ON THE ISSUE OF BIOCOMPATIBILITY OF CERAMIC IMPLANTS IN THE PROVISION OF ORTHOPEDIC CARE

Furkatov Shokhjakhon
Latipov Zhurabek
Odilov Bakhodir
Mustafoyev Aziz
Samarkand State Medical University

Abstract: When organizing orthopedic care, specialists should be aware of scientific data on the ability of the used zirconium dioxide implant system to osseointegration. The biological compatibility of implants depends on various parameters such as the nature of the material, chemical composition, surface topography, chemical composition and load, surface treatment, physical and mechanical properties. Zirconium has a high biocompatibility with soft tissues, resistance to bacterial biofilms. Zirconium dioxide implants are a promising alternative to titanium, especially for patients with titanium allergies.

Key words: ceramic implants, zirconium dioxide, orthopedic care, dental implantology.

According to research, the latest generation of zirconium dioxide implants with a micro-rough surface demonstrates identical integration with hard tissues compared to titanium implants. Currently, not every company offers evidence-based data or provides information about the implant surface and osseointegration characteristics of the respective product.

The purpose of the study was to review the scientific foreign literature on the biocompatibility of ceramic implants in the provision of orthopedic care. Preclinical data on zirconium dioxide implants and titanium implants in various animal models over 30 years indicate the presence of histological evidence of comparable or better osseointegration of zirconium dioxide implants compared to titanium implants. In general, these preclinical results confirm the possibility of using zirconium dioxide-based ceramics in dental implantology [1-4]. Clinical studies of ceramic implants study marginal bone loss, survival rates, biocompatibility with tissue, complication rate, etc. The short-term results of clinical studies mostly confirm the comparability of zirconium implants with titanium implants and their suitability as an alternative treatment option for replacing missing teeth [5-8]. The biological compatibility of implants depends on various parameters such as the nature of the material, chemical composition, surface topography, chemical composition and load, surface treatment, physical and mechanical properties. Zirconium has a high biocompatibility with soft tissues, resistance to bacterial biofilms. Examination of titanium particles in the tissues around the implant in peri-implantitis, as well as immunological reactions to these particles, revealed bleeding during probing, a probing depth of ≥6 mm and radiographic bone loss around the dental implant of ≥3 mm. Analysis using scanning electron microscopy and energy dispersive X-ray spectroscopy (SEM-EMF) revealed titanium wear particles in 90% of tissue samples due to mixed chronic inflammatory infiltration. Significant overexpression of the RANKL cytokine was observed with a tendency to overexpression of IL 33 and TGF-B1 in areas with titanium [10]. Comparative analysis of the reaction of human gingival mesenchymal stromal cells (human gingival mesenchymal stromal cells (hG-MSC)) with titanium and zirconium nanoparticles (1000 mcg/ml), but not with zirconium dioxide nanoparticles, which was accompanied by enhanced apoptosis. Both types of nanoparticles (>25 micrograms/ml) induced significant expression of IL 8 in the gum MSCs, and a slightly higher effect was observed for titanium nanoparticles. Both nanoparticles significantly enhanced the production of interleukin IL 8 induced by LPS, a higher effect was observed for zirconium dioxide nanoparticles [11]. In vitro experiments have shown the effect of differences in materials and surface roughness of zirconium dioxide implants on biofilm formation. The formation of the biofilm in situ was mainly influenced by the surface roughness of the samples. To reduce biofilm formation, polishing of zirconium dioxide is recommended, while heat treatment does not have a significant effect [15]. The assessment of the biocompatibility of rough and smooth surfaces of yttrium-zirconium (Y-TZP) discs compared with pure zirconium (ZrO2) discs showed similar cell proliferation rates and dense cell matting on the surface of both materials. The indicators of mineral absorption and immune response were characteristic of Y-TZP, which indicates a higher biocompatibility of the material [16]. When evaluating periodontal integration, it was described that fibroblasts adhere better to zirconium dioxide, which leads to a stronger formation of a "cuff" around these implants. This leads to a decrease in the depth of the pocket with a predominantly non-inflammatory environment. It was shown that zirconium dioxide accumulated fewer parameters (surface roughness, contact angle, number of bacteria, bacterial adhesion, biofilm thickness, bacterial distribution, specific immunological parameters) of oral biofilm [17, 18]. Analysis of the reaction of gingival fibroblasts and human osteoblasts to laser-textured microbursts of various sizes on the surface of zirconium dioxide implants showed cellular adhesion after 24 hours with comparable morphology in all samples for both cell types. Cell viability increased over time, but no differences were found between them. Proliferation, ALP (alkaline phosphatase) activity, and levels of type I collagen, osteopontin, and interleukin did not differ significantly for any of the cell types. The results obtained showed similar cell behavior based on cell viability and differentiation by microtopography of dental implants made of zirconium dioxide [19]. On the surface of zirconium dioxide, an increase in roughness is recorded at the micro and nanoscale, which leads to increased wettability and biological reaction. In addition, adhesion, propagation, proliferation and differentiation In in vitro experiments have shown the effect of differences in materials and surface roughness of zirconium dioxide implants on biofilm formation. The formation of the biofilm in situ was mainly influenced by the surface roughness of the samples. To reduce biofilm formation, polishing of zirconium dioxide is recommended, while heat treatment does not have a significant effect [15]. The assessment of the biocompatibility of rough and smooth surfaces of yttrium-zirconium (Y-TZP) discs compared with pure zirconium (ZrO_2) discs showed similar cell proliferation rates and dense cell matting on the surface of both materials. The indicators of mineral absorption and immune response were characteristic of Y-TZP, which indicates a higher biocompatibility of the material [16]. When evaluating periodontal integration, it was described that fibroblasts adhere better to zirconium dioxide, which leads to a stronger formation of a "cuff" around these implants. This leads to a decrease in the depth of the pocket with a predominantly non-inflammatory environment. Analysis of the reaction of gingival fibroblasts and human osteoblasts to laser-textured microbursts of various sizes on the surface of zirconium dioxide implants showed cellular adhesion after 24 hours with comparable morphology in all samples for both cell types. Cell viability increased over time, but no differences were found between them. Proliferation, ALP (alkaline phosphatase) activity, and levels of type I collagen, osteopontin, and interleukin did not differ significantly for any of the cell types.

The results obtained showed similar cell behavior based on cell viability and differentiation by microtopography of dental implants made of zirconium dioxide [19]. On the surface of zirconium dioxide, an increase in roughness is recorded at the micro and nanoscale, which leads to increased wettability and biological reaction. In addition, adhesion, propagation, proliferation and differentiation of the ability of the used zirconium dioxide implant system to osseointegration. At the same time, zirconium dioxide implants may be the only alternative to titanium implants for patients with absolute contraindications to the use of titanium. The researchers note the need to expand the sample size, larger multicenter, longitudinal and randomized clinical trials, expanded data on possible complications, assessment of their long-term survival, degree of success and indicators of marginal bone loss, the role of titanium in initiating bone loss, as well as critical analysis of the purity and topography of the implant surface, etc. [1, 8, 9, 21–24]. Thus, the review of the scientific literature allows us to conclude that ceramic implants have recently appeared to be a promising alternative to titanium implants in terms of mechanical strength, biological functionality, chemical stability, a combination of optical properties and osseointegration. Bioceramics is the optimal material for solving a wide range of biomedical problems, including dental orthopedics. Zirconium dioxide (ZrO_2) is most successfully used as a material for the manufacture of dental implant supraconstructions and fixators during metal-free restoration.

REFERENCES:

1. Koller M., Steyer E., Theisen K., Stagnell S., Jakse N., Payer M. Two-piece zirconia versus titanium implants after 80 months: Clinical outcomes from a prospective randomized pilot trial // Clin Oral Implants Res. 2020; 31(4): 388–396. DOI: 10.1111/clr.13576;

2. Borges H., Correia A.R.M., Castilho R.M., de Oliveira Fernandes G.V. Zirconia Implants and Marginal Bone Loss: A Systematic Review and Meta-Analysis of Clinical Studies // Int J Oral Maxillofac Implants. 2020; 35(4): 707–720. DOI: 10.11607/jomi.8097

3. Thiem D.G.E., Stephan D., Kniha K. et al. German S3 guideline on the use of dental ceramic implants // Int J Implant Dent. 2022; 8(1): 43. DOI: 10.1186/s40729-022-00445-z

4. Duddeck D.U., Albrektsson T., Wennerberg A. et al. Quality Assessment of Five Randomly Chosen Ceramic Oral Implant Systems: Cleanliness, Surface Topography, and Clinical Documentation // Int J Oral ol.Maxillofac Implants. 2021; 36(5): 863–874. DOI: 10.11607/jomi.8837

5. Berryman Z., Bridger L., Hussaini H.M., Rich A.M., Atieh M., Tawse-Smith A. Titanium particles: An emerging risk factor for peri-implant bone loss // Saudi Dent J. 2020; 32(6): 283–292. DOI: 10.1016/j. sdentj.2019.09.008

6. Nemec M., Behm C., Maierhofer V. et al. Effect of Titanium and Zirconia Nanoparticles on Human Gingival Mesenchymal Stromal Cells // Int J Mol Sci. 2022; 23(17): 10022. DOI: 10.3390/ ijms231710022

7.Sivaraman K., Chopra A., Narayan A.I., Balakrishnan D. Is zirconia a viable alternative to titanium for oral implant? A critical review // J Prosthodont Res. 2018; 62(2): 121–133. DOI: 10.1016/j. jpor.2017.07.003

8. Thomé G., Sandgren R., Bernardes S. et al. Osseointegration of a novel injection molded 2-piece ceramic dental implant: a study in minipigs // Clin Oral Invest. 2021; 25: 603–615. DOI: 10.1007/ s00784-020-03513-z

9. Aragoneses J., Valverde N.L., Fernandez-Dominguez M. et al. Relevant Aspects of Titanium and Zirconia Dental Implants for Their Fatigue and Osseointegration Behaviors // Materials (Basel). 2022; 15(11): 4036. DOI: 10.3390/ma15114036

10. Bezdetko G.I., Shkatova E.Yu. Kachestvo zhizni pacientov, poluchivshix uslugu protezirovaniya zubov na implantatax [Quality of life of patients who received dental prosthetics on implants]. Mezhdunarodnaya nauchno-prakticheskaya konferenciya: novaya social`naya politika i kachestvo zhizni: issledovaniya i prognozy` [International Scientific and Practical Conference: New Social Policy and Quality of life: research and forecasts]. 2017: 66-71 (In Russian)

11. Sadowsky S.J. Has zirconia made a material difference in implant prosthodontics? // A review. Dent Mater. 2020; 36(1): 1–8. DOI: 10.1016/j.dental.2019.08.100

12. Duan C., Ye L., Zhang M., et al. Clinical performance of zirconium implants compared to titanium implants: a systematic review and meta-analysis of randomized controlled trials // Peer J. 2023; 11: e15010. DOI: 10.7717/peerj.15010

13. Фуркатов Ш.Ф., Хазратов А.И. ПОСЛЕДСТВИЯ ПРИМЕНЕНИЯ СЛАВЯНСКОГО СМЯГЧАЮЩЕГО СРЕДСТВА ДЛЯ РЕПАРАЦИИ ПРОТЕЗОВ ПАРОДОНТАЛЬНОГО ОТДЕЛА // Молодежный инновационный вестник. - 2023. - Т. 12. - №S2. - С. 467-470.

14. Ахмедов А. А., Фуркатов Ш. Ф., Анваровна Х. М. ПОЛНЫЙ ЦИФРОВОЙ РАБОЧИЙ ХОД ДЛЯ ИЗГОТОВЛЕНИЯ СКОРОТЕЧНОЙ РЕСТАВРАЦИИ С ОПОРОЙ НА ИМПЛАНТАТЫ: КЛИНИЧЕСКИЙ СЛУЧАЙ И НОВЫЙ МЕТОД

15.//MODELS AND METHODS FOR INCREASING THE EFFICIENCY OF INNOVATIVE RESEARCH. – 2023. – Т. 2. – №. 20. – С. 106-115.

16. Исматов Ф. А., Мустафоев А. А., Фуркатов Ш. Ф. АНАЛИЗ ЭФФЕКТИВНОСТИ НЕСТЕРОИДНЫХ АНТИВОСПОЛИТЕЛЬНЫХ ПРЕПАРАТОВ ПРИ ИЗЛЕЧЕНЬЕ ВЕРХНЕЧЕЛЮСТНОГО АЛЬВЕОЛИТА //THEORY AND ANALYTICAL ASPECTS OF RECENT RESEARCH. – 2023. – Т. 1. – №. 12. – С. 49-57.

17. Исхакова З. Ш. и др. Использование остеогенного материала для замещения полостных дефектов челюстей //Formation of psychology and pedagogy as interdisciplinary sciences. – 2023. – Т. 2. – №. 15. – С. 43-48.

18. Rizaev J. A. et al. Clinical and radiological characteristics of periodontic interweaves in patients with chew recessional //European Journal of Interdisciplinary Research and Development. – 2023. – Т. 11. – С. 36-41.

19. Фуркатов Ш. Ф., Хатамова М. А. ПРИМЕНЕНИЯ ВРЕМЕННЫХ НЕСЪЕМНЫХ ЗУБНЫХ ПРОТЕЗОВ ПРИ ДЕНТАЛЬНОЙ ИМПЛАНТАЦИИ //АКТУАЛЬНЫЕ ВОПРОСЫ СТОМАТОЛОГИИ. – 2023. – С. 814-820.

20. Rizaev J. A. et al. The need of patients with systemic vasculitis and coronavirus infection in the treatment of periodontal diseases //Applied Information Aspects of Medicine (Prikladnye informacionnye aspekty mediciny). – 2022. – Т. 25. – №. 4. – С. 40-45.

21. Ризаев Ж. А., Нарзиева Д. Б., Фуркатов Ш. Ф. РЕГИОНАРНАЯ ЛИМФОТРОПНАЯ ТЕРАПИЯ ПРИ ФУРУНКУЛАХ И КАРБУНКУЛАХ ЧЕЛЮСТНО-ЛИ-ЦЕВОЙ ОБЛАСТИ //ТОМ-1. – 2022. – С. 386.