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Bioceramic cements in contemporary endodontics: fundamentals and perspectives

Bioceramic cements in contemporary endodontics: fundamentals and perspectives

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Summary

Bioceramic sealers represent one of the main innovations in contemporary endodontics, notable for their superior physicochemical and biological properties. This article discusses the evolution of these materials, their clinical applications, and their advantages and limitations compared to traditional root canal sealers, such as epoxy-based and MTA. Aspects such as biocompatibility, bioactivity, apical sealing, mechanical strength, dimensional stability, and clinical performance in different contexts are addressed. A review of the literature indicates significant benefits of bioceramic sealers, such as improved tissue response, adaptation to dentin walls, regenerative potential, and ease of use in procedures such as obturation, perforation sealing, resorption, and paraendodontic surgery. However, challenges such as difficult removal during retreatments and heterogeneity among commercial formulations still limit their universal adoption.

It is concluded that bioceramic cements have the potential to establish themselves as the materials of choice in endodontic practice, provided their indication is based on well-established clinical criteria. Future advances may include customized bioactive formulations and integration with digital technologies, further expanding their applicability in regenerative therapies.

Keywords

Biocompatible Materials; Root Canal Filling Materials; Endodontics; Dental Cements; Dental Materials; Root Canal Obturation

Abstract

Bioceramic cements represent one of the main innovations in contemporary endodontics, standing out for their superior physicochemical and biological properties. This article aims to discuss the evolution of these materials, their clinical applications, advantages, and limitations in comparison to traditional obturation cements, such as epoxy-based and MTA-based cements. Topics such as biocompatibility, bioactivity, apical sealing, mechanical strength, dimensional stability, and clinical performance in different contexts are addressed. The literature review highlights significant benefits of bioceramic cements, such as better tissue response, adaptation to dentinal walls, regenerative potential, and ease of use in procedures such as obturation, perforation sealing, resorption, and periradicular surgeries. However, challenges such as difficulty of removal during withdrawals and heterogeneity among commercial formulations still limit their universal adoption. It is concluded that bioceramic cements have the potential to become the materials of choice in endodontic practice, provided that their indication is based on well-established clinical

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Introduction

The search for ideal filling materials in Endodontics has been constant in recent years. decades. Among the various options available, bioceramic cements have been gaining highlighted by its superior physical-chemical properties, such as alkaline pH, biocompatibility, bioactivity and ability to induce tissue formation mineralized (1,2). Initially developed as alternatives to the trioxide aggregate mineral (MTA), these materials evolved and began to be applied in different clinical procedures such as root canal filling, perforation sealing and apexifications (3,4).

The introduction of bioceramic cements into endodontic practice represents a breakthrough significant, especially because they present characteristics such as volumetric expansion controlled, adequate setting time and low solubility, essential factors for the treatment success (5,6). However, despite the advantages, there are still challenges associated with its use, such as high cost, difficulty in retractability and heterogeneity among the formulations available on the market (7–9).

In this context, a critical analysis of recent literature is necessary to understand the real effectiveness of bioceramic cements and guide their clinical application evidence-based.

Objective

This literature review aims to gather and analyze scientific evidence available on bioceramic cements used in Endodontics, with emphasis on its physical-chemical properties, clinical indications, advantages and limitations, aiming guide clinical practice based on updated data from the literature.

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Methodology

This work is a bibliographic review, with a qualitative approach. The selection of the articles was carried out in the PubMed, Scopus, SciELO and ScienceDirect databases, using the following descriptors in English: “bioceramic cement”, “endodontics”, “root canal sealer” and “biocompatibility”. Articles published between 2000 and 2025 were included, with priority given to the most recent studies, especially those published since 2017. The initial screening was done by reading the titles and abstracts, followed by reading in full the articles considered relevant.

Studies that address the physicochemical properties, applicability were selected clinical, biological performance and limitations of bioceramic cements used in Endodontics. Duplicate articles, no access to full text, redundant reviews, and non-scientific publications were excluded. The information obtained was organized in thematic axes according to the topics discussed in this work.

Discussion

Bioceramic cements represent one of the most relevant technological innovations in contemporary Endodontics. Developed from ceramic compounds such as calcium silicate and calcium phosphate, these materials offer effective sealing, bioactivity and excellent compatibility with dental and periapical tissues(5,6,10).

Despite sharing fundamental characteristics such as alkaline pH, release of calcium ions and hydroxyapatite formation during setting, bioceramic cements do not constitute a homogeneous group. Their **clinical classification** may vary according to the **composition, form of presentation and therapeutic indications** (11,12).

Main types of bioceramic cements:

1. **Repair cements:** Used in specific situations such as perforations root canals, pulp capping, apexigenesis, apexification and retrograde filling.

Ex.: *MTA Repair HP®* (Angelus), *NeoMTA Plus®* (Avalon Biomed), *EndoSequence BC RRM®* (Brasseler) (13,14).

2. **Obturating cements:** Indicated for filling root canals, often applied with the single cone technique. Ex.: *BioRoot™ RCS* (Septodont), *TotalFill BC Sealer®* (FKG), *EndoSequence BC Sealer®* (Brasseler), *Bio-C Sealer®* (Angelus) (10,15,16).
3. **Hybrid or multifunctional cements:** They combine the characteristics of repairers and obturators, being versatile enough for use in both procedures surgical and conventional obturation. Ex.: *EndoSequence BC RRM®, NeoMTA Plus®, CeraSeal®* (Meta Biomed), *Bio-C Repair®* (Angelus) (5,10,12).

The form of presentation has also evolved over the years. First-generation cements, like classic MTA, they require manual handling and have a setting time prolonged. In contrast, the most modern materials are available in **pre-mixed** form (ready-to-use), reducing operational errors and facilitating insertion, especially in canals with complex anatomy (17,18).

Furthermore, several of these products are recognized and commercialized on a large scale. international, supported by multicenter scientific studies and systematic reviews. Among the most used globally are *EndoSequence BC RRM®, NeoMTA Plus®, TotalFill BC RRM®* and *CeraSeal®.* In Brazil, Angelus products — such as *Bio-C Repair®* and *Bio-C Sealer®* — also gaining prominence, with growing expansion in the international market.

Table 1 presents a comparative overview of some of the main brands of hybrid bioceramic cements currently available.

Commercial Name (Type)	Composition Main	Clinical Indications	Main features
EndoSequence BC RRM® (Hybrid / Repairer)	Tricalcium silicate, calcium phosphate, zirconium oxide	Perforations, pulp capping, retrofilling, revascularization	Premixed; excellent bioactivity; base hydrophilic
NeoMTA Plus® (Hybrid / Repairer)	Tricalcium silicate, calcium oxide, bismuth, control gel	Pulp capping, drilling, apical surgery, apexigenesis	Shorter setting time; suitable for pediatric use
TotalFill BC RRM® (Hybrid / Repairer)	Calcium silicate, calcium phosphate, zirconium oxide	Perforations, retrofilling, tissue regeneration	Formula equivalent to EndoSequence;

			good adaptation dentin
CeraSeal® (Hybrid / Shutter)	Calcium silicate, zirconium oxide, calcium tungstate	Multifunctional obturator, retrograde, sealing of side canals	High fluidity; good radiopacity; ready to use
BioRoot™ RCS (Shutter Enlarged)	Tricalcium silicate, calcium phosphate, zirconium oxide	Root canal filling, apical sealing	Hand-manipulated; pure bioceramic; excellent biocompatibility
Bio-C Repair® (Hybrid / Repairer)	Tricalcium silicate, calcium oxide, zirconium oxide	Capping, perforations, retro, pulp regeneration	High reactivity ionic; water-based; available in syringe
Bio-C Sealer® (Hybrid / Shutter)	Tricalcium silicate, calcium oxide, zirconium oxide, water-soluble resin	Obturator simple perforations, wide channels	High fluidity; presence of bioceramic, polymer, water-soluble; ready for use

Source: Prepared by the authors based on data from manufacturers and scientific literature(5,10,12–16,18,19).

This overview provides the necessary basis for the critical analysis of the physicochemical, biological and clinical properties of bioceramic cements, which will be discussed in more detail below.

1. Physicochemical properties of bioceramic cements

Bioceramic cements have physical-chemical properties that make them highly effective in endodontic procedures. Among their main characteristics are high alkaline pH, **release** of calcium ions, **formation** of hydroxyapatite , low solubility **and** dimensional stability(5,6,10,19).

The high pH, which can reach values close to 12, creates a hostile environment for microorganisms and promotes periapical repair. This alkalinity results from the reaction of tricalcium silicate with moisture, forming calcium hydroxide and, later, crystals of hydroxyapatite, responsible for biological sealing (10,18,20).

Unlike resin cements, bioceramics exhibit discreet expansion volumetric during setting, which contributes to effective sealing, even in channels irregular (4,13,18). Its hydrophilic nature allows activation by residual moisture from the canal, eliminating excessive drying(10,14).

The ultra-fine formulation, with particles between 1 and 2 µm, facilitates application with syringes or endodontic tips, in addition to ensuring penetration into branches and tubules dentinal materials (10,19). These materials also present adequate radiopacity **and** mechanical resistance compatible with the masticatory function, maintaining stability even in loading areas (18,19).

2. Biocompatibility and bioactivity of bioceramic cements

Biocompatibility and bioactivity are central differentiators of cements bioceramics. These materials induce minimal inflammatory response and stimulate tissue regeneration, making them ideal for conservative and restorative procedures (12,15,21,22).

Several studies demonstrate high cell viability and stimulation of differentiation osteoblastic and mineralized formation, especially in materials like *BioRoot™ RCS, BC Sealer®* and *Bio-C Repair®* (13,23,24). This response is related to the release sustained calcium ion nucleation, which favors the nucleation of apatite at the interface with the tissues(5,15,25).

Furthermore, these cements maintain an alkaline environment for a long time, which inhibits bacterial proliferation and enhances biological repair in periapical regions or perforated (10,20,24).

Compared to MTA, modern bioceramics exhibit similar performance or superior in aspects such as bioactivity, periapical repair and bridge induction dentin, with the additional benefit of better clinical handling and shorter processing time. prey (14,26,27).

Although variations in laboratory tests indicate subtle differences between formulations, the literature is clear in indicating that bioceramic cements offer a biological profile safe and effective, supported by experimental and clinical evidence(18,28).

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3. Clinical applications of bioceramic cements

Bioceramic cements have become protagonists in several clinical applications of Modern endodontics. Its versatility, combined with bioactivity and ease of use, allows its indication for both conventional filling and procedures reparative and regenerative (5,10,15).

In root canal filling, these materials offer excellent apical sealing, thanks to its adaptability and slight expansion during setting. Cements such as *BC Sealer®, BioRoot™ RCS* and *Bio-C Sealer®* are especially effective in wide canals, with irregular anatomy or retreatments, favoring obturation with a single cone technique (13,15,19).

In root repair procedures such as perforations, retrofillings and resorptions internally, materials such as *NeoMTA Plus®, BC RRM®* and *Bio-C Repair®* demonstrate high clinical success rate, with induction of mineralized neoformation and effective control of inflammation(14,16,20).

The application in conservative procedures of pulp vitality, such as capping, pulpotomy and apexigenesis, has grown with the use of cements such as *Biodentine®* and *Bio-C Repair®,* which features chemical stability, effective sealing and stimulation of hair formation of structured dentin bridge(5,21,23,29).

In surgical cases, bioceramics have been shown to be effective in apical retrogrades, favoring bone regeneration and periapical healing, even in situations complex such as reabsorptions or residual cysts (12,26,27).

These materials also stand out for their simplified handling, mainly in pre-mixed versions, in addition to the ability to operate in a humid environment, which makes them ideal for challenging clinical scenarios (10,11,19).

4. Challenges and limitations of bioceramic cements

Bioceramic cements represent a significant advance in relation to materials conventional endodontics, mainly due to their bioactivity and clinical performance.
The sustained release of calcium ions and the formation of hydroxyapatite at the interface with the

tissues favor biological sealing and periapical regeneration, being differential in relation to resin or zinc oxide-based cements (5,15,19).

These materials have high biocompatibility, alkaline pH, low solubility, controlled expansion **and** chemical adhesion to dentin, which contributes to the prevention of marginal infiltration and for the healing of adjacent tissues (6,10,18,20). Studies demonstrate their effectiveness even in challenging clinical conditions, such as perforations and retrograde, with formation of new mineralized tissue and control of inflammation (12,16,27).

Hydrophilicity and the possibility of use in wet fields expand its applicability, facilitating clinical routine and allowing its use in cases where absolute isolation is limited (10,11,14). Premixed versions, such as *BC Sealer®* and *Bio-C Sealer®,* still They offer practicality and reduce the risk of handling errors (13,19).

Among the limitations, the prolonged setting time of some formulations stands out, especially repair cements, which may require greater operative control (15,18). Furthermore, the differences between commercial formulations—both in composition as in clinical properties — require detailed knowledge on the part of the professional(18,28).

Another point of attention is the high cost of these materials compared to cements. conventional methods, which may restrict their use in certain clinical situations. Still thus, the biological benefits and predictability of results justify its adoption, especially in cases involving tissue regeneration or increased risk of endodontic failure (15,23,25).

5. Comparison with other filling materials

The performance of bioceramic cements has been widely compared to other filling materials established in Endodontics, especially cements based on epoxy resin, such as AH Plus®, and MTA. Several studies show that bioceramics present effective apical sealing, with levels of microleakage comparable or inferior to those obtained with resin cements, especially when employed with the single cone technique, in which its slight volumetric expansion compensates for channel irregularities (13,15,30).

From a biological point of view, bioceramic cements stand out for their lower toxicity cellular and better compatibility with periapical tissues, surpassing epoxy cements in inflammatory response and stimulation of mineralization, even in contact situations directly with living tissue (22,23,31). Compared to MTA, bioceramics present similar clinical behavior regarding bioactivity and tissue repair, with the operational advantage of dispensing with manual handling, reducing time clinical and variability in application (17,20).

On the other hand, epoxy-based cements are still easier to remove. during retreatments, which can be decisive in the choice of material in patients with higher risk of endodontic reintervention (27) Although bioceramics are evolving in this aspect, its chemical adhesion to dentin and its hardening in depth can make unblocking difficult in some cases.

Regarding mechanical properties, bioceramics offer good resistance to compression and dimensional stability. However, its adhesion to the walls dentin is still inferior to that of resin cements, which raises questions about its performance in posterior teeth with great coronary structural loss, where the pin or core anchorage may be critical (18).

Thus, although bioceramic cements present clinical and biological advantages relevant, the choice of material should consider the individual clinical condition, the treatment objectives and the possibility of future retreatment. Its use is shown highly recommended in cases of wide canals, single cone filling, need for bioactivity and difficult-to-control sealing.

Conclusion

Bioceramic cements represent a milestone in the evolution of Endodontics, by combining superior physicochemical properties, bioactivity, and clinical versatility. Its application goes beyond conventional filling, encompassing regenerative procedures, restorative and surgical, with consistent results in apical sealing, stimulation of mineralization and integration with periapical tissues (5,11,15,20).

The literature highlights its favorable performance when compared to resin cements and to MTA itself, both in terms of tissue compatibility and ease operative, especially in premixed formulations(17,30,31). Despite this, important limitations still persist, such as the difficulty of removal in retreatments and the variability between commercial formulations, which requires attention in material selection more appropriate to each clinical context(18,27,28).

Future prospects point to the development of bioceramics with specific functionalities, such as controlled ion release, properties targeted antibacterials and integration with regenerative therapies, in addition to the potential use of 3D printing and digital customization in personalized Endodontics(28).

Therefore, the incorporation of bioceramic cements into clinical practice requires mastery dental surgeon's technical expertise, up-to-date knowledge of the literature, and individualized assessment of each case. As new evidence emerges and technology advances, these materials consolidate their role as one of the most promising choices of contemporary Endodontics.

Conflict of interest

This work was prepared independently, without financial ties, institutional or commercial matters that may represent conflicts of interest.

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