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Bioceramics Sealers: A Narrative Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Root canal sealers are required an impenetrable seal between the core material and root canal dentin. In cultures, the majority of standard root canal sealers have shown inadequate biological activity and are cytotoxic, incredibly when freshly mixed. To address these drawbacks, bioceramic sealers were created, and it has been demonstrated that they perform better in clinical settings. They are bio-inert, non-toxic, and have several other benefits like dimensional stability. Additionally, when they are set, they form hydroxyapatite, which has inherent osteoconductive properties and stimulates the body's healing processes. Therefore, this review aims to go through the different bioceramic sealers and their classification, characteristics, benefits, and drawbacks.

Keywords: Bioactive; bioinert; biocompatibility; bioceramic sealers; calcium silicate based.

1. INTRODUCTION

"The three-dimensional obturation helps to seal endodontic voids, which permanently confines the root canal contents from the periapical tissues and prevents chronic irritation and foreign body reactions by material components, this is the most perfect endodontic treatment result" [1].

Traditional obturation materials have a solid core, a sealer, and gutta-percha. Numerous studies have reviewed root canal sealers, either collectively or individually [2].

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Sealers are categorized based on their composition, including zinc oxide eugenol [3], calcium hydroxide [4], glass ionomer [5], and resin-based sealers [6]. A new category of sealers has gained popularity, tricalcium silicate-based.

Over the past thirty years, bioceramic-based sealers have become widely used in endodontics; this development coincides with the growth of bioceramic technology in medicine and dentistry.

"Bioceramics are ceramic substances created especially for use in the medical and dental fields. Alumina, zirconia, bioactive glass, glass ceramics, hydroxyapatite, and calcium phosphates" [7].

"Based on the interaction with the surrounding living tissue, bioceramic materials are categorized as bioactive or bioinert materials" [8].

"Glass and calcium phosphate are forms of bioactive materials that interact with the surrounding tissue to promote the formation of more durable tissues" [9].

"Zirconia and alumina are bioinert materials with little to no biological or physiological impact on the surrounding tissue" [8].

The stability of bioactive compounds is further categorized into degradable and nondegradable.

Bioceramic materials as root canal sealers, there are two key benefits. First off, their biocompatibility keeps the surrounding tissues from rejecting them [9].

Second, the chemical composition and crystalline structure of bioceramic materials are similar to those of materials made of tooth and bone apatite [10], which promotes the setting capabilities of bioceramics and enhances sealer-to-root dentin bonding.

"However, a significant drawback of these materials is how challenging it is to remove them from the root canal after they are placed for later retreatment or post-space preparation" [11].

2. MECHANISM OF ACTION

The mechanism of action is still unknown however following mechanisms have been suggested for calcium silicate-based sealers.

1) "The sealer particles penetrate the dentinal tubules to create mechanical interlocking bonds" [12].

2) "Infiltration of the sealers into the intertubular dentin establishes a mineral infiltration zone produced after denaturing the collagen fibers with a strong alkaline sealer" [13,14].

3) "Partial reaction of calcium silicate hydrogel with calcium hydroxide and phosphate produced through the reaction of calcium silicates in the presence of the dentin's moisture, resulting in the formation of hydroxyapatite along the mineral infiltration zone" [15].

3. CLASSIFICATION OF BIOCERAMIC SEALERS

The biological and physical qualities of bioceramic-based root canal sealers (Table 1) were studied based on Grossman's [18] definition of the ideal root canal sealer features, as stated in the following list:

(1) It should be tacky when mixed to provide good adhesion between it and the canal wall when set.
(2) It should make a hermetic seal.
(3) It should be radiopaque so that it can be visualized on the radiograph.
(4) The powder particles should be very fine so they can mix easily with liquid.
(5) It should not shrink upon setting.
(6) It should not discolor the tooth structure.
(7) It should be bacteriostatic or at least not encourage bacterial growth.
(8) It should set slowly.
(9) It should be insoluble in tissue fluids.
(10) It should be well tolerated by the periapical tissue.
(11) It should be soluble in common solvents if it is necessary to remove the root canal filling.

3.1 Endo-CPM Sealer

This was introduced in 2004 to combine the biological qualities of MTA with the physicochemical properties of a root canal sealer.

"End-CPM had an antimicrobial activity on E. faecalis before setting, but it did not continue to have an antibacterial effect after setting" [19].

Table 1. Classifications of bioceramic sealers [16]

Type	Brand name
Calcium silicate-based sealer(CSBS)	iRoot SP Endo Sequence BC Sealer
MTA-based sealer	MTA Fillapex Endo CPM sealer, MTA-Angelus, ProRoot Endo Sealer
Calcium phosphate-based sealer	Sankin apatite root canal sealer (I, II, and III), Capseal (I and II)

Table 2. Lists the CSBS that are offered in the worldwide industry and provides data on the delivery and composition of the products [17]

Delivery	**1-component materials**	
Sealer	**Manufacturer**	**Composition**
iRoot SP	Innova_veBioceramix, Vancoucer, Canada	zirconium oxide, dicalcium silicate, tricalcium silicate, calcium phosphate monobasic, calcium hydroxide, filler, thickening agents
Endosequence BC Sealer	Brasseler USA, Savannah, USA	zirconium oxide, dicalcium silicate, tricalcium silicate, calcium phosphate monobasic, calcium hydroxide, filler, thickening agents
Total Fill BC Sealer	FKG Dentaire, La Chaux-de-Fonds, Switzerland	calcium silicates, calcium phosphate monobasic, zirconium oxide, tantalum oxide, and thickening agents
Endoseal MTA	Maruchi, Wonju, Korea	calcium silicates, calcium aluminates, calcium aluminoferrite, calcium sulfates, radiopacifier, thickening agents
MTA-Fillapex	Angelus, Londrina, PR, Brazil	Salicylate resin, diluting resin, natural resin, bismuth
		trioxide, nanoparticulate silica, MTA, and pigments
Well-Root ST	Vericom, Gangwon-Do, Korea	calcium aluminosilicate, zirconium oxide, filler, thickening agent
Nano-Ceramic Sealer	B&L Biotech, Fairfax, USA	calcium silicates, zirconium oxide, filler, thickening agent
EndoSequence BC Sealer Hi-Flow	Brasseler USA, Savannah, USA	Zirconium Oxide, Tricalcium Silicate, Dicalcium Silicate, Calcium Hydroxide, and fillers
Cereal	Meta Biomed Co., 270, Chungcheongbuk-do, South Korea	Calcium silicates, zirconium oxide, thickening agent
Delivery	**2-component materials**	
Endo CPM	EGEO SRL, Buenos Aires, Argentina	Powder: mineral trioxide aggregate, bismuth oxide, barium sulfate, silica dioxide Liquid: aqueous solution of calcium chloride, sodium citrate, propyleneglycol alginate, propylenglycol
Tech Bio Sealer	Endo Isasan SRL, Revello Porro, Italy	Powder: White Portland cement, bismuth oxide, anhydride, sodium fluoride Liquid: Alfacaine SP solution (4% articaine +1/100.000Epinephrine
Bio Root RCS	Septodont, Saint-Maur-des-Fossés, France	Powder: tricalcium silicate, zirconium oxide, povidone Liquid: aqueous solution of calcium chloride and polycarboxylate

Delivery	1-component materials	
Sealer	**Manufacturer**	**Composition**
ProRoot ES	Dentsply, York, USA	Powder: tricalcium silicate, dicalcium silicate, calcium sulfate, bismuth oxide & tricalcium aluminate Liquid: water, viscous water- soluble polymer
NeoMTA Plus	Avalon Biomed Bradenton,USA	Powder: tricalcium silicate, dicalcium silicate, tricalcium aluminate, calcium sulfate & gypsum Liquid: Water-based gel with thickening agents and water soluble

To prevent the surface necrosis of cells in contact with the material, calcium carbonate was added to lower the pH from 12.5 to 10.0 after it was set [20]. This resulted in the deposition of mineralized tissue.

"The addition of calcium chloride to MTA decreases setting time, enhances sealing ability, and makes it easier to insert into cavities without affecting its biocompatibility" [21].

3.1.1 I root sp

Root canal sealer is made of calcium silicate and devoid of aluminum. In an antibacterial examination, it was able to kill E. faecalis and displayed an alkaline pH up to 7 days after setting [22]. iRoot SP has a higher solubility compared to other BC materials. In a filter diffusion test, it was discovered that fresh iRoot Sp was much more hazardous than Pro Root MTA and that iRoot SP had more residual filler after retreatment than epoxy resin- and zinc oxide-eugenol-based sealers [23]. "Additionally, it has stronger push-out bonds than other CSBS and greater resilience to fracture than epoxy resin-based sealers, showing deeper dentinal tubule penetration" [19].

3.2 Endosequence BC Sealer

Endosequence BC Sealer (BCS), a calcium silicate-based material that is insoluble, radiopaque, and aluminum-free, relies on water to set and harden before it can be used for filling and sealing. It is an injectable root canal material that has been pre-mixed and is ready to use [24]. It is designed to be used in the single cone and lateral condensation techniques. The working period can last up to four hours or longer at room temperature. It takes four hours to set. However, the setting time may exceed 10 hours in really dry root canals (Table 2).

3.3 Total Fill BC Sealer

A pre-mixed, ready-to-use bioceramic paste called TotalFill BC Sealer was created for use as a permanent root canal filling and sealing paste.

"It is a calcium silicate-based substance that is insoluble radiopaque and aluminum free. Compared to AH Plus or MTA Fillapex, it showed more cell proliferation and collagen type I.

Adhesion" [18]. "TotalFill recorded higher observations of complete apical healing, compared to AH-Plus" [25].

3.3.1 Endoseal-MTA

MTA serves as the principal component of this sealer, which excludes resin. It doesn't contain eugenol and will not impede adhesion inside the root canal.

Due to its exceptional flowability, this premixed, injectable endodontic sealer fills the entire root canal system, including accessory and lateral canals.

"Endoseal MTA sets in roughly 12.31 minutes and has a radiopacity greater than 3 mm aluminum thickness. After 30 days in the water, it expanded less than epoxy resin-based sealers. On human periodontal ligament cells (PDL), it exhibits less biocompatible than BioRoot RCS" [26].

3.3.2 MTA fillapex

MTA Fillapex is a root canal sealer made of resin-based MTA and nano-silicate particles [27]. The total setting time is between two and four hours, with the working time being roughly 30 minutes. "The lateral and accessory canals are easily penetrated by MTA Fillapex because of their high flow rate (27 mm) and thin film thickness" [28]. The resin component or other sealer components may be responsible for MTA Fillapex's considerably greater cytotoxicity [29].

3.4 Nano Ceramic Sealer (NCS)

It is cytocompatible, however not as effective as Bioroot RCS.

"Cell viability is significantly increased for 7 days while using a nano-ceramic sealer. Due to its smooth surface, it exhibits advantageous cell adhesion and proliferation. It has good initial osteoblastic potential, which is better for periapical healing at the beginning" [30].

3.5 Endosequence BC Sealer HiFlow

To provide a sealer suited for use in warm canal filling processes, a new formulation of Endosequence BC Sealer has been developed into Endosequence BC Sealer HiFlow (BCHiF). BCHiF and BCS shared the same elemental makeup. Both sealers' carbon, oxygen, and silicon percentages were similar, while calcium and zirconium concentrations varied. However, the manufacturer claims that it is more radiopaque than Endosequence BCS and has a reduced viscosity when heated. In terms of cytocompatibility, cell migration, cell adhesion, and bioactivity potential, BCHiF performed similarly to its predecessor BCS [29].

3.5.1 Cera seal

Cera seal is a bioceramic sealer made of calcium phosphate that is administered using a pre- mixed syringe. With a setting time of roughly 3.5 hours and a radiopacity of less than 8 mm, CeraSeal has a high pH (12.73).

It shows a significant calcium ion release, has higher cell viability, and enables faster migration than endoseal [31].

3.6 BioRoot RCS

The single cone approach or cold lateral condensation root filling are both recommended for use with BioRoot RCS, a powder/liquid hydraulic tricalcium silicate-based cement. It has a flow of more than 17 mm, a radiopacity greater than 3 mm aluminum thickness, and a film thickness of less than 50 m.

It has a setting time of roughly five hours. When kept in phosphate-buffered saline, it is soluble for six months [32]. It releases more calcium ions than other CSBS and exhibits long-lasting alkaline activity [33]. When applied using the single-cone approach, BioRoot RCS's Push-out bond strength (POBS) was lower than AH Plus's [34]. "The use of EDTA as a final irrigant hurt the POBS of BioRoot RCS, whereas chlorhexidine enhanced the dislodgement resistance" [35]. "BioRoot RCS showed low toxicity and genotoxicity on PDL cells and are proven to be biocompatible with human PDL cells and gingival fibroblasts" [26].

3.7 ProRoot Endo Sealer

"In ProRoot Endo Sealer, a calcium silicate-based endodontic sealer has a water-soluble polymer added to MTA that increases the flow even at a high powder-to-liquid ratio. It is to be used in conjunction with root filling material in either cold lateral warm vertical or carrier- based filling technique" [36].

"It shows biocompatibility when in contact with a physiological solution, andthe set sealer liquid discharges calcium and hydroxyl ions, which is responsible for its bioactivity" [37]. "When it is extruded through the apical constriction, it also has favorable cytotoxicity and hence minimally irritates the tissue" [38].

3.7.1 NeoMTA

"NeoMTA Plus is a new finer powder tricalcium silicate material and has tantalum oxide (Ta_2O_5) as a radiopacifying agent that is mixed with a water-based gel that imparts good handling properties. A thin consistency can be employed as an orthograde sealer or a thick combination for root-end filling, based on the powder-to-gel mixing ratio" [39].

3.7.2 Well root ST

"Well Root ST is an injectable, premixed sealer that is injected into root canals without contaminating the access cavity. Zirconium oxide serves as a radio pacifier in Well Root ST, which also includes calcium silicate and thickening/filling agents. MTA Fill apex and Dia-Proseal, Well Root ST generated clinically noticeable discoloration in 4 weeks" [39]. "Due to their high pH when they were in the fresh state, they demonstrated much higher cell viability at 3 days, but they showed decreased cell viability over time in fresh media. It was found to be the most effective of human periodontal ligament stem cells to the set surface" [40].

3.8 Tec Bio Sealer

"This material is based on phyllosilicate (montmorillonite) in addition to tricalcium silicate, calcium sulfate, calcium chlorite, bismuth oxide, and sodium fluoride in powder. one report demonstrated that the dislocation resistances to Tec Bio sealer did not significantly improve time after the root canals were irrigated with different protocols. This calls for further research on the bioactivity of this material" [41].

4. CONCLUSION

Bioceramic-based sealers are a modern alternative to the current "golden standard" of multi- phase (guttapercha—epoxy sealer) warm techniques because of their potent antimicrobial property, absolute biocompatibility, osteoconductivity, ability to achieve excellent fluid-tight seal in a constantly wet environment, formation of the chemical bond with dentin, insolubility in tissue fluids, expansion during the time of set, very good radiopacity, and ease of handling. To evaluate the clinical results linked to the usage of these sealers, additional research is needed.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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