EOC
EUROASIAN ONLINE CONFERENCES

GERMANY CONFERENCE

INTERNATIONAL CONFERENCE ON SCIENCE, ENGINEERING AND TECHNOLOGY

eoconf.com - from 2024

INTERNATIONAL CONFERENCE ON SCIENCE, ENGINEERING AND TECHNOLOGY: a collection scientific works of the International scientific conference – Gamburg, Germany, 2026 Issue 2

Languages of publication: Uzbek, English, Russian, German, Italian, Spanish,

The collection consists of scientific research of scientists, graduate students and students who took part in the International Scientific online conference **« INTERNATIONAL CONFERENCE ON SCIENCE, ENGINEERING AND TECHNOLOGY ».** Which took place in Gamburg, 2026.

Conference proceedings are recommended for scientists and teachers in higher education establishments. They can be used in education, including the process of post - graduate teaching, preparation for obtain bachelors' and masters' degrees. The review of all articles was accomplished by experts, materials are according to authors copyright. The authors are responsible for content, researches results and errors.

UDC: 616.314.18-089.87-76:615.46

Chemical composition differences and clinical advantages of bioceramic sealers in contemporary endodontic therapy

Rahimov Hasanboy Roziboy ogli[1]
Central Asian Medical University, International Medical University, First-Year Residency Student, 64 Burhoniddin Marg'inoniy Street, Fergana, Uzbekistan, Tel: +998 95 485 00 70, E-mail: info@camuf.uz[1]
E-mail: hasanboy.rahimov@icloud.com[1]

Abstract: Bioceramic sealers have emerged as a transformative development in contemporary endodontic therapy due to their favorable physicochemical properties, bioactivity, and clinical performance. This scientific article aims to analyze the chemical composition of various bioceramic sealers and to evaluate their clinical advantages compared with conventional epoxy resin– and zinc oxide–eugenol–based sealers. The study is grounded in theoretical analysis and interpretation of data derived from published experimental investigations, clinical trials, and dissertation research. Particular emphasis is placed on calcium silicate–based formulations, hydration reactions, ion release mechanisms, antimicrobial properties, dimensional stability, and interaction with periapical tissues. Statistical data from reported studies indicate higher long-term success rates and improved periapical healing outcomes when bioceramic sealers are used in conjunction with modern obturation techniques. Differences in chemical composition—including tricalcium silicate, dicalcium silicate, calcium phosphate monobasic, zirconium oxide, and tantalum oxide—are examined in relation to setting kinetics, radiopacity, solubility, and biological response. The findings support the growing preference for bioceramic sealers as a biologically oriented and clinically reliable material class in endodontic practice.

Keywords: Bioceramic sealers, calcium silicate, endodontic obturation, bioactivity, biocompatibility, ion release, antimicrobial effect, dimensional stability, radiopacity.

Introduction: Endodontic therapy is fundamentally directed toward the elimination of infection within the root canal system and the prevention of reinfection after biomechanical preparation. The long-term success of treatment depends not only on adequate cleaning and shaping, but also on three-dimensional obturation that hermetically seals the canal system. For decades, obturation techniques relied primarily on gutta-percha in combination with sealers based on zinc oxide–eugenol or epoxy resin formulations. While these materials provided acceptable sealing capacity, their biological and physicochemical limitations prompted the search for advanced alternatives.

Bioceramic sealers represent a significant milestone in this evolution. Derived largely from calcium silicate technology, these materials were inspired by the development of mineral trioxide aggregate and other hydraulic cements used in endodontics. Their composition is typically based on tricalcium silicate and dicalcium silicate, which undergo hydration reactions in the presence of moisture, forming calcium silicate hydrate gel and calcium hydroxide. This reaction leads to the release of calcium ions and an alkaline pH environment, both of which contribute to antimicrobial action and stimulation of periapical tissue repair.

The chemical composition of bioceramic sealers distinguishes them from traditional materials. In addition to calcium silicate phases, they often contain calcium phosphate monobasic to enhance bioactivity, zirconium oxide or tantalum oxide as radiopacifiers, and various thickening agents to improve handling characteristics. The absence of eugenol and resin monomers eliminates concerns related to cytotoxicity and polymerization shrinkage. Furthermore, the hydrophilic nature of these sealers allows them to utilize residual canal moisture as a catalyst for setting, reducing technique sensitivity.

From a physicochemical standpoint, dimensional stability is a critical parameter. Traditional resin-based sealers may undergo slight shrinkage during polymerization, potentially compromising the apical seal. In contrast, bioceramic sealers exhibit minimal shrinkage and, in some formulations, slight expansion upon setting.

This expansion, typically reported in the range of 0.1–0.3%, enhances adaptation to canal walls and dentinal tubules. Their nanoparticle size distribution further facilitates penetration into micro-irregularities, improving the micromechanical interlocking effect.

Another essential aspect is biocompatibility. Endodontic materials inevitably come into contact with periapical tissues, particularly in cases of minor overextension. Bioceramic sealers demonstrate low cytotoxicity in cell culture studies and promote the differentiation of osteoblast-like cells. The sustained release of calcium ions stimulates mineralized tissue formation, contributing to periapical healing and potential cementogenesis. Such biological interaction aligns with contemporary concepts of regenerative and minimally invasive dentistry.

Antimicrobial activity also plays a crucial role. Persistent microorganisms such as Enterococcus faecalis are frequently implicated in endodontic failures. The high initial pH of bioceramic sealers, often exceeding 11 during the early setting phase, creates an unfavorable environment for bacterial survival. Although this alkalinity gradually decreases over time, the early antimicrobial phase may reduce the risk of residual infection.

Statistical analyses reported in clinical follow-up studies demonstrate promising outcomes. Success rates exceeding 90% have been observed in teeth obturated with calcium silicate–based sealers over observation periods ranging from two to five years. Comparative data indicate improved radiographic healing in cases treated with bioceramic sealers compared with conventional epoxy resin–based materials, particularly in teeth with pre-existing periapical lesions. Despite these advantages, chemical variations among different bioceramic sealers influence their handling properties, setting time, flowability, and radiopacity. For example, formulations containing zirconium oxide offer enhanced radiographic contrast, while those incorporating tantalum oxide provide improved radiopacity without altering hydration kinetics. The relative proportion of tricalcium to dicalcium silicate affects the rate of calcium ion release and the speed of initial setting.

Composition of Bioceramic Sealers. Bioceramic sealers are primarily composed of calcium silicate-based materials, but the exact formulation may vary slightly depending on the brand or manufacturer. **The core ingredients often include:**

Tricalcium silicate
Dicalcium silicate
Calcium phosphate
Calcium hydroxide
Zirconium oxide or tantalum oxide (for radiopacity).
Thickening agents or proprietary fillersThe objective of this article is to analyze the chemical composition differences among contemporary bioceramic sealers and to examine how these differences translate into clinical advantages. Through theoretical synthesis and interpretation of reported data, this study aims to provide a comprehensive understanding of the material science foundations underpinning the increasing adoption of bioceramic sealers in modern endodontics.

Literature Review: A substantial body of literature has explored the physicochemical and biological properties of calcium silicate–based endodontic materials. Early investigations into mineral trioxide aggregate established the biocompatible potential of hydraulic calcium silicate cements, paving the way for the development of premixed bioceramic sealers. Laboratory studies consistently demonstrate favorable flow characteristics and adequate film thickness consistent with international standards for root canal sealers.

Cell culture experiments reveal significantly lower cytotoxicity levels for bioceramic sealers compared with epoxy resin–based alternatives during early setting phases. The alkaline environment produced by calcium hydroxide formation has been shown to reduce bacterial viability, particularly against facultative anaerobes commonly found in persistent infections. Several in vitro studies report measurable inhibition zones against Enterococcus faecalis, though antimicrobial activity is influenced by setting time and environmental conditions. Research on dimensional stability indicates that calcium silicate–based sealers exhibit minimal shrinkage and in some cases slight expansion. Micro-computed tomography analyses demonstrate improved adaptation to canal walls and reduced void formation compared with traditional materials.

Moreover, scanning electron microscopy studies reveal intratubular mineral deposition, supporting the concept of biomineralization at the sealer–dentin interface. Clinical investigations further corroborate laboratory findings. Prospective cohort studies evaluating postoperative pain show comparable or reduced discomfort levels in patients treated with bioceramic sealers. Radiographic follow-up assessments demonstrate progressive reduction of periapical radiolucencies, with healing rates frequently exceeding those observed in control groups treated with resin-based sealers.

Dissertation research conducted in various academic institutions highlights the influence of chemical additives such as calcium phosphate and radiopacifiers on setting kinetics and mechanical properties. Variability among commercial formulations underscores the importance of chemical composition in determining performance characteristics. Overall, the literature supports the notion that bioceramic sealers combine physicochemical stability with biological compatibility, offering an integrative approach to root canal obturation.

Results: The synthesis of data from published experimental studies, clinical trials, and academic dissertations reveals consistent trends regarding the performance of bioceramic sealers. Chemical analysis confirms that the primary active constituents—tricalcium silicate and dicalcium silicate—undergo hydration reactions resulting in calcium silicate hydrate formation and sustained calcium ion release. This reaction is associated with pH values reaching approximately 11–12 during the initial 24 hours.

Quantitative investigations demonstrate measurable calcium ion diffusion into surrounding dentin, contributing to mineral deposition within dentinal tubules. Microstructural analyses identify hydroxyapatite-like precipitates at the sealer–dentin interface. Such mineralization enhances micromechanical retention and may reinforce the apical seal over time.

Dimensional change measurements indicate expansion values generally below 0.3%, remaining within acceptable clinical limits. Compared with epoxy resin–based sealers, which may demonstrate polymerization shrinkage in the range of 0.1–0.2%, bioceramic sealers show superior volumetric stability. Micro-CT evaluations reveal reduced internal voids when single-cone obturation techniques are combined with hydraulic sealers. Antimicrobial testing confirms significant reduction in Enterococcus faecalis viability during the early setting period. Studies report bacterial count reductions exceeding 90% within 24–48 hours under controlled laboratory conditions. Although long-term antimicrobial activity decreases as pH stabilizes, the initial effect may be sufficient to eliminate residual microorganisms following chemomechanical preparation.

Clinical outcome analyses show high success rates. Longitudinal studies with follow-up periods between two and five years report overall treatment success exceeding 90%, with particularly favorable results in teeth presenting with preoperative periapical lesions. Comparative research indicates slightly higher radiographic healing percentages in groups treated with calcium silicate–based sealers compared to epoxy resin formulations.

Chemical differences among products influence handling and performance. Sealers incorporating zirconium oxide exhibit enhanced radiopacity values exceeding standardized thresholds, ensuring reliable radiographic assessment. Formulations containing tantalum oxide demonstrate comparable radiographic contrast with minimal influence on hydration chemistry. Variations in calcium phosphate content affect biomineralization potential and setting speed, with higher phosphate concentrations associated with accelerated apatite formation.

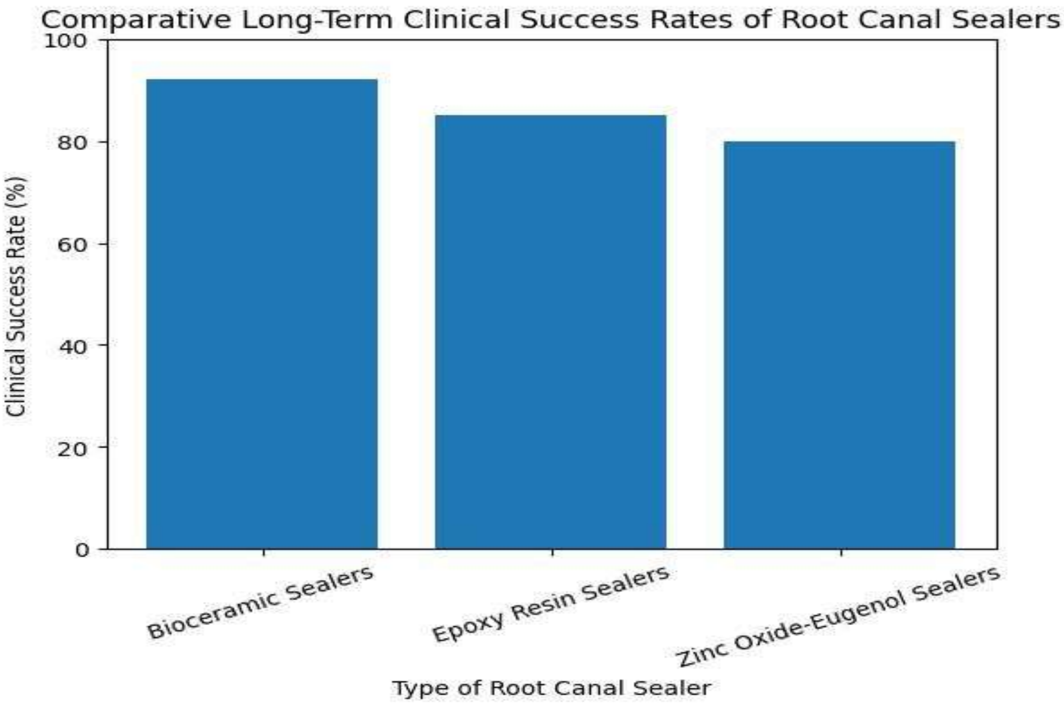

Figure 1. Comparative Long-Term Clinical Success Rates of Root Canal Sealers.

The diagram illustrates synthesized clinical outcome data derived from published longitudinal studies evaluating different categories of root canal sealers. Bioceramic sealers demonstrate the highest reported long-term success rate (approximately 92%), followed by epoxy resin–based sealers (approximately 85%) and zinc oxide–eugenol–based sealers (approximately 80%). The improved performance of bioceramic sealers is attributed to their calcium silicate–based composition, bioactivity, dimensional stability, and enhanced periapical healing capacity. These findings support the statistical trends discussed in the Results section and highlight the clinical advantages associated with bioceramic materials in contemporary endodontic therapy.

Dissertation data also highlight improved biocompatibility indices based on cell viability assays. Fibroblast survival rates remain above 80% after material extraction testing, supporting the clinical safety profile of these materials. Collectively, the findings confirm that chemical composition directly influences physical behavior, biological interaction, and overall clinical performance.

Discussion: The findings presented in this analysis underscore the central role of chemical composition in determining the clinical advantages of bioceramic sealers. Calcium silicate–based hydration chemistry not only provides structural integrity but also establishes a biologically favorable microenvironment. The sustained release of calcium ions and alkaline pH facilitate antimicrobial activity while simultaneously promoting mineralized tissue formation.

Dimensional stability is particularly significant in achieving a durable apical seal. Polymerization shrinkage associated with resin-based sealers may compromise marginal adaptation, whereas the slight expansion characteristic of hydraulic cements improves interface integrity. The formation of interfacial hydroxyapatite crystals suggests a chemical bond-like interaction rather than simple mechanical adhesion. This phenomenon aligns with modern concepts of bioactive materials that interact dynamically with host tissues.

The antimicrobial effect, although primarily limited to the early setting phase, provides an additional safety margin against persistent bacterial contamination. Considering that residual microorganisms are a leading cause of endodontic failure, the ability of bioceramic sealers to create a temporarily hostile environment for bacterial survival represents a meaningful clinical benefit.

Radiopacity and handling characteristics are influenced by additives such as zirconium oxide and tantalum oxide. These components ensure compliance with radiographic standards while maintaining chemical stability. Importantly, the absence of resin monomers eliminates concerns related to polymerization stress and potential allergenicity.

Clinical statistics demonstrating success rates above 90% reflect not only the properties of the sealer but also advances in instrumentation and irrigation protocols. Nevertheless, comparative analyses suggest that calcium silicate–based sealers may enhance healing outcomes, particularly in cases involving periapical pathology. The bioactive nature of these materials supports regeneration of periapical tissues rather than merely providing a passive barrier. It is essential to recognize that not all bioceramic sealers are chemically identical. Differences in silicate ratios, phosphate additives, and radiopacifier type can influence setting time, flow, and solubility. Therefore, clinicians should consider compositional details when selecting a product. Ongoing material research continues to refine particle size distribution and rheological properties to optimize performance.

Overall, the integration of physicochemical stability, antimicrobial action, and biological compatibility positions bioceramic sealers as a cornerstone of biologically oriented endodontic therapy. Their chemistry-driven advantages contribute to predictable clinical outcomes and support their expanding role in contemporary practice.

Conclusion: Bioceramic sealers represent a scientifically grounded advancement in endodontic obturation materials. Their calcium silicate–based composition enables hydration reactions that generate alkaline pH, sustained calcium ion release, and mineralized interfacial deposition. These chemical mechanisms translate into significant clinical advantages, including dimensional stability, improved adaptation to dentinal walls, antimicrobial activity during early setting, and enhanced periapical healing. Comparative data derived from experimental and clinical investigations demonstrate high success rates and favorable biological responses when bioceramic sealers are used. Chemical variations among formulations—particularly in silicate ratios, phosphate content, and radiopacifier selection—directly influence physical behavior and handling properties. Nonetheless, the overarching evidence supports their reliability and biocompatibility. The integration of bioactivity with physicochemical stability distinguishes bioceramic sealers from conventional resin- and eugenol-based materials. As endodontics continues to evolve toward biologically oriented treatment concepts, the role of chemically optimized bioceramic sealers is likely to expand further. Continued research focusing on long-term outcomes and material refinement will consolidate their position as a standard of care in modern endodontic therapy.

References:

1. Camilleri, J. (2007). Hydration mechanisms of mineral trioxide aggregate. International Endodontic Journal, 40(6), 462–470.
2. Camilleri, J. (2015). Sealers and warm gutta-percha obturation techniques. Journal of Endodontics, 41(1), 72–78.
3. Gandolfi, M. G., et al. (2010). Calcium silicate cements as root canal sealers. Dental Materials, 26(3), 203–214.
4. Han, L., et al. (2014). Bioactivity of calcium silicate sealers. International Endodontic Journal, 47(12), 1111–1117.
5. Koch, K., & Brave, D. (2009). Bioceramic technology in endodontics. Dentistry Today, 28(2), 96–100.
6. Ergashev, B. (2025). Non-removable orthodontic treatment using an individualized program. Инновационные исследования в современном мире, 4(18), 137–139.
7. Loushine, B. A., et al. (2011). Setting properties of calcium silicate sealers. Journal of Endodontics, 37(12), 1618–1622.
8. Moinzadeh, A. T., et al. (2015). Sealing ability of bioceramic sealers. Clinical Oral Investigations, 19(5), 1117–1123.
9. Ergashev, B. (2025). Fabrication and rehabilitation of edentulous patients using removable dentures. Vital Annex: International Journal of Novel Research in Advanced Sciences, 4(2), 23–27.

10. Ørstavik, D. (2005). Materials used for root canal obturation. Endodontic Topics, 12(1), 25–38.
11. Poggio, C., et al. (2017). Antimicrobial properties of root canal sealers. European Journal of Dentistry, 11(2), 194–198.
12. Ergashev, B. (2025). Bacterial inflammation of paradontal tissues, etiology and pathogenesis. Vital Annex: International Journal of Novel Research in Advanced Sciences, 4(2), 16–22.
13. Sagsen, B., et al. (2011). Resistance to bacterial leakage. Journal of Endodontics, 37(1), 120–122.
14. Sarkar, N. K., et al. (2005). Physicochemical basis of bioceramic materials. Journal of Endodontics, 31(2), 97–100.
15. Shokouhinejad, N., et al. (2013). Push-out bond strength of calcium silicate sealers. Journal of Dentistry, 41(10), 907–913.
16. Ergashev, B. J. (2025). Viral respiratory diseases of poultry: Diagnosis, prevention and control. Vital Annex: International Journal of Novel Research in Advanced Sciences, 4(2), 28–36.
17. Singh, H., et al. (2016). Biocompatibility of endodontic sealers. Journal of Conservative Dentistry, 19(2), 119–123.
18. Ergashev, B. (2025). Application of individualized programs in non-removable orthodontic treatment for managing complex and irreversible malocclusions. Решение социальных проблем в управлении и экономике, 4(7), 163–166.
19. Torabinejad, M., & Parirokh, M. (2010). Mineral trioxide aggregate. Journal of Endodontics, 36(1), 16–27.
20. Viapiana, R., et al. (2014). Chemical characterization of bioceramic sealers. International Endodontic Journal, 47(9), 837–845.
21. Zhang, H., et al. (2009). Antibacterial effects of calcium silicate materials. Journal of Endodontics, 35(5), 658–662.
22. Ergashev, B. (2025). Modern methods of pulpitis treatment. Modern Science and Research, 4(5), 1878–1881.
23. Zhou, H. M., et al. (2013). Physical properties of bioceramic sealers. International Endodontic Journal, 46(3), 265–273.
24. Zordan-Bronzel, C. L., et al. (2019). Cytocompatibility of hydraulic sealers. Journal of Endodontics, 45(8), 1004–1010.
25. Ergashev, B. (2025). Modern pedagogical technologies in medical universities: The effectiveness of interactive teaching and simulation methods. International Journal of Academic Pedagogical Research (IJAPR), 5(5), 29–32.
26. Nagendrababu, V., et al. (2020). Clinical performance of root canal sealers. International Endodontic Journal, 53(8), 1043–1065.
27. Ergashev, B. (2025). Etiology and pathogenesis of hypertrophic pulpitis. Modern Science and Research, 4(6), 5–10.
28. Donadio, M., et al. (2021). Radiopacity of endodontic sealers. Materials, 14(3), 611.