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DIFFERENCE BETWEEN ZIRCONIUM CROWNS AND STAINLESS STEEL CROWNS IN PREMOLAR PROSTHETICS

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A B S T R A C T	K E Y W O R D S
One of the reasons for the rejection of the use of CAD/CAM technologies in dentistry is reports of the insolvency of all-ceramic frame restorations made of polycrystalline ceramics based on zirconium dioxide and chipped veneers [1, 2]. The discrepancy in the recommendations for the manufacture of frame all-ceramic restorations raises a number of questions. Sandblasting is still widely used to improve surface roughness, strengthen bonding between the veneer and the frame and increase the strength of the connection during cementing.	

Introduction

According to the theory, the resulting microcracks cause a phase transition from the metastable tetragonal lattice structure to the monoclinic lattice structure. This is accompanied by an increase in volume by 4-5%. This allows you to block cracks by creating compressive stresses, but at the same time changing the phase ratio. After shot blasting of the surface, the so-called reduction firing is recommended. High-temperature exposure can promote reverse phase transitions. However, high-temperature exposure can lead to the removal of expansion blocks and further crack propagation. The analysis of the literature in order to clarify the chemical elements of this problem led to diametrically opposed opinions about the qualitative effect of abrasive and heat treatment on tetragonal zirconium dioxide. Therefore, it is necessary to find out the nature and extent of the influence of sandblasting and diamond tool processing on the strength properties and phase state of YTZP samples, as well as the advantages of "regenerative" firing to restore the original properties of the material and the phase state of YTZP. The study of this issue can solve many problems associated with the violation of the integrity of all-ceramic dentures. Our clinical studies have demonstrated the excellent strength and functional properties of zirconium dioxide ceramics. 100% of the manufactured bridges, regardless of the manufacturing system, retained the integrity of the restoration for more than two years of follow-up. At the same time, some patients complained about the violation of the integrity of previously made zirconium dioxide frame prostheses and chipped ceramic veneers. The existence of this problem is also confirmed by numerous literature data. A comprehensive analysis of the failures of previous treatment showed that in most cases they were due to the negligence of technical or clinical treatment protocols. The process of manufacturing the frame includes elements of polishing and heat treatment. A detailed study of the manufacturing process revealed discrepancies in the recommendations for the treatment of ceramics based on zirconium dioxide. Therefore, the study was undertaken to determine the nature and extent of the influence of sandblasting and diamond tool processing on the strength properties and phase state of zirconium dioxide (YTZP) ceramics samples, as well as the possibility of "regenerative" firing to restore the original properties of the material and the phase state of zirconium dioxide.

The purpose of the study: to determine the nature and degree of influence of sandblasting and diamond tool processing on the strength properties and phase state of zirconium dioxide.

Materials and methods: Standard blocks of pre-synthesized ceramics based on zirconium dioxide (VITA InCeram YZ Cubes for in Lab, Vita) were used as a test material for automated production of fixed prosthesis frames using the CEREC in Lab system (Sirona, Switzerland). Zahnfabri was used as a test material. All samples were finally synthesized in the Zyrcomat T furnace (Vita Zahnfabrik, Germany) at a temperature of 1500°C for 8 hours in accordance with the manufacturer's recommendations. Samples of a beam shape with a rectangular cross-section were tested. Samples of the first series (control (K)) were subjected to additional mechanical and thermal treatment. The samples of the second series (P) were sandblasted for 10 s at a distance of 10 mm from the surface using 50 μm Al2 O3 particles in a sandblasting machine. Samples of the third series (PO) were subjected to similar sandblasting in a sandblasting apparatus, followed by "restorative" firing at 1000 °C for 15 min. Samples of the fourth series (A) were subjected to grinding of turbine tips under intensive water cooling using fine-grained diamond burs Red Code ZR8850.314.016 (Komet, Germany). The fifth series (AO) consisted of samples treated with diamond burs and further synthesized according to the scheme described above. The total number of samples was 100 (20 from each series). All specimens were subjected to destruction on a universal testing machine Instron 5581 (Instron Limited, High Wycombe, UK), equipped with a 2000 N load cell, to study the strength of three-point bending. The study was conducted at the Baikov Institute of Metallurgy and Materials Science of the Russian Academy of Sciences in accordance with the requirements of ISO 6872:2008 (Dentistry - ceramic materials). The strength was calculated from the length and width of the specimen, the distance between the loading points, and the maximum load at which fracture occurs at temperature. The loading speed during the tests was 0.5 mm/min. The distance between the beams was 10 mm. The maximum stress in the sample was calculated according to the equation: σizg = 3PL/2BW2, where σizg is the bending strength, MPa; P is the maximum load, N; L is the distance between the supports, B is the width of the specimen, W is the height of the specimen, mm The numerical data were subjected to statistical processing. For visual analysis of experimental objects, a Tescan VEGA II microscope (Czech Republic) was used and scanning electron microscopy (SEM) methods were used at magnification up to 1000x. To study the morphology of particles in the raster mode, the samples were glued to copper substrates using conductive carbon glue and sprayed with a layer of gold (Univex 300 sputtering plant - "Leybold", Germany; Fine Coat - "JEOL", Japan). All received photographs were recorded. To identify qualitative and quantitative phase changes on the surface of the treated samples, the X-ray phase analysis (XRF) method for polycrystalline samples was used. This method allows you to conduct research without scraping the material in the mortar used in powder analysis. This is very important for the objectivity of this study, since any mechanical impact can affect the data obtained. The research and analysis of the results were carried out at the Institute of Crystallography of the Russian Academy of Sciences and the Kurchatov Center for Synchrotron Radiation and Nanotechnology on the MarResearch diffractometer at the Belok research station (Germany). The diffractometer was focused from the sample using the Bragg-Brentano method. The content of the crystalline phase on the surface of the sample was estimated by integral maxima in the range of angles 2° - 40° 2θ. The amount of crystalline phase in the sample was determined by the relative integral activity, which is proportional to the first. For the analysis, the peak with the highest integral activity was selected. After selecting the highest peak, the relative intensity was calculated as a percentage of it. At least three studies were conducted with each sample. All data were recorded and analyzed. RESULTS AND DISCUSSION Evaluation of the strength of samples of metastable zirconium dioxide under three-point bending. The results of the studies showed that both abrasive mechanical action and sintering of additives on zirconium dioxide samples affect their strength characteristics. Comparison of the average results of studies by series (see table) shows that there is a certain dynamics of changes in the flexural strength of zirconium dioxide ceramics. In both cases, when polishing the surface, the strength tends to change upwards, and further heat treatment reduces the strength, although its values remain higher than those of the controls. Statistical processing of the results of the study was carried out using the ANOVA analysis of variance by checking the significance of differences between the means by comparing variations. Based on the data obtained and their statistical processing, a diagram was constructed showing the relationship between the mean and median values and the stability of the properties of the material samples in the series (Fig. 1). Mean values are represented by squares in squares, median values by horizontal lines in squares, and maximum and minimum values by dashed lines at the top and bottom. The specimen with the highest average value of the bending strength belongs to the P series (1326.26 ± 174 MPa). However, as in the case of the A series (1110.73 ± 152 MPa), the samples of this series, despite the high strength values, also show the maximum spread of values that are the so-called emissions, i.e. indicate instability: 869.00 ± 100 MPa for the PO series and 1043.95 ± 84 MPa. However, both values remain high compared to the K control, which averages 824.95 ± 91.9 MPa; the difference between the groups K-P, P-PO, K-A and K-AO is significant (Fig. 2). Thus, sandblasting significantly increases the bending strength values of zirconia ceramic samples compared to control. A similar pattern is observed in the case of zirconium dioxide samples exposed to diamond tools: in comparison with the control K, the bending strength in group A increases significantly. The K series is the most stable in the analysis of variance. The variation in the values of groups P and A indicates relative instability in comparison with the groups PO, AO and K.

Conclusion: the local inclusion of the monoclinic phase on the surface of the skeleton leads to an inverse ratio of the coefficients of thermal expansion. This can adversely affect the adhesion of the ceramic cladding to the frame. Subsequent reduction firing reduces the strength of the material, but not lower than the original value. This is due to the partial removal of blocking "distracting pillows" at the edges of the cracks formed. However, additional firing normalizes the phase composition, KTLR of the frame surface and its interaction with the ceramic lining, which ultimately contributes to the normal functioning of the prosthesis in the oral cavity. This is due to the fact that the presence of compressive stresses on the inner surface of the frame in this case has a positive effect.

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