International Journal of Enhanced Research in Medicines & Dental Care (IJERMDC),
ISSN: 2349-1590, Vol. 13 Issue 3, March 2026

Bioceramic Based Root Canal Sealers: Review

Amulya Vanti

ABSTRACT

Bioceramic based root canal sealers are considered beneficial in endodontics. Several studies were evaluated related to Bioceramic-based root canal sealers, Different properties including physical properties, biocompatibility, adhesion, sealing ability, solubility and antibacterial efficacy were covered. Bioceramic-based sealers was found to be superior in properties compared to other commercial sealers.

INTRODUCTION

Root canal sealers primarily function to

(i) Fill and seal voids, accessory canals, and multiple foramina,

(ii) Create an adhesive interface between the filling core and the canal walls, and

(iii) Function as a lubricant to aid in the placement of the core material while also helping to entomb residual bacteria.[1,2]

Bioceramics are a class of ceramic materials designed specifically for applications in medicine and Dentistry. Common examples include alumina, zirconia, bioactive glass, glass ceramics, hydroxyapatite, and calcium phosphates [3]. These materials are broadly categorized as either bioactive or bioinert,based on how they interact with surrounding living tissues [4]. Bioactive bioceramics—such as calcium phosphates and bioactive glass—stimulate tissue responses that promote the formation of stronger, more durable tissue structures [5]. In contrast, bioinert materials like zirconia and alumina elicit minimal biological or physiological responses, effectively remaining passive within the body [6].

Bioactive ceramics are further divided into degradable and non-degradable types, depending on their long-term stability. Clinically, Bioceramics are widely used in orthopaedics for joint and tissue replacements, as well as for coating metal implants to enhance biocompatibility. Additionally, porous ceramics, particularly those based on calcium phosphate, are utilized as substitutes in bone grafting procedures [7].

"Bioceramic materials offer two key advantages when used as root canal sealers. Firstly, their high biocompatibility minimizes the risk of rejection by surrounding tissues [8]. Secondly, the presence of calcium phosphate enhances their setting characteristics, contributing to a chemical composition and crystalline structure that closely resemble those of natural tooth and Bone apatite [9]. This similarity promotes improved bonding between the sealer and root dentin. Despite these benefits, a notable drawback is the difficulty of removing set bioceramic sealers during retreatment or post-space preparation, which can complicate future clinical procedures [10].

While the precise mechanism by which Bioceramic-based sealers bond to root dentin remains unclear, several theories have been proposed regarding calcium silicate-based sealers .Sealer particles may diffuse into the dentinal tubules (tubular diffusion), creating mechanical interlocking bonds [11].The mineral components of the sealer may infiltrate the intertubular dentin, forming a mineral infiltration zone. This occurs after the denaturation of collagen fibres by the highly alkaline nature of the sealer. A partial chemical reaction may take place between phosphate ions and the calcium silicate hydrogel or calcium hydroxide—by-products of calcium silicate reacting with moisture in dentin—leading to hydroxyapatite formation along the mineral infiltration zone [12].

Here is a concise table version of the Bioceramic-based root canal sealers:

Table 1

Type	Brand	Manufacturer	Key Components
Calcium silicate-based	iRoot SP EndoSequence BC Sealer	Innovative BioCeramix, Canada Brasseler USA	Zirconium oxide, calcium silicates, phosphate, hydroxide Not specified
MTA-based	MTA-Fillapex	Angelus, Brazil Egeo, Argentina	MTA, resins, bismuth trioxide, silica, pigments

	Endo CPM sealer MTA-Angelus ProRoot Endo Sealer	Angelus, Brazil DENTSPLY, USA	Silicon dioxide, calcium carbonate, bismuth trioxide Calcium silicates, bismuth oxide, iron oxide, others Calcium silicates, bismuth oxide, water-soluble polymer
Calcium phosphate-based	Sankin apatite sealer (I-III)	Sankin Kogyo, Japan	Tricalcium phosphate, hydroxyapatite, iodoform (types II & III)
	Capseal (I & II)	Experimental	TTCP, DCPA, Portland cement, zirconium oxide

DISCUSSION

Ideal properties of Root Canal Sealer

1. Biocompatibility

Biocompatibility is essential for root canal sealers since they contact vital tissues at the root's apical and lateral foramina. It means the material does not cause harmful reactions like toxicity or inflammation. Most bioceramic sealers are biocompatible due to their calcium phosphate content, which is also found in teeth and bone, and can even promote bone regeneration if extruded beyond the root[14].

2. Setting Time

The ideal root canal sealer should allow enough working time before setting. However, slow setting can cause tissue irritation, as many sealers remain toxic until fully set. For example, EndoSequence BC Sealer's setting is moisture-dependent, usually taking about 4 hours, but can be much longer in dry canals [15]. Studies report varied setting times—from 2.7 hours to up to 168 hours—due to different humidity conditions . Its setting involves a two-phase chemical reaction producing hydroxyapatite and calcium silicate hydrate . MTA-Fillapex claims a setting time of around 2 hours, supported by studies, though some report even shorter times. The detailed setting process of MTA-based sealers is still not fully described [16].

3. Flow

Flow helps sealers fill tiny spaces in the root canal. ISO standards require a minimum flow of 20 mm. Flow is affected by particle size, temperature, shear rate, and mixing time. Many Bioceramic sealers claim to meet this standard, but studies often disagree[17].

4. Retreatability

Root canal sealers must be removable during retreatment to ensure healing. EndoSequence BC Sealer is often hard to remove and can block the apical foramen, though some studies say its removability is similar to AH Plus. Sankin apatite sealer and MTA-Fillapex are easier to remove and comparable to AH Plus in retreatable cases[18].

5. Solubility

Solubility refers to the mass a material loses when immersed in water. According to ANSI/ADA Specification 57, root canal sealers should not lose more than 3% of their mass. Highly soluble sealers can create gaps between the material and root dentin, leading to leakage and potential infection. Both iRoot SP and MTA-Fillapex exhibit high solubility (20.64% and 14.89%, respectively), exceeding ANSI/ADA limits. This is attributed to hydrophilic nanosized particles in these sealers, increasing surface area and liquid interaction. However, studies conflict on MTA-Fillapex's solubility, with some reporting it below 3%, meeting ISO standards. EndoSequence BC also meets ISO solubility standards. Differences in results may stem from varying drying methods after testing. MTA-Angelus shows low solubility compliant with ANSI/ADA, due to an insoluble crystalline silica matrix that maintains its structure in water[19].

Solubility measures how much a sealer loses mass in water. Sealers should lose less than 3% to avoid gaps and leakage. iRoot SP and MTA-Fillapex exceed this limit due to their hydrophilic nanoparticles, but studies conflict on MTA-Fillapex's solubility. EndoSequence BC and MTA-Angelus meet standards, with MTA-Angelus's low solubility thanks to a stable silica matrix[20].

6. Discolouration of Tooth Structure

For aesthetic reasons, a root canal sealer should not cause tooth staining. The discoloration effect of root sealers increases when excess sealer remains on the coronal dentin of the pulp chamber. According to Partovi et al, Sankin apatite III causes the least discoloration nine months after application compared to AH26, Endofill, Tubli-Seal, and zinc oxide eugenol sealers. The most significant discoloration was observed in the cervical third of the crown. MTA-Fillapex was found to cause minimal crown discoloration, to the point that it was not clinically noticeable [21].

7. Radiopacity

Root canal sealers need to be sufficiently radiopaque to stand out from surrounding anatomical structures, enabling evaluation of the root filling quality via radiographs. According to ISO 6876/2001, the minimum radiopacity should equal 3.00 mm of aluminum. Candeiro et al. reported EndoSequence BC Sealer's radiopacity as 3.83 mm. Endo CPM sealer showed 6 mm radiopacity, attributed to bismuth trioxide and barium sulfate. Likewise, MTA-Fillapex, containing bismuth trioxide, has a radiopacity of 7 mm[22] .

8. Antimicrobial Properties

The antimicrobial activity of root canal sealers improves endodontic success by eliminating residual or new infections. This activity mainly comes from their alkalinity and calcium ion release, which also aids tissue repair. Antibacterial effects of bioceramic sealers are typically tested using agar diffusion and direct contact methods [23].

Endo Sequence BC Sealer and iRoot SP show high pH (>11) and calcium release, with iRoot SP's antibacterial effect reducing after seven days; its hydrophilicity and calcium hydroxide diffusion also enhance efficacy . MTA-Fillapex and Endo CPM have strong initial antibacterial activity, but this decreases after setting, with MTA-Fillapex's effect linked to its resin content[24].

Enterococcus fecalis, a common root canal pathogen, is widely used for testing, along with other microbes like Staphylococcus aureus and Candida albicans. Fresh Endo CPM inhibits Staphylococcus aureus and Streptococcus mutans but less effectively than AH-26. MTA-Angelus is effective against several bacteria and fungi [25].

9. Adhesion

Root canal sealer adhesion is its ability to stick to both the root canal dentin and the gutta-percha (GP) cone, helping to create a strong bond between them. This adhesive potential is typically evaluated using microleakage and bond strength tests. Although numerous studies have investigated the sealing properties of bioceramic-based sealers in laboratory settings, there has been a lack of research on their long-term sealing effectiveness and clinical results until recently[26,27,30].

Bond strength is the force needed to separate a sealer from dentin. Though it doesn't directly correlate with leakage, it's important because strong bonding creates a "monoblock" that improves sealing and tooth strength. Bioceramic sealers like iRoot SP and EndoSequence BC Sealer show bond strengths comparable to or better than traditional sealers like AH Plus. Moist conditions enhance bonding, and calcium hydroxide pretreatment can improve iRoot SP's adhesion. Some sealers, such as Endo CPM and ProRoot Endo Sealer, demonstrate even higher bond strengths. Overall, bioceramic sealers provide strong bonds that help maintain tooth integrity and increase fracture resistance[28,29].

CONCLUSION

Bioceramic-based root canal sealers show promise but still fall short of meeting all ideal sealer criteria. Their biocompatibility and biomineralization suggest potential for use in direct pulp capping and root-end filling. More research is needed to confirm their clinical effectiveness.
Conflict of Interests: NO

REFERENCES

[1] Grossman L. Obturation of root canal. In: Grossman L., editor. Endodontic Practice. 10th. Philadelphia, Pa, USA: Lea and Febiger; 1982. p. p. 297. [Google Scholar]

[2] Krell K. F., Wefel J. S. A calcium phosphate cement root canal sealer—scanning electron microscopic analysis. Journal of Endodontics. 1984;10(12):571–576. doi: 10.1016/s0099-2399(84)80103-x. [DOI] [PubMed] [Google Scholar]

[3] Krell K. V., Madison S. Comparison of apical leakage in teeth obturated with a calcium phosphate cement or Grossman's cement using lateral condensation. Journal of Endodontics. 1985;11(8):336–339. doi: 10.1016/S0099-2399(85)80040-6. [DOI] [PubMed] [Google Scholar]

[4] Chohayeb A. A., Chow L. C., Tsaknis P. J. Evaluation of calcium phosphate as a root canal sealer-filler material. Journal of Endodontics. 1987;13(8):384–387. doi: 10.1016/S0099-2399(87)80198-X. [DOI] [PubMed] [Google Scholar]

[5] Pissiotis E., Spngberg L. S. W. Biological evaluation of collagen gels containing calcium hydroxide and hydroxyapatite. Journal of Endodontics. 1990;16(10):468–473. doi: 10.1016/S0099-2399(07)80175-0. [DOI] [PubMed] [Google Scholar]

[6] Barkhordar R. A., Stark M. M., Soelberg K. Evaluation of the apical sealing ability of apatite root canal sealer. Quintessence International. 1992;23(7):515–518. [PubMed] [Google Scholar]

[7] Schmalz G. Use of cell cultures for toxicity testing of dental materials—advantages and limitations. Journal of Dentistry. 1994;22(2):S6–S11. doi: 10.1016/0300-5712(94)90032-9. [DOI] [PubMed] [Google Scholar]

[8] Bilginer S., Esener T., Söylemezoglu F., Tiftik A. M. The investigation of biocompatibility and apical microleakage of tricalcium phosphate based root canal sealers. Journal of Endodontics. 1997;23(2):105–109. doi: 10.1016/s0099-2399(97)80255-5. [DOI] [PubMed] [Google Scholar]

[9] Ginebra M. P., Fernández E., De Maeyer E. A. P., et al. Setting reaction and hardening of an apatitic calcium phosphate cement. Journal of Dental Research. 1997;76(4):905–912. doi: 10.1177/00220345970760041201. [DOI] [PubMed] [Google Scholar]

[10] Sun Z. L., Wataha J. C., Hanks C. T. Effects of metal ions on osteoblast-like cell metabolism and differentiation. Journal of Biomedical Materials Research. 1997;34(1):29–37. doi: 10.1002/(sici)1097-4636(199701)34:1<29::aid-jbm5>3.0.co;2-p. [DOI] [PubMed] [Google Scholar]

[11] Cherng A. M., Chow L. C., Takagi S. In vitro evaluation of a calcium phosphate cement root canal filler/sealer. Journal of Endodontics. 2001;27(10):613–615. doi: 10.1097/00004770-200110000-00003. [DOI] [PubMed] [Google Scholar]

[12] International Organization for Standardization. ISO. 6876. Geneva, Switzerland: International Organization for Standardization; 2001. Dental root canal sealing materials. [Google Scholar]

[13] Kim J.-S., Baek S.-H., Bae K.-S. In vivo study on the biocompatibility of newly developed calcium phosphate-based root canal sealers. Journal of Endodontics. 2004;30(10):708–711. doi: 10.1097/01.don.0000125318.90702.01. [DOI] [PubMed] [Google Scholar]

[14] Paqué F., Luder H. U., Sener B., Zehnder M. Tubular sclerosis rather than the smear layer impedes dye penetration into the dentine of endodontically instrumented root canals. International Endodontic Journal. 2006;39(1):18–25. doi: 10.1111/j.1365-2591.2005.01042.x. [DOI] [PubMed] [Google Scholar]

[15] Yang S.-E., Baek S.-H., Lee W., Kum K.-Y., Bae K.-S. In vitro evaluation of the sealing ability of newly developed calcium phosphate-based root canal sealer. Journal of Endodontics. 2007;33:978–981. doi: 10.1016/j.joen.2006.07.023. [DOI] [PubMed] [Google Scholar]

[16] Best S. M., Porter A. E., Thian E. S., Huang J. Bioceramics: past, present and for the future. Journal of the European Ceramic Society. 2008;28(7):1319–1327. doi: 10.1016/j.jeurceramsoc.2007.12.001. [DOI] [Google Scholar]

[17] Cotton T. P., Schindler W. G., Schwartz S. A., Watson W. R., Hargreaves K. M. A retrospective study comparing clinical outcomes after obturation with Resilon/Epiphany or Gutta-Percha/Kerr Sealer. Journal of Endodontics. 2008;34(7):789–797. doi: 10.1016/j.joen.2008.03.018. [DOI] [PubMed] [Google Scholar]

[18] Weller R. N., Tay K. C. Y., Garrett L. V., et al. Microscopic appearance and apical seal of root canals filled with gutta-percha and ProRoot Endo Sealer after immersion in a phosphate-containing fluid. International Endodontic Journal. 2008;41(11):977–986. doi: 10.1111/j.1365-2591.2008.01462.x. [DOI] [PubMed] [Google Scholar]

[19] Zhang H., Shen Y., Ruse N. D., Haapasalo M. Antibacterial activity of endodontic sealers by modified direct contact test against Enterococcus faecalis . Journal of Endodontics. 2009;35(7):1051–1055. doi: 10.1016/j.joen.2009.04.022. [DOI] [PubMed] [Google Scholar]

[20] Koch K., Brave D. A new day has dawned: the increased use of bioceramics in endodontics. Dentaltown. 2009;10:39–43. [Google Scholar]

[21] Gandolfi M. G., Prati C. MTA and F-doped MTA cements used as sealers with warm gutta-percha. Long-term study of sealing ability. International Endodontic Journal. 2010;43(10):889–901. doi: 10.1111/j.1365-2591.2010.01763.x. [DOI] [PubMed] [Google Scholar

[22] Mukhtar-Fayyad D. Cytocompatibility of new bioceramic-based materials on human fibroblast cells (MRC-5) Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology. 2011;112(6):e137–e142. doi: 10.1016/j.tripleo.2011.05.042. [DOI] [PubMed] [Google Scholar]

[23] Bryan T. E., Khechen K., Brackett M. G., et al. In vitro osteogenic potential of an experimental calcium silicate-based root canal sealer. Journal of Endodontics. 2010;36(7):1163–1169. doi: 10.1016/j.joen.2010.03.034. [DOI] [PubMed] [Google Scholar]

[24] Han L., Okiji T. Uptake of calcium and silicon released from calcium silicate-based endodontic materials into root canal dentine. International Endodontic Journal. 2011;44(12):1081–1087. doi: 10.1111/j.1365-2591.2011.01924.x. [DOI] [PubMed] [Google Scholar]

[25] Darvell B. W., Wu R. C. 'MTA'—an hydraulic silicate cement: review update and setting reaction. Dental Materials. 2011;27(5):407–422. doi: 10.1016/j.dental.2011.02.001. [DOI] [PubMed] [Google Scholar]

[26] Atmeh A. R., Chong E. Z., Richard G., Festy F., Watson T. F. Dentin-cement interfacial interaction: calcium silicates and polyalkenoates. Journal of Dental Research. 2012;91(5):454–459. doi: 10.1177/0022034512443068. [DOI] [PMC free article] [PubMed] [Google Scholar]

[27] Salles L. P., Gomes-Cornélio A. L., Guimarães F. C., et al. Mineral trioxide aggregate-based endodontic sealer stimulates hydroxyapatite nucleation in human osteoblast-like cell culture. Journal of Endodontics. 2012;38(7):971–976. doi: 10.1016/j.joen.2012.02.018. [DOI] [PubMed] [Google Scholar]

[28] Zhou H.-M., Shen Y., Zheng W., Li L., Zheng Y.-F., Haapasalo M. Physical properties of 5 root canal sealers. Journal of Endodontics. 2013;39(10):1281–1286. doi: 10.1016/j.joen.2013.06.012. [DOI] [PubMed] [Google Scholar]

[29] Silva E. J., Santos C. C., Zaia A. A. Long-term cytotoxic effects of contemporary root canal sealers. Journal of Applied Oral Science. 2013;21(1):43–47. doi: 10.1590/1678-7757201302304. [DOI] [PMC free article] [PubMed] [Google Scholar]

[30] Viapiana R., Flumignan D. L., Guerreiro-Tanomaru J. M., Camilleri J., Tanomaru-Filho M. Physicochemical and mechanical properties of zirconium oxide and niobium oxide modified Portland cement-based experimental endodontic sealers. International Endodontic Journal. 2014;47(5):437–448. doi: 10.1111/iej.12167. [DOI] [PubMed] [Google Scholar]