

## Review Article

### Recent advancements in root canal sealers- An overview

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#### ABSTRACT:

Each one of the root canal sealers beholds their own advantages and disadvantages. Zinc oxide eugenol sealer was the most commonly and standard sealer used as compared to other sealers. Recently, bio ceramic-based sealers consisting of calcium silicate and calcium phosphate gained considerable attention because of their physical and biological properties. Bio ceramic materials containing calcium phosphate, enhances the setting properties of bio ceramics, thereby improving sealer-to-root dentin bonding. This review article focuses on advantages, disadvantages, indications, contraindications and recent advances of root canal sealer.

**Keywords:** Bio ceramic root canal sealer, MTA fill apex, neoapex, MTA obtura, Bioroot RC.

Received: 17 February, 2023

Accepted: 21 March 2023

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**This article may be cited as:** Sharma D, Worlikar N, Shah K, Sharma Y. Recent advancements in root canal sealers- An overview. J Adv Med Dent Scie Res 2023;11(4):82-91.

#### INTRODUCTION

The most effective way in the practice of endodontics is to disinfect and obturate the pulp chamber as efficiently and effectively as possible.<sup>1</sup>The important constituent of root filling includes a sealer and a solid core material. The most frequently used material is considered to be gutta percha also called polyisoprene, trans-1,4-polyisoprene that occupies the bulk of the canal space. Root canal sealer, on the other hand fills the intermediate space between the core material and dentin wall.<sup>2</sup>

Various types of sealers are available like resin sealers, Mineral Trioxide aggregate sealer, Bio-ceramic containing sealers, ZOE sealers, Glass ionomer containing sealer, calcium hydroxide containing sealer etc.

Epoxy resins-based sealers currently possess very good physical properties, ensure adequate biological performance and excellent apical sealing. The creation of most desired 'Three dimensional obturation', nonetheless seems to get shackled by the general lack of chemical union between the polyisoprene component of gutta-percha cone and the components of endodontic sealer.<sup>3</sup>

#### HISTORY OF CONVENTIONAL ROOT CANAL SEALER

Based on Grossman or Rickerts's formula, early sealers were modified zinc oxide-eugenol (ZOE) cements that were widely used throughout the world. Setting reaction of ZOE-based sealers is a chelation reaction occurring between eugenol and the zinc ion of the zinc oxide, unlike the resin-based sealers. This reaction is also thought to occur with the zinc oxide phase of GP along with the calcium ions of dentin which might explain the decreased setting shrinkage associated with the ZOE-based sealers<sup>4</sup>.

Michaud et al.<sup>5</sup> estimated the three-dimensional expansion of GP at various powder/liquid ratios of Pulp Canal Sealer extended working time by using spiral (helical) computed tomography (SCT). They came to a conclusion that increasing the ratio of eugenol in sealer resulted in volumetric increase of GP. It is thought that the free eugenol component of freshly mixed ZOE sealer can seep out and cause cytotoxic effect on human gingival fibroblasts, periodontal ligament (PDL) cells, and osteoblast-like cells<sup>6</sup>. Leakage of eugenol into periapical tissues is very low, and it dramatically decreases over time was reported by Haseihetal<sup>7</sup>.

**DEFINITION**

Root canal sealers are used in conjunction with biologically acceptable semisolid or solid obturating materials to establish an adequate seal of the root canal system<sup>8</sup>.

According to Dr. Vimal Sikri, Root canal sealers are defined as ‘binding agents used to fill up the gap between root canal and obturating material’.

**IDEAL REQUIREMENTS: -9**

- Establishes a hermetic seal
- Bacteriostatic, or at least does not encourage bacterial growth

- Radiopaque, so that it can be seen on a radiograph
- Very fine powder, so that it can mix easily with liquid
- No shrinkage on setting
- No staining of tooth structure
- Exhibits tackiness when mixed to provide good adhesion between it and the canal wall when set
- Soluble in a common solvent if it is necessary to remove the root canal filling
- Exhibits a slow set
- Insoluble in tissue fluids
- Tissue tolerant; that is, nonirritating to periarticular tissue

**CLASSIFICATION**

Endodontic sealers have been previously classified: according to eugenol content; absorbance; usage; etc.<sup>10,11</sup>

ROOT CANAL SEALERS	BRAND NAME
1. Zinc Oxide Eugenol based sealers	Roth sealer Kerr PCS Procoseal Endomethasone
2. Epoxy resin based sealers	AH Plus AH 26 Top Seal 2- Seal
3. Silicon based sealers	RoekoSeal Gutta flow
4. MTA based sealers	Endo-CPM-Sealer MTA Obtura ProRoot Endo Sealer MTA fillapex
5. Calcium-silicate-Phosphate based bioceramic sealers	Endosequence/iRoot SP iRoot BP Bioaggregate
6. Methacrylate resin based sealer	First generation- Hydron Second generation- EndoREZ, Realseal Third generation- Epiphany, Fibrefill Fourth generation- Realseal SE, Metaseal SE, Smartseal
7. Calcium-phosphate based sealers	Capseal I Capseal II

**Table 1:** Categorisation of Endodontic sealers according to their composition.

**RECENT ADVANCES IN SEALERS**

There have been certain advances in the growth of dental sealers. It includes-

**1)Bioceramic sealers: -<sup>12</sup>**

Bioceramic sealer, a calcium phosphate silicate based cementis premixed, hydrophilic, injectable and commercially available as EndoSequence BC Sealer (Brasseler, USA) and iRoot SP (Innovative BioCeramic Inc, Canada) injectable root canal sealer.

Composition: inorganic components, radiopacifier and water free thickening vehicles.

- **Water-free thickening vehiclesenable the sealer as to be delivered in the form of a premixed paste.**

Major inorganic components	Tricalcium silicate Dicalcium silicate Calcium phosphate Colloidal silica Calcium hydroxide
Radiopacifier	Zirconium oxide

## CLASSIFICATION OF BIOCERAMIC SEALERS<sup>-13</sup>

**Table 1.** Classification of bioceramic endodontic sealers

	Natural	Synthetic
Premixed (single component)	1. EndoSeal MTA	1. Endosequence BC Sealer (iRoot SP, TotalFill BC Sealer) 2. Well Root 3. Nano-Ceramic Sealer
Non-premixed (double component)	1. ProRoot MTA ES 2. MTA - Obtura 3. Endo CPM Sealer 4. Tech BioSealer Endo	1. BioRoot RCS

### ADVANTAGES

Excellent biocompatibility properties due to their similarity with biological hydroxyapatite.<sup>14</sup>

- Intrinsic osteo-inductive capacity due to their ability to absorb osteo-inductive substances when there is a bone healing process adjacent to it.
- Achieves excellent hermetic seal, form a chemical bond with the tooth structure and exhibits good radiopacity.
- Function as a regenerative scaffold of resorbable lattices that provide a framework which eventually dissolved as the body rebuilds tissue.<sup>15</sup>

### ENDOSEAL MTA

Two different endodontic materials used for sealing the root canal system are EndoSequence BC Sealer and MTA (Mineral Trioxide Aggregate). Nevertheless, there is a product called "EndoSequence EndoSeal MTA," which is a combination of both materials.



**FIGURE-1**

The product providing flowability and maneuverability, makes it possible to completely fill the root canal system including accessory and lateral canals. Being eugenol-free, it doesn't impede adhesion inside the root canal. ENDOSEAL MTA evolved for root canal filling and root perforation repair, avoiding secondary infection and periapical tissue irritation. The MTA particles in the sealer aids to fill any irregularities or voids in the root canal system, whereas the resin carrier helps to ensure a complete seal.<sup>16</sup>

It is a pozzolan-based MTA which is premixed and preloaded in an air-tight syringe, and can be applied directly into the root canals. (Moazami F et al, 2020). It is composed of, calcium aluminates, calcium aluminoferrite, calcium silicates and calcium sulfates. The pozzolan cement, the main component of this sealer, gets its cementitious properties after pozzolanic reaction comprising of calcium hydroxide and water, and enables

sufficient flow of the pre-mixed substrate through injection tips with adequate working consistency. (Yoo Y et al, 2016).

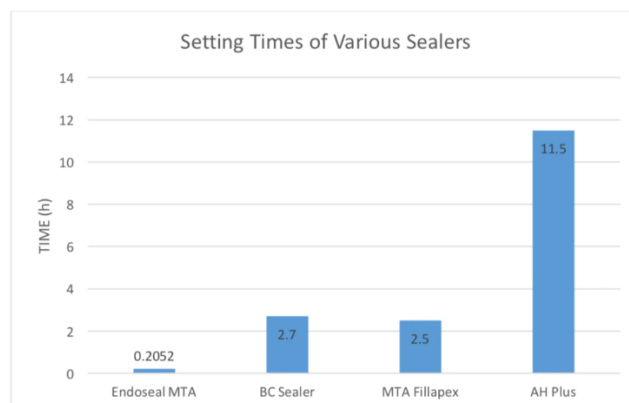


Table 1 Setting times of ENDOSEAL MTA and various root canal sealers

TABLE-1<sup>17</sup>

**ADVANTAGES**

- High biocompatibility.
- Excellent antimicrobial properties.
- Exceptional flow.
- Low solubility in contact with tissue fluids.
- A substantially shortened setting time (in mere minutes).
- High radiopacity.
- Expansion during setting- Slight expansion may contribute to superior sealing ability, but excessive expansion is undesirable when the material is employed as a root canal filling material as it may elicit cracks in the root.<sup>18</sup>

- High cost.
- It can also cause discoloration of teeth when used in the anterior region due to the presence of iron oxide in the material.

**INDICATIONS**

- Sealing root canals: EndoSeal MTA is commonly used to seal root canals as it has good sealing ability and is biocompatible.
- Apexification: EndoSeal MTA can be used to form an apical barrier in cases where the root apex is not fully formed, preventing further infection or inflammation.
- Pulp capping: EndoSeal MTA can be used for pulp capping to encourage the formation of new dentin and protect the pulp from further damage.
- Perforation repair: EndoSeal MTA can be used to repair perforations in the root or in the pulp chamber.

**DISADVANTAGES**

- Long setting time- it takes several hours to set and harden, which can prolong the duration of the endodontic procedure.
- If the material is not handled properly, it can lead to contamination or incomplete sealing of the root canal, which can result in treatment failure.

**PROPERTIES OF ENDOSEAL MTA AND VARIOUS ROOT CANAL SEALERS<sup>19</sup>**

Properties	ENDOSEAL MTA	BC Sealer	MTA Fillapex	AH Plus
Flow (mm)	21	23.1	29.04	21.2
Film Thickness (µm)	15	22	23.92	16.07
Solubility (%)	0.7	2.9	1.1	0.06
Radioopacity (mm Al)	10.5		8.9	12.5

Table 2 Properties of ENDOSEAL MTA and various root canal sealers

TABLE-2

### ENDOSEAL BC SEALER

Based on calcium silicate, Endosequence BC Sealer (BCS), is an radiopaque, insoluble, and aluminum-free material that needs the presence of water to set and harden filling and sealing. It is a premixed ready-to-use injectable material that's developed for root canal for use in the single cone and lateral condensation technique.<sup>20</sup>

Working time -more than 4 hours at room temperature. Setting time is 4 hours. However, the setting time can be more than 10 hours in very dry root canals.

#### ADVANTAGES

1. Endoseal BC Sealer has excellent antibacterial properties, which helps to reduce the risk of infection.
2. Biocompatible.
3. Endoseal BC Sealer has a strong adhesive property-creates a tight seal between the sealer and the root canal walls, preventing any leakage.
4. Endoseal BC Sealer is self-setting, requiring no additional heat or light to set.
5. Easy to use.
6. Radiopacity.
7. It has excellent durability.

### DISADVANTAGES

1. More expensive compared to other types of root canal sealers.
2. It has a longer setting time compared to other types of root canal sealers.
3. Technique sensitivity.
4. Due to its sticky and viscous consistency, it's difficult to handle and manipulate during the root canal treatment.

#### INDICATIONS

1. Used as a permanent filling material in root canal treatments.
2. Apical surgery.
3. Pulp capping.
4. Endoseal BC Sealer can be used to repair root perforations caused by trauma or iatrogenic damage during root canal treatment.
5. Can be used to fill gaps or voids that are left after the removal of previous root canal filling materials during retreatment.

#### CONTRAINDICATIONS

1. Inadequate isolation.
2. Inadequate cleaning and shaping.
3. Active infection.
4. Allergies.
5. Resorption.

### PRO-ROOT MTA



FIGURE-2

A calcium silicate-based endodontic sealer that is used in conjunction with root filling material in either cold lateral warm vertical or carrier-based filling technique. The major constituent of the powder is tricalcium silicate and dicalcium silicate, in addition with calcium sulfate as setting retardant, bismuth oxide as radiopacifier and tricalcium aluminate. The liquid component constitutes of viscous aqueous solution of water-soluble polymer.<sup>21</sup>

#### ADVANTAGES

1. Stimulates tissue repair.

2. Biocompatible.
3. Radiopaque.
4. Versatility.
5. Sealing ability.

#### DISADVANTAGES

1. Discoloration.
2. Potential for overfilling.
3. Limited storage time.
4. ProRoot MTA has a longer set time than other dental materials, that may further increase the

length of the procedure and the time required for follow-up appointments.

5. Technique sensitive.
6. Cost.

#### **INDICATIONS**

1. Retrograde filling.
2. Root end filling.
3. Perforation repair.
4. Apexification.
5. Pulpotomy.

#### **CONTRAINDICATIONS**

1. Large periapical lesions.
2. Deep caries.
3. Extremely narrow canals.
4. Immature teeth with open apices.

#### **MTA FILLAPEX ROOT CANAL SEALER (ANGELUS)**

After mixture, its composition is basically MTA, salicylate resin, natural resin, bismuth and silica. MTA Fillapex is first paste: paste MTA-based salicylate resin root canal sealer which delivers easily and without waste. It also exhibits excellent handling properties with an efficient setting time.<sup>22</sup>

#### **PROPERTIES OF MTA FILLAPEX**

1. MTA Fillapex has a high flow rate (27 mm) and a low film thickness, so it easily penetrates the lateral and accessory canals.
2. MTA Fillapex delivers high sealing capability that is not adversely affected by heat.
3. Working time- 35 minutes perfect for cases with multiple roots canals.
4. It exhibits a high pH for extended antibacterial action.<sup>23</sup>

#### **ADVANTAGES**

1. Easy handling.
2. Resistant to resorption.

#### **DISADVANTAGES**

1. Lack of solubility.
2. Staining.

#### **INDICATIONS**

1. Root canal surgery.
2. Apexification.
3. Perforation repair.
4. Retrograde filling.

#### **CONTRAINDICATIONS**

1. Hemostasis issue.
2. Pulp vitality.
3. Inability to achieve proper seal.

#### **CPM SEALER (EGEO SRL, MTM ARGENTINA SA, BUENOS AIRES, ARGENTINA)**

The powder of calcium-phosphate-monobasic sealer consists of tricalcium silicate, tricalcium oxide, tricalcium aluminate and other oxides. The liquid consists of saline solution and calcium chloride (Schware T Ley Joe 20028 749). It becomes solid and forms a hard sealer in 1 hour.<sup>24</sup>

As it happens to be a white modified Portland cement-based material, the most significant difference is the presence of large amount of calcium carbonate, which intends to offer good sealing properties, increase the release of calcium ions, adhesion to dentinal walls adequate flow rate, and biocompatibility. pH reduces from 12.5 to 10 after setting due to addition of calcium carbonate. Thereby surface necrosis in contact with material is restricted which allows action of alkaline phosphatase.<sup>25</sup>

Higher ratio of leakage was seen for CPM sealer as compared to AH Plus and Sealapex.<sup>26</sup>

#### **MTA OBTURA**

The composition of the powder is similar to gray MTA Angelus, consisting of Portland cement clinker and bismuth oxide. The sealer exhibited stable leakage values at 15 and 30 days, as expected for an MTA-based material. Its reproduced good sealing ability of MTA as repair material 26, 27. Although, at 60 days MTA Obtura presented with a considerable increase in leakage.

#### **ADVANTAGES**

1. Sealing ability.
2. Antimicrobial properties.
3. Biocompatible.
4. Easy handling.

#### **DISADVANTAGES**

1. Setting time.
2. Color.

#### **INDICATIONS**

1. Perforations.
2. Pulp capping.
3. Resorptions.

#### **CONTRAINDICATIONS**

1. Fractured teeth.
2. Anatomic limitations.
3. Allergy.

#### **ZINC OXIDE EUGENOL SEALER**

The most commonly used sealer, Zinc oxide-eugenol, has irritating effects on oral tissue- higher concentration is more cytotoxic due to eugenol. Furthermore, it lacks adequate bonding to root canal dentin<sup>23</sup>. Zinc oxide eugenol sealers also release formaldehyde after setting<sup>27</sup>.

SafeEndo EugeSeal -an Zinc Oxide Eugenol based sealer in powder-liquid form used for permanent

filling of root canals. This sealant is particularly designed to tightly seal the apex of the root and the

prepared root canal and can be easily removed along with Gutta Percha Point when refilling is necessary.



**FIGURE-3**

**COMPOSITION**

Powder contains - Zinc oxide, Calcium Phosphate, Thymol Iodide, Zirconium Dioxide, Dexamethasone – 0.01%, Hydrocortisone Acetate – 1.00%, Plasticizer

Liquid contains- Eugenol, Modified by Additives Calcium phosphate helps in Bone Regeneration. Thymol iodide is a strong antiseptic material. Anesthetics - Dexamethasone and Hydrocortisone significantly reduces the periapical pain. Plasticizer allows to make a plastic paste during mixing of Powder and Liquid at the ratio 7:1. Nonshrinkage after its hardening and insolubility in distilled water at the temperature of 37°C is ensured by liquid containing Eugenol, modified with Polymeric Material.

Paste is used for filling with gutta-percha points. Eugenol, slightly melts the surface of gutta-percha points, sticking them together and thus allows to fill the canal thoroughly. Paste, made do not lose its plasticity on mixing pad within 5-6 hours and hardens in oral cavity (in 37°C) within 24-48 hours.

**INDICATIONS**

- Sealing of prepared root canals with gutta-percha points.
- Sealing of root canals without gutta-percha points in deciduous teeth.

**ADVANTAGES**

- Easily mixed and remains flexible during 2-3 hours.
- Strong bactericidal effect due to thymol iodide.
- Low solubility.
- Radiopaque.
- Significant periapical sensibility reduction.

**EPOXY RESIN BASED SEALER**

These have been used because for their reduced solubility, better apical seal and micro-retention to root canal dentin<sup>27</sup>. The manufacturers of AH26 (Dentsply, Germany) developed an improved product named AH PLUS (Dentsply, Tulsa, OK, USA) which

have better clinical, technical and cytotoxic characteristics than the original AH26. The epoxy resin “glue” of AH26 has been retained, but new amines are added to maintain the natural color of the tooth.

AH Plus consists of two paste system. The resin paste consists of epoxy resin, calcium tungstate, zirconium oxide and aerosol iron oxide. The amine paste contains adamantas amine, N, N didenyl – 5 – oxanone diamine, zirconium oxide, aerosil and silicone oil. It has working time of 4 hours, setting time- 8 hours and film thickness of 26mm<sup>28</sup>.

Due to its properties, such as low solubility, small expansion, adhesion to dentin and very good sealing ability, AH Plus is looked as a “Gold Standard” sealer<sup>29</sup>.

**DISADVANTAGES**

- Sensitivity: can be caused by an allergic reaction or irritation to the sealer, which can result in discomfort or pain.
- Opacity: AH Plus is radiopaque, which means it can be easily seen on dental x-rays but, the opacity of the sealer can make it difficult to visualize the root canal system during the procedure.
- Difficult to remove: AH Plus can be difficult to remove from the root canal system if retreatment is necessary.
- Potential for overfilling: if too much sealer is used or the sealer is over-injected into the root canal system, it can lead to overfilling.

**INDICATIONS**

- Root end filling.
- Obturation of lateral canals and isthmuses.
- Retreatment of failed RCT.

**CONTRAINDICATIONS**

- Resorption.
- Presence of moisture.
- Calcium hydroxide usage.



### CERASEALBASED SEALER



**FIGURE-4**

Optimal biocompatible environment to tissues in the root canal is provided by the Calcium silicate-based CeraSeal. Due to high pH of calcium hydroxide, its antimicrobial action eliminates the bacteria present in the root canal.

#### ADVANTAGES

- Premixed: easy to use.
- No shrinkage and expansion.
- Perfect sealing ability.
- Proper setting time.
- Prevent from wash-out phenomena.
- Excellent Radiopacity.
- Anti Microbial (pH 12.73).
- High biocompatibility.

#### Physical Properties

Setting Time	3.5 h
pH	12 <
Radiopacity	8mm <

#### Components

CeraSeal	Pre-mixed syringe x 1EA (2g) Intra canal tips x 10EA
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### SEPTODONT BIO ROOT RCS

BioRoot RCS- powder/liquid hydraulic tricalcium silicatebased cement recommended for single cone technique or cold lateral condensation root filling.



**FIGURE-5**

It has a radiopacity greater than 3 mm aluminium thickness, film thickness lesser than 50 µm and flow greater than 17 mm. It has a setting time of 5 hours. When stored in phosphate buffered saline, it has solubility over a 6-month period.<sup>30</sup>

### NEOAPEX ROOT CANAL SEALER

It is used as a temporary or permanent filling material after pulpectomy. This Calcium hydroxide paste containing iodoformis packaged in a convenient syringe in order to prevent messy mix. The iodoform is added to provide antibacterial action and improve the radiopacity. It has excellent tissue tolerance. The



material to adapt well even to morphologically complicated canals due to easy flowing composition.

### INDICATIONS

- Temporary & long term root canal filling material.
- Apexification.
- Weeping canals & exudation control.
- Root resorption cases.
- Periapical lesions.
- Pulp capping.

### ADVANTAGES

- Non-hardening oil-based paste.
- Specially designed dispensing tips.
- Radio opaque formulation with Barium sulfate.
- Best rheology gives a smooth and complete filling.
- Easy handling and straightforward application.

### CONCLUSION

Till date no sealer alone has been able to satisfy or meet all the requirements for clinical use. There is no single stereotype material available that fulfils all the needs together. Concluding one can say that the choice of sealer depends upon core material and obturation technique that will further depend upon the anatomy of the root canal. The choice of material is also said to be affected by pre-existing periapical conditions for proper healing outcome.

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