



## BIOCERAMIC SEALERS: AN OVERVIEW

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### ABSTRACT

The application of bioceramic root canal sealers for obturation of the root canal space has been a subject of interest in the recent years. Chemical bonding to root canal dentinal walls, an intrinsic osteo-conductive activity and an ability to induce regenerative responses in the human body are some of their benefits. While various branded bioceramic-based root canal sealers are available in the market, laboratory and clinical testing are essential to ascertain their efficacy. The aim of this review was to gain insight into the commercially available sealers.

**Keywords:** Bioceramic sealers, Root canal sealers, Root canal treatment, Obturation

### INTRODUCTION

Endodontic sealers have been conventionally used to seal dentinal tubules, creating a homogenous interface between the obturation material and the

dentinal walls. They help reduce endodontic infection by entombing residual bacteria and preventing leakage of nutrients and reinfection of the root canal space.

They also seal minor discrepancies between the dentinal wall of the root canal and the root filling material, including irregularities in the apical foramen. Therefore, the physical properties of root canal sealers have a major impact on the quality of the root canal filling.

In contemporary endodontics, Bioceramic sealers play a significant role as a bioactive material with osteoinductive and osteoconductive properties. Their biocompatibility prevents rejection by surrounding tissues, presence of calcium and phosphate enhances setting properties resulting in chemical composition and crystalline structure similar to tooth and bone apatite materials, thereby improving sealer-to-root dentin bonding. One of the major disadvantage is the difficulty in removing them from the root canal once they are set for later retreatment or post-space preparation [1].

They have been broadly classified based on primary constituent as follows:

- Mineral trioxide aggregate (MTA)-based sealers
- Calcium silicate-based sealers
- Phosphate-based sealers
- Calcium phosphate-based sealers

Based on the commercial availability as:

MTA-based sealers:

1. Endo CPM Sealer (EGEO SRL, Buenos Aires, Argentina).

2. MTA Obtura (Angelus, Angelus Odontologica, Londrina, PR, Brazil).
3. ProRoot Endo Sealer (Dentsply Tulsa Dental Specialties, Dentsply/Maillefer, Ballaigues, Switzerland).
4. MTA Plus
5. NeoMTA Plus
6. MTA-Fillapex (Angelus, Londrina, PR, Brazil)
7. MTAS experimental sealer
8. Aureoseal (OGNA, Italy)
9. F-doped MTA cements
10. Endoseal MTA (Maruchi, Wonju, Korea)
11. Nano Ceramic Sealer (B&L Biotech, Fairfax, VA, USA)

Calcium silicate-based sealers (CSBS):

1. iRoot SP (Innovative BioCeramix Inc., Vancouver, Canada)
2. EndoSequence BC Sealer (Brasseler USA, Savannah, GA, USA)
3. EndoSequence BC Sealer HiFlow
4. iRoot BP (Innovative BioCeramix Inc., Vancouver, Canada)
5. iRoot® BP Plus Root Canal Repair Filling Material (Innovative BioCeramix Inc., Vancouver, Canada)
6. iRoot FS (Innovative Bioceramic Inc., Vancouver, Canada)
7. TotalFill BC (FKG Dentaire, La Chaux-de-Fonds, Switzerland)

8. Bioroot RCS (Septodont, Saint-Maur-des-Fossés, France)
9. Tech Biosealer Endo (Isasan, Como, Italy)
10. CeraSeal Bioceramic root canal sealer (Meta Biomed CO. LTD, Korea)
11. Cerafill RCS (Prevest DenPro)
12. GuttaFlow Bioseal (Coltène/Whaledent AG, Altstätten, Switzerland)
13. Sealer Plus BC (MK Life Produtos Medical e Dental, Porto Alegre, Brazil)
14. Smartpaste Bio (CRD Ltd, Stamford, UK)
15. Well-Root ST (Vericom, Gangwon-Do, Korea)

Phosphate-based bioceramic sealers:

1. Bio aggregate (Innovative Bioceramix Inc., Vancouver, Canada)

Calcium phosphate-based sealers:

1. Sankin apatite root canal sealer (I, II, and III) (Sankin Kogyo, Tokyo, Japan)
2. Capseal (I and II) [2]

Endo CPM Sealer (EGEO SRL, MTM Argentina SA, Buenos Aires, Argentina)

In 2004, CPM sealer was developed in an attempt to combine the sealing and physiochemical properties of root canal sealer with biological properties of MTA. Endo CPM had an antibacterial effect

against *E. faecalis* before setting but it did not maintain antibacterial activity after setting. Calcium carbonate was added to reduce the pH from 12.5 to 10.0, to restrict the surface necrosis of cells in contact with the material, resulting in the deposition of mineralized tissue. Addition of calcium chloride to MTA reduces setting time, improves sealing ability and facilitates the insertion into cavities without interfering with its biocompatibility [3].

### MTA Obtura

This sealer was developed by replacing saline with a liquid resin as cure initiator. The composition of the powder in this cement is similar to gray MTA Angelus, consisting of Portland cement clinker and bismuth oxide. The development of MTA Obtura aimed at the achievement of an endodontic sealer combining the biological and sealing properties of MTA. This sealer presented very stable leakage values at 15 and 30 days, as expected for an MTA-based material. Its performance reproduced good sealing ability similar to MTA as repair material. However, at 60 days, MTA Obtura exhibited a considerable increase in leakage.

ProRoot Endo Sealer (Dentsply Tulsa Dental Specialities)

ProRoot ES is an enhanced formula of its counterpart ProRoot MTA root repair material. The water-based, easy-to-mix formula creates a smooth stringy

consistency for excellent handling, and provides a flexible working time, setting quickly, even in the presence of moisture. The major components of the powder are tricalcium silicate and dicalcium silicate, with inclusion of calcium sulfate as setting retardant, bismuth oxide as radiopacifier and a small amount of tricalcium aluminate. The liquid component consists of viscous aqueous solution of water-soluble polymer.

#### **MTA Plus**

The basic composition of MTA Plus is similar to that of the original MTA. The powder of MTA Plus is finer and it is recommended that MTA powder is to be mixed with a proprietary water-based gel when the material is used as a root canal sealer. This gel contains film forming polymers and accelerators but no salts.

#### **NeoMTA Plus**

NeoMTA Plus is a new finer powder of tricalcium silicate, which has tantalum oxide ( $Ta_2O_5$ ) as a radiopacifying agent. It is mixed with a water-based gel that imparts good handling properties. The powder-to-gel mixing ratio can be varied and a thin consistency can be used as an orthograde sealer or a thick mixture for root-end filling [4].

#### **MTA Fillapex Root Canal Sealer (Angelus)**

MTA Fillapex is a two-paste sealer composed of MTA. Paste A is composed of

salicylate resin (methyl salicylate, butylene glycol, and colophony), bismuth oxide, and silica. Paste B includes silicon dioxide, titanium dioxide, and base resin (pentaerythritol, rosin, and toluene sulphonamide), and 13.2% set MTA particles as filler. According to the manufacturer, MTA Fillapex has a high flow rate (27 mm) and a low film thickness, so it easily penetrates the lateral and accessory canals. The significantly higher cytotoxicity of MTA Fillapex may be caused by the resin component or by other components of the sealer [5].

#### **MTAS Experimental Sealer**

It was developed by the authors at discipline of Endo Araraquara Dental School UNESP, University of Estadual Paulista, Sao Paulo, Brazil. It is composed of 80% white Portland cement, zirconium oxide as radio opacifying agent, calcium chloride as additive, and resinous vehicle. It is prepared using powder to liquid ratio of 5:3 by weight, which was determined in previous pilot studies. It has similar initial and final setting time to those of AH Plus sealer.

#### **Aureoseal (OGNA, Italy)**

It is a root repair sealer with a modified mineral oxide (MTA) and Portland sealer base. This eugenol-free sealer is perfect for numerous uses with difficult clinical resolutions. For the repair of root perforations, apicectomies, pulpectomies,

direct pulp capping and for the treatment of reabsorbable or divergent apices.

#### **F-doped MTA Cements**

Powder consists of white Portland cement, bismuth oxide, anhydrite, sodium fluoride (Carlo Erba, Italy). Liquid consist of Alphacaine SP solution. Sodium fluoride was included in FMTA as an expansive and retardant agent. Fluoride-doped MTA demonstrated stable sealing during a period of up to 6 months and significantly better than conventional calcium silicate MTA cements and comparable to AH Plus.

#### **Endoseal MTA (Maruchi, Wonju, Korea)**

It is a material based on pozzolan cement with excellent physical and biological properties of MTA. It is available in the form of a premixed, preloaded paste in an airtight syringe, and according to the manufacturer, it has various clinical applications, including obturation of root canals and repair of root perforations. It is composed of calcium silicate, calcium aluminate, calcium aluminoferrite, and calcium sulfate. During the setting process of EndoSeal MTA, pozzolan cement, which is a siliceous or siliceous-aluminous material, chemically reacts with calcium hydroxide in the presence of moisture to form compounds with adequate cementitious properties that may contribute to the effective flow of the substance, sufficient working consistency, and a

reduced setting time up to approximately 4 minutes. The Endoseal MTA manufacturer has proposed a new method in which ultrasonic power is applied directly to the master gutta-percha cone in order for it to be able to transfer the energy to preplaced sealer for achieving better filling quality with less voids [6].

#### **Nano Ceramic Sealer (B&L Biotech, Fairfax, VA, USA)**

Nanoceramic sealer shows significantly increased cell viability for 7 days. It shows favourable cell attachment and proliferation because of its smooth surface. It has favourable initial osteoblastic potential, which is more beneficial for initial periapical healing than other sealers [7].

#### **iRoot SP (Innovative BioCeramix Inc., Vancouver, Canada)**

It is a convenient premixed ready-to-use injectable white hydraulic cement paste developed for permanent root canal filling and sealing applications. Unlike traditional endodontic sealers, it has absolutely no shrinkage which gives a gap-free seal. It showed an alkaline pH up to 7 days after setting and was capable of killing *E. faecalis* in an antibacterial investigation. iRoot SP is available as Endosequence BC Sealer, which is a private label, distributed by Brasseler USA.

#### **EndoSequence BC Sealer (Brasseler USA, Savannah, GA, USA)**

It is available as a premixed and injectable material for use in single cone and lateral condensation technique. It is composed of zirconium oxide, calcium silicates, calcium phosphate monobasic, calcium hydroxide and thickening agents. It is a hydrophilic, insoluble, radiopaque and aluminium-free material which utilizes the moisture naturally present in the dentinal tubules to initiate and complete its setting reaction. This allows good chemical bond to dentin and expansion of the material inside the root canal, improving its sealing ability.

#### **EndoSequence BC Sealer HiFlow**

A new formulation of Endosequence BC Sealer has been modified into Endosequence BC Sealer HiFlow (BCHiF) to obtain a suitable calcium-silicate based sealer to use in warm canal filling techniques. According to the manufacturer's claims, BC Sealer HiFlow exhibits a lower viscosity when heated and is more radiopaque than BC Sealer, making it optimized for warm obturation techniques. Recent studies demonstrated that HiFlow had similar cytocompatibility and bioactivity to that of BC Sealer, while it showed better performance on flow than BC Sealer when the warm vertical compaction technique was used [8].

#### **iRoot BP Injectable Root Canal Repair Filling Material (Innovative BioCeramix Inc., Vancouver, Canada)**

iRoot BP Injectable Root Canal Repair Filling Material is a convenient ready-to-use white hydraulic premixed injectable paste developed for permanent root canal repair and filling applications. It is an insoluble, radiopaque and aluminum-free material based on a calcium silicate composition, which requires the presence of water to set and harden. It does not shrink during setting, demonstrates excellent physical properties, and is packaged in a preloaded syringe with disposable tips.

#### **iRoot® BP Plus Root Canal Repair Filling Material (Innovative BioCeramix Inc., Vancouver, Canada)**

iRoot BP plus is a convenient ready-to-use white hydraulic premixed putty developed for permanent root canal repair and filling applications. iRoot® BP plus is an insoluble, radiopaque and aluminum-free material based on a calcium silicate composition, which requires the presence of water to set and harden. iRoot BP plus does not shrink during setting and demonstrates excellent physical properties. iRoot® BP plus is packaged in a preloaded jar.

#### **iRoot® BP FS Root Canal Repair Filling Material**

iRoot® FS is next generation permanent root canal repair and filling material with fast setting properties. It is an insoluble, radiopaque and aluminium-free material

based on a calcium silicate composition, which requires the presence of water to set and harden. It does not shrink during setting and demonstrates excellent physical properties.

**TotalFill BC (FKG Dentaire, La Chaux-de-Fonds, Switzerland)**

TotalFill BC Sealer is a pre-mixed ready-to-use injectable bioceramic paste developed for permanent root canal filling and sealing application. It is highly radiopaque, hydrophilic, forms hydroxyapatite upon setting, and chemically bonds to both dentine and to bioceramic points (TotalFill® BC Points™). TotalFill recorded higher observations of complete apical healing compared to AH-Plus [9].

**Bio-C Sealer (Angelus, Londrina, PR, Brazil)**

The Bio-C Sealer is a new, premixed bioceramic sealer developed for permanent filling and sealing during root canal treatment. Bio-C Sealer is available in a single syringe, composed of calcium silicates, calcium aluminate, calcium oxide, zirconium oxide, iron oxide, silicon dioxide, and dispersing agents. According to the manufacturer, its bioactivity is attributed to the release of calcium ions that stimulate the formation of mineralized tissue.

**Bioroot RCS (Septodont, Saint-Maur-des-Fossés, France)**

BioRoot RCS is powder/liquid hydraulic tricalcium silicate-based cement recommended for single cone technique or cold lateral condensation root filling. The powder is composed of tricalcium silicate, zirconium dioxide, and povidone, and the liquid is composed of water, calcium chloride, and polycarboxylate. It has a minimum working time of 10 minutes and a maximum setting time of 4 hours. This silicate-based root canal sealer has less toxic effects on human periodontal ligament cells than zinc oxide-eugenol sealer and induces a higher secretion of angiogenic and osteogenic growth factors than ZOE. BioRoot RCS compared to contemporary root canal sealers has the lower cytotoxicity and genotoxicity. The sealing properties of BioRoot RCS combined with gutta-percha are comparable to those of AHPlus, but microCT has revealed a higher void volume for BioRoot RCS than resin-based sealer, possibly due to the shorter working time and less flow than AHPlus [10].

**Tech Biosealer Endo (Isasan, Como, Italy)**

Tech Biosealer is another MTA-like cement. Its powder is a mixture of tricalcium silicate, beta dicalcium silicate ( $\beta$ -Ca<sub>2</sub>SiO<sub>4</sub>), anhydrous calcium sulfate, calcium carbonate and bismuth oxide. Its liquid is composed of Dulbecco's phosphate buffered saline (PBS).

**CeraSeal Bioceramic root canal sealer (Meta Biomed CO. LTD, Korea)**

CeraSeal is calcium phosphate based bioceramic sealer dispensed using a pre-mixed syringe. It has high pH (12.73) with a setting time about 3.5 hours. It exhibits significant release of calcium ions and have higher cell viability [11].

**Cerafill RCS (Prevest DenPro)**

Cerafill RCS root canal filling and sealing material is a ready to use injectable premixed filling and sealing material, which is based on the bioceramic technology. It is an alumina free calcium silicate based material with excellent handling characteristics and superior physical properties. It is a radiopaque material, which requires water to set and harden.

**GuttaFlow Bioseal (Coltène/Whaledent AG, Altstätten, Switzerland)**

GuttaFlow Bioseal contains bioactive substances, such as calcium and silicate, which stimulate tissue regeneration and healing. It combines free-flow gutta-percha with an appropriate sealer at room temperature according to manufacturer's instructions [12].

**Sealer Plus BC (MK Life Produtos Medical e Dental, Porto Alegre, Brazil)**

The sealer in addition to acting as a material with bioceramic compounds (zirconium oxide and di- and tri-calcium silicate) possesses an additional amount of

calcium hydroxide in its composition and is resin free [13].

**Smartpaste Bio (CRD Ltd, Stamford, UK)**

The Smart Seal obturation system consists of a bioceramic sealer (Smartpaste Bio®, CRD Ltd, Stamford, UK) identified as a hydroxyapatite-based cone polymer with an external layer of the expandable hydrophilic hydrogel Smartpoint. The manufacturer affirms that Smartpaste Bio produces hydroxyapatite and calcium hydroxide as by-products of a setting reaction consistent with alkaline pH, antibacterial activity, radiopacity, and biocompatibility [14].

**Well-Root ST (Vericom, Gangwon-Do, Korea)**

This sealer is a premixed, ready-to-use, injectable bioceramic cement paste developed for permanent obturation of the root canal. The composition of Well-Root as described by the manufacturer includes zirconium oxide, calcium silicate, filler, and thickening agents. The material is hydrophilic and uses moisture in dentinal tubules to initiate and complete its setting reactions. The setting time is 25 minutes, but in root canals, the setting time can be more than 2.5 hours. According to the manufacturer, the Well-Root ST should be used in conjunction with gutta-percha points [15].

**Bioaggregate (Innovative BioCeramix Inc., Vancouver, Canada)**

A new generation of a dental root canal repair filling material. BioAggregate® Root Canal Repair Filling Material is a fine white hydraulic powder cement mixture for dental applications. It utilizes the advanced science of nano-technology to produce ceramic particles that, upon reaction with water produce biocompatible and aluminum-free ceramic material.

The BioAggregate® Powder promotes a complicated set of reactions upon mixing with BioA Liquid (deionized water), which leads to the formation of a nano-composite network of gel-like calcium silicate hydrate intimately mixed with hydroxyapatite bioceramic, and forms a hermetic seal when applied inside the root canal. It has convenient setting and hardening time, easy workability and handling properties, make it an ideal root canal repair filling material [16].

BioAggregate® also is available as DiaRoot Root Canal Repair Filling Material which is a private label distributed by DiaDent.Group International.

Sankin apatite root canal sealer (I, II, and III) (Sankin Kogyo, Tokyo, Japan)

It is composed of a mixture of tetracalcium phosphate, dicalcium phosphate dihydrate and zirconium oxide as solid phase and sodium phosphate buffer as liquid phase. The cytotoxicity of the Sankin apatite root

canal sealer is the result of the presence of iodoform and polyacrylic acids in the sealer [17].

**Capseal (I and II)**

Capseal I and Capseal II are calcium silicate and calcium phosphate based experimental root canal sealers. Capseal contains both calcium silicate and calcium phosphate as its component. Based on previous research, calcium silicate produces calcium hydroxide when mixed with water; when calcium hydroxide comes in contact with phosphate ion, it could form hydroxyapatite, which is a major constituent of human dental tissues. Since Capseal contains calcium silicate and calcium phosphate, the formation of hydroxyapatite is expected to be enhanced by the calcium phosphate in Capseal. This would be beneficial in increasing Capseal's root canal sealing ability, which was reported to be greater than that of Sealapex.<sup>18</sup>

**CONCLUSION**

Bioceramic-based root canal sealers show promising results as root canal sealers. It is important for clinicians to understand that, successful outcome of root canal treatment is primarily driven by adequate removal of micro-organisms from the canal system, prevention of recolonization and entombment of residual species, and creating a satisfactory coronal restoration. However, considering the biological

advantages of bioceramic materials, their use in multiple paradigms of endodontic therapy appears to be the future.

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