. partial dentures).

As the most famous process often used in the final treatment metallic construction for smoothing and cleaning surface, replacing the traditional mechanical processing is electropolishing (GUPTA K.P. 2005), the tested sample has been subjected to electrolytic polishing process.

Parameter determining the speed of the electropolishing process (chemical processing) include current density, in this study, the current density was $i = 0.25 A/cm^2$. The working solution was a glycol aqueous solution of sulfuric acid and hydrochloric acid for a constant temperature of 30 °C and the process was continued for 10 minutes. The measurement results were compared to an untreated sample (Table 1).

The paper presents the most representative results of surface topography casting of alloy based on Cr-Co-Mo. In the paper the roughness analysis is performed - surface roughness measured with pin profilometer (Taylor Hobson), measuring section 4 mm for each sample. To better illustrate the results of surface roughness the 3D images with optical microscope Olympus (with EPI overlay) were carried out.

Table 1. Determination of Collado CC based Cr-Co-Mo alloy samples

Dental Alloy - Collado CC	
current density *i*, A/cm^2	**symbol**
0	1
0.25	2

Source: own study

3. Results

In Figure 1 the determined surface profiles for sample 1(non-treated) and 2 (after electropolishing process, i = 0.25 A/cm^2,t = 10 min) are presented. With respect to the profilometry roughness measurements the roughness parameters recorded during analysis are shown in Table 2. For comparison a set of the parameters i.e. *Ra*, *Rz* and *Rt* was taken into account – as in the previous works of the team (RADOMSKA K., PAWŁOWSKA G., KLIMECKA-TATAR D. 2015a,b,c). The parameter *Ra* is the arithmetic mean deviation of roughness profile (arithmetic average of absolute values), *Rz* parameter indicates the amount of roughness by 10 points (expresses the sum of the maximum value of profile peak height on the profile curve, and the maximum value of profile valley depth in a sampling length), and the parameter *Rt* determines the total amount of the profile.

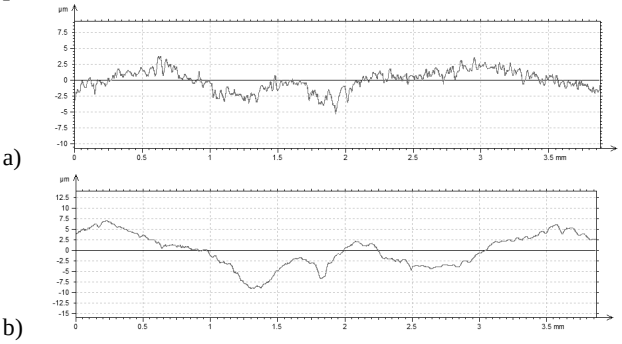

Fig. 1. Analysis of the local areas (profile) of dental alloy Collado CC: a) sample 1 without electropolishing; b) sample 2 after electropolishing process

Source: own study

Table 2. Selected surface roughness parameters determined for Collado CC based Cr-Co-Mo alloy samples

Parameters	Sample 1	Sample 2
Ra, µm	1,23 ± 0,09	0,84 ± 0,07
Rt, µm	9,00 ± 0,47	6,27 ± 0,38
Rz, µm	8,02 ± 0,09	4,35 ± 0,01

Source: own study

From the obtained results, presented in Table 2 and graphically in Figure 2, results are that the surface of sample 2 is substantially smoothed by the applied chemical treatment.

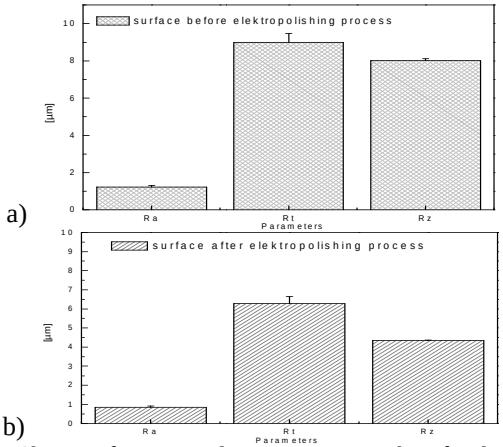

Fig. 2. Change of Ra, Rz and Rt parameters values for dental alloy Collado CC: a) sample 1 without electropolishing; b) sample 2 after electropolishing process

Source: own study

The confirmation of the results are 3D images of studied surfaces. Pictures were taken with an optical microscope with EPI overlay at 50X magnification. As a result of electropolishing, surface of the sample 2 is significantly smoother (Fig. 3).

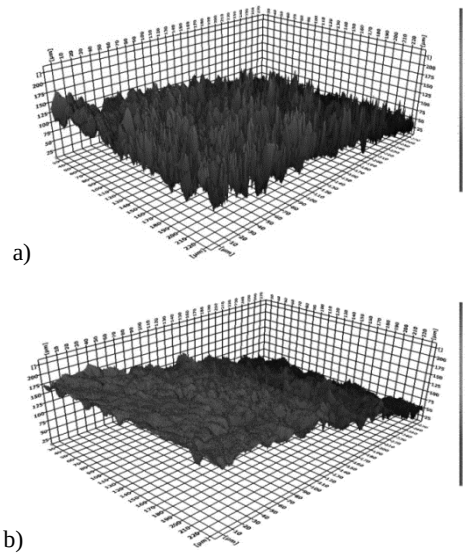

Fig. 3. Surface topography image of dental alloy Collado CC: a) sample 1 without electropolishing, b) sample 2 after electropolishing process

Source: own study

5. Summary and conclusions

After the electropolishing process, the roughness parameters are significantly lower than those of the starting sample. Microscopic examination confirmed that this process contributes to the smoothing surface of the prosthetic construction and improve product quality.

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