

Grizodub V. I., Ryaboshapko O. A., Yakimenko D. O., Maksimenko P. V. Bioinert ceramic inserts with zirconium oxide: manufacturing technology and clinical application. *Journal of Education, Health and Sport*. 2022;12(3):350-355. eISSN 2391-8306. DOI <http://dx.doi.org/10.12775/JEHS.2022.12.03.031> <https://apcz.umk.pl/JEHS/article/view/51371> <https://zenodo.org/record/12190347>

The journal has had 40 points in Ministry of Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Education and Science of December 1, 2021. No. 32343. Has a Journal's Unique Identifier: 201159. Scientific disciplines assigned: Physical Culture Sciences (Field of Medical sciences and health sciences); Health Sciences (Field of Medical Sciences and Health Sciences).

Punkty Ministerialne z 2019 - aktualny rok 40 punktów. Załącznik do komunikatu Ministra Edukacji i Nauki z dnia 1 grudnia 2021 r. Lp. 32343. Posiada Unikatowy Identyfikator Czasopisma: 201159. Przypisane dyscypliny naukowe: Nauki o kulturze fizycznej (Dziedzina nauk medycznych i nauk o zdrowiu); Nauki o zdrowiu (Dziedzina nauk medycznych i nauk o zdrowiu).

© The Authors 2022;

This article is published with open access at Licensee Open Journal Systems of Nicolaus Copernicus University in Torun, Poland  
Open Access. This article is distributed under the terms of the Creative Commons Attribution Noncommercial License which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author (s) and source are credited. This is an open access article licensed under the terms of the Creative Commons Attribution Non commercial license Share alike. (<http://creativecommons.org/licenses/by-nc-sa/4.0/>) which permits unrestricted, non commercial use, distribution and reproduction in any medium, provided the work is properly cited.  
The authors declare that there is no conflict of interests regarding the publication of this paper.

Received: 23.02.2022. Revised: 05.03.2022. Accepted: 31.03.2022.

## Bioinert ceramic inserts with zirconium oxide: manufacturing technology and clinical application

V. I. Grizodub, O. A. Ryaboshapko, D. O. Yakimenko, P. V. Maksimenko

International Humanitarian University, Odesa

### Abstract

**The aim of the study.** Experimental studies on the degree of influence on the surrounding tissues during implantation of samples of the main materials used for the manufacture of bioinert ceramic inserts in the clinic. In order to improve the method of manufacturing dental prostheses based on frameless ceramics, research was conducted on improving the edge fit, increasing the strength of the connection of the facing layer, which are the main direction in improving the inertness, strength and aesthetics of inlays during prosthetics. The conducted studies showed that there is also a need to study the bioinertness of the inlay material, which significantly distinguishes ceramic inlays from other designs that can be applied in similar clinical situations. **Research materials and methods.** A morphological study of the skin of white Wistar rats was carried out after intradermal implantation of Weron 99, Wirocer, Wirobond, IPS e.max Press ceramics. During the experiment, the animals were kept in the conditions and on the diet of the vivarium in accordance with the prescribed normative data. Experiments with animals were conducted according to established rules for working with them. **Scientific novelty.** The conducted research was aimed at improving the technique of manufacturing hip ceramic inserts using frameless ceramics. Studies have shown that unidirectional dystrophic changes in the epithelium and dermis of the skin of experimental animals during intradermal implantation of alloys: Weron 99, WeroCer, Wirobond and IPS e.max

Press ceramics are expressed to a lesser extent, which indicates a more significant bioinertness of ceramics when implanted in the tissues of the oral cavity . The result of experimental and bench research was an improved method of manufacturing a hip pressed insert. **Conclusions.** The conducted studies showed high inertness and structural strength of the material of the tabs, which gives grounds for their use in clinical practice.

**Key words: bioinert ceramic insert; zirconium oxide; dental microprosthesis; intradermal implantation**

In recent years, the use of zirconium dioxide ceramics as a framework material for the manufacture of microprostheses, single crowns and small bridges has increased. Their use in dental practice became possible with the help of CAD/CAM technologies [1]. Clinical studies of ceramic restorations based on zirconium dioxide showed promising clinical results and high survival rates [2]. However, chipping and fragility of ceramic masses layered on zirconium dioxide frameworks remains an actual and urgent problem of modern orthopedic dentistry [3].

In modern global dental practice, layer-by-layer veneering on refractory models, CAD/CAM technology, and hot pressing techniques are used to achieve such results.

Of course, the pressing technique is an ideal option for the production of inlays and veneers - it provides high quality (color, accuracy of fixation) in combination with an efficient work process and high strength [4].

In modern dentistry, the IRS e.max Press technologies occupy a rather significant place due to the simplicity and manufacturability of the process, but their use is restrained by the fear of orthopedists-dentists related to the fragility of metal-free structures and the complexity of clinical stages. Therefore, most often in case of destruction of the crown part of the tooth, metal hip inserts are used, the manufacturing technology of which continues to improve.

Numerous in vitro studies of the bond strength between layered porcelain and zirconia ceramics have been published over the past decades [5, 6].

For a long time, metal-ceramic systems remained the most optimal option for the prosthetics of dentition defects both on natural teeth and on supports in the form of implants, proved to be a reliable option for fixed orthopedic dentistry and remain the gold standard [7].

It is believed that in the manufacture of metal-ceramic fixed dentures according to the International Standards Organization (IOS), a bond strength of more than 25 MPa between ceramic and metal is required. However, when it comes to metal-free restorations, no such standards have been defined.

Zirconium dioxide has a lower thermal conductivity than other framework materials used to make microprostheses and crowns. Excessive quenching loads lead to the appearance of

microcracks inside the layered porcelain caused by the increase in temperature during the cooling process. In metal-ceramic structures, the degree of residual stress on the surface of the connection between the layered porcelain and metal frameworks depends on the heat treatment modes of the ceramics. Therefore, the bond strength between the layered porcelain and the metal frameworks could be stronger if a controlled cooling rate was used after the firing procedures [8].

Based on the above, it follows that the problem of manufacturing structures from zirconium oxide that are subjected to increased transverse loads, such as hip tabs, inlay tabs, onlays, overlays, is a relevant topic for scientific research aimed at improving the quality of aesthetic microprosthetics. Ways to solve the problem, presented in the latest studies, summarized in this review, in the improvement of methods of final processing of zirconium oxide frames and / or refusal of layer-by-layer application of ceramic facing masses, final processing of the finished structure.

Numerous in vitro studies on the bond strength between layering materials and zirconia frameworks have been conducted to overcome chipping of porcelain veneering restorations based on zirconia. Various approaches for obtaining stable bond strength are currently being developed. In addition, development and testing of new materials and methods is required to minimize chipping and breakage of veneering (layering) porcelain. Further studies are needed to validate these protocols and provide additional information on long-term clinical performance.

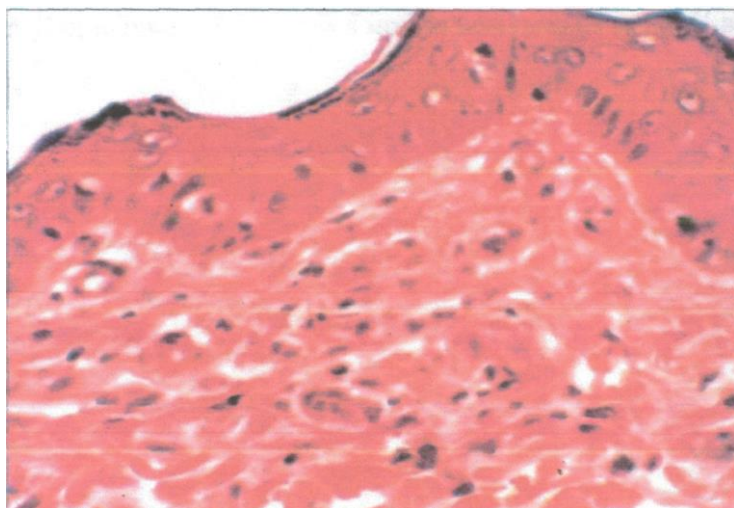
Based on the analysis of scientific literary sources, the main direction in improving the inertness, strength and aesthetics of inlays during prosthetics with dental prostheses based on frameless ceramics is the improvement of marginal fit, increasing the strength of the connection of the facing layer - the basic ceramic frame.

In modern orthopedic dentistry, the problem of improving the quality of the restoration of the frontal group of teeth by improving and testing the technology of pressed ceramics is urgent. All of the above, in fact, determined the main direction of this research.

**The goal of the work.** Experimental studies on the degree of influence on the surrounding tissues during implantation of samples of the main materials used for the manufacture of bioinert ceramic inserts in the clinic. **Materials and methods.** A morphological study of the skin of white Wistar rats was carried out after intradermal implantation of Weron 99, Wirocer, Wirobond, IPS e.max Press ceramics. During the experiment, the animals were kept in the conditions and on the diet of the vivarium in accordance with the prescribed normative data. Experiments with animals were conducted according to established rules for working with them. All manipulations that caused pain were carried out under ethanol-sodium anesthesia (40 mg/kg intraperitoneally). Work with animals was carried out in accordance with the International Code

of Medical Ethics (Venice, 1983), the "European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes" (Strasbourg, 1986), "General Ethical Principles of Animal Experiments", adopted by the First National congress on bioethics (Kyiv, 2001), Directive 2010/63/EU of the European Parliament and Council on the protection of animals used for scientific purposes, the Law of Ukraine "On the Protection of Animals from Cruelty Treatment" No. 440-IX dated 14.01.2020.

**Research results and their discussion.** To improve the method of manufacturing dental prostheses based on frameless ceramics, research was conducted on improving the edge fit, increasing the strength of the connection of the facing layer, which are the main direction in improving the inertness, strength and aesthetics of the inlays during prosthetics. The conducted studies showed that there is also a need to study the bioinertness of the inlay material, which significantly distinguishes ceramic inlays from other designs that can be applied in similar clinical situations. For this purpose, we conducted a study on rats, which allows us to assess the degree of influence on the surrounding tissues during the implantation of samples of the main materials used for the manufacture of tabs in the clinic. The results of morphological studies of the skin of white Wistar rats showed that the intradermal implantation of alloys: Weron 99, Wirocer, Wirobond, IPS e.max Press ceramics is accompanied by unidirectional dystrophic changes in the epithelium and dermis of the skin of experimental animals, however, when ceramics are implanted, these changes are expressed in to a lesser extent (Fig. 1), which indicates



a more significant bioinertness of ceramics when introduced into the tissues of the oral cavity of experimental animals.

Fig. 1 - Rat skin after ceramic implantation.  
paint hematoxylin and eosin x 400.

All the conducted studies, the results of which are given above, formed the basis of the developed method of manufacturing a ceramic tab.

After determining the indications for prosthetics and assessing the condition of the periapical tissues and the condition of the tooth root, they started preparing the root for the pin structure.

At the stage of manufacturing the ceramic hip insert, wax modeling was performed. The wax blanks were installed on the core base at a distance of at least 3 mm between each other, all the points of attachment of the nozzles to the object of pressing and to the core base were carefully rounded. A fire gauge was set on top, excess packing mass was removed, and the prepared fire was kept for 30 minutes until it solidified.

Zirconium pins and ceramic blanks were placed in the cold Programat P 90 furnace for preheating to the final temperature  $T = 850\text{ }^{\circ}\text{C}$ . To increase the strength of the hip ceramic insert, "fast" cooling was used - the insert was removed without slow cooling in the furnace.

After complete cooling, unpacking, sandblasting was carried out, summers were cut off with diamond discs. A workpiece cast from ceramics was fitted on the working model. Final cleaning of the restoration was carried out by sandblasting the inner surface with polishing shot under a pressure of 2 atm., and the outer surface - under a pressure of 0.5 atm.



Given that the bond strength of white, unpainted zirconium dioxide with facing materials was significant compared to painted zirconium dioxide (Section 3.2), staining of the acetabular tab was not performed (Fig. 2).

Fig. 2 – Finished ceramic tab

Fixation of the tab in the oral cavity was carried out using the universal two-component adhesive system Totalcem ("Itena", France).

The base liquid composite of the selected shade was mixed with a paste-catalyst of high viscosity in a ratio of 1:1, introduced into the cavity with a slight excess. The tab was immersed in the prepared cavity, firmly holding it with dental tweezers. Excess material was removed, the restoration was covered with water-soluble glycerin to prevent the formation of an oxygenated layer, and illuminated with a photopolymer lamp. Final cleaning of the restoration was carried out with diamond veneers, polishers, discs. They began to manufacture the covering structure.

**Conclusions.** The conducted studies showed high inertness and structural strength of the material of the tabs, which gives grounds for their use in clinical practice.

The conducted research was aimed at improving the technique of manufacturing hip ceramic inserts using frameless ceramics. Studies have shown that unidirectional dystrophic changes in the epithelium and dermis of the skin of experimental animals during intradermal implantation of alloys: Weron 99, WeroCer, Wirobond and IPS e.max Press ceramics are expressed to a lesser extent, which indicates a more significant bioinertness of ceramics when implanted in the tissues of the oral cavity. The result of experimental and bench research was an improved method of manufacturing a hip pressed insert.

### References

1. Misch C.E., Misch-Dietsh F., Silc J. & et al. (2008) Posterior implant single-tooth replacement and status of adjacent teeth during a 10-year period: a retrospective report // *Peziodontol.*, 79(12), 2378-2382.
2. Magnusson A.-H. (2005) Esteticheskiye tsel'nokeramicheskiye restavratsii dlya perednikh zubov. [Aesthetic all-ceramic restorations for anterior teeth]. *Novoye v stomatologii - New in dentistry*, 4, 25-39 [in Russian].
3. Lepsky V.V., Denga O.V., Verbitskaya T.G. & Makarenko O. A. (2012) Profilaktika razlichnykh oslozhneniy pri ortopedicheskom lechenii vklyuchennykh odinochnykh defektov zubnykh ryadov. [Prevention of various complications in the orthopedic treatment of included single defects in the dentition]. *Vísnik stomatologii - Bulletin of Dentistry*, 1, 53-57 [in Russian].
4. Abou-Madina M.M., Ozcan M. & Abdelasis K.M. (2012) Influence of Resin Cements and Aging on the Fracture Resistance of IPS e.max Press Posterior Crowns. *Int. J. Prosthodont.*, 25(1), 33-35.
5. Kuzmichenko R. & Garanko M. (2010) Seramco 3 margin and opaque correction liquid - zhidkost' dlya plechevoy massy, korrektora opaka i mnogo drugogo. [Ceramco 3 margin and opaque correction liquid - liquid for shoulder mass, opaque corrector and much more]. *Zubnoye protezirovaniye - Dental prosthetics*, 3, 19-23 [in Russian].
6. Filippenkova L. (2012) Prakticheskoye primeneniye dioksida tsirkoniya NexxZr [Practical application of zirconium dioxide NexxZr]. *Zubnoye protezirovaniye - Dental prosthetics*, 1, 40-43 [in Russian].
7. Scurria M.S., Bader J.D. & Shegars D.A. (1998) Meta-analysis of fixed partial denture survival: pprostheses and abutments. *J. Prosthet.Dent.*, 79, 459-464.
8. Gostemeyer G., Jendras M., Dittmer M.P. & [et al.] (2010) Influence of cooling rate on zirconia veneer interfacial adhesion. *Acta Biomater*, 6, 4532-4538.