

Bioceramic sealers – A Review

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Abstract

Root canal sealers are used to achieve impervious seal between the core material and root canal dentin. Most of the conventional root canal sealers have shown inadequate biological activity and been cytotoxic in cultures especially when freshly mixed. Bioceramic sealers were developed to overcome these limitations and have been proved to show better clinical performance. They have several advantages like biocompatibility, dimensional stability, non-toxicity, and are bio-inert. Also during their setting, they form Hydroxyapatite which possesses an intrinsic osteo-conductive activity and induces regenerative responses

in the human body. Therefore, this review aims to discuss the various bio ceramic sealers and their classification, properties, mechanisms, advantages, disadvantages and retreatment.

Keywords: Bio ceramic sealer, Calcium silicate, iRoot SP, BiorootRCS.

Introduction

The objectives of endodontic treatment are elimination of infection from the root canal by filling and sealing the root canal space and prevention of its reinfection.^[1] Although biomechanical preparation significantly decreases the number of microorganisms in the root canal, but 40–60% of root canals still remain

positive for presence of bacteria after this treatment.^[2]

Thus, root canal sealers play an important role in controlling endodontic infection and preventing leakage of nutrients and reinfection of the root canal.^[3]

The main functions of root canal sealers are (i) sealing off voids, multiple foramina, and patent accessory canals, (ii) forming a bond between the core filling material and the root canal wall, and (iii) act as a lubricant while facilitating the placement of the filling core and entombing any remaining bacteria.^[4]

Root canals can be obturated using a conventional technique with a combination of gutta-percha and root canal sealer, or thermoplastic technique. The goal standard of root canal sealers for obturating of the root canal should have adequate setting time, low porosity and solubility, and ability to promote hard tissue formation.^[5] A variety of root canal sealers are available including zinc oxide eugenol, silicone, calcium hydroxide, resin, glass ionomer, and bio ceramic-based sealers.^[6]

Bio ceramics materials have been recently introduced and had shown a significant change in the field of endodontics. Bio ceramics are metal oxides or biocompatible materials with improved sealing abilities along with antifungal and antibacterial properties applied for use in dentistry. They have the ability to resorb and promote regeneration of natural tissues. Bio ceramics include zirconia, titanium, glass ceramics, bioactive glass, hydroxyapatite, calcium silicate, resorbable calcium phosphate and radiotherapy glasses.^[7]

In general, bio ceramics can be categorized into bioinert, bioactive and biodegradable based on their interactivity with the surrounding tissues. Bioinert ceramics such as zirconia and alumina which trigger no toxic response and are well-tolerated by the tissue. Bioactive ceramics such as ceramics, glasses, glass-ceramics which can

interact with tissue and form a direct bond through the formation of hydroxyapatite layer as the interfacial bonding. This layer has a similar structure and chemical constituent to the inorganic component of bone. The biodegradable ceramics such as tricalcium phosphate and calcium sulphate which are replaced or incorporated into the hard tissue and become part of the structure.^[8]

History

1989- 1st bio ceramic material used for obturation of root canal

[calcium phosphate sealers - Sankin apatite root canal sealers (I, II and III) (Sankin Kogyo, Tokyo, Japan) and Cap seal (I and II)]

Mid 1990's- MTA was introduced as root repair material [Portland-derived cements - ProRoot MTA (Dentsply Tulsa, Tulsa, OK, USA)]

2010- The first sealer based on MTA was MTA Fill apex (Angelus, Londrina, Brazil)^[9]

Classification of bioactive sealers in endodontics

Broadly classified on basis of primary constituent as follows

1. Mineral trioxide aggregate (MTA)-based sealers
2. Calcium silicate-based sealers
3. Phosphate-based bio ceramic sealers
4. Calcium phosphate-based sealers.

Based on the commercial availability as

MTA-based sealers:

1. Endo-CPM-Sealers
2. MTA-Angelus
3. MTA Obtura
4. ProRoot Endo Sealer
5. MTA Fill apex.

Calcium silicate-based sealers

1. Endo Sequence BC Sealer
2. iRoot SP
3. iRoot BP.

Phosphate-based bio ceramic sealers

1. Bio aggregate

Calcium phosphate-based sealers

1. Sankin appetite 1 and 2

2. Cap seal 1 and 2.

Based on dispensing as

1. Powder and liquid systems

2. Paste systems

3. Premixed syringe systems

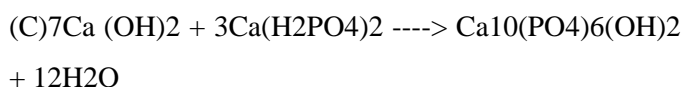
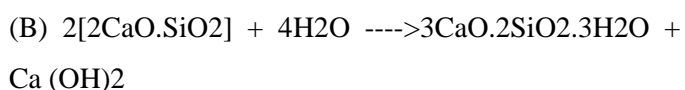
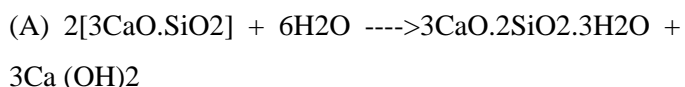
4. Endo Sequence BC sealer

5. MTA total fill.^[10]

Mechanism of action

Bioceramic sealers uses the water inherent in the dentinal tubules for the setting reaction leading to the beginning of hydration reaction of the material and thus reducing the setting time. Upon hydration, calcium silicate gel and calcium hydroxide are formed by the calcium silicates in the powder. The calcium hydroxide reacts with phosphate ions and forms the precipitation of hydroxyapatite and water. The hydroxyapatite that is produced may be used for reconstruction material and in bone repair as it is nontoxic. The continuous interaction of calcium silicate with water leads to formation of calcium silicate hydrate.

The hydration reactions (A, B) of calcium silicates and precipitation reaction (C) of calcium phosphate are:^[11]



The exact mechanism of bonding of bio ceramic-based sealer to root dentin is still not known; however, the following mechanisms have been proposed for calcium silicate-based sealers:

Tubular diffusion -Diffusion of the sealer particles into the dentinal tubules which produce mechanical interlocking bonds.^[12]

Infiltration of the sealer's mineral content into the intratubular dentin which results in the establishment of a mineral infiltration zone produced after denaturing the collagen fibres with a strong alkaline sealer.^[13]

Partial reaction of phosphate with calcium silicate hydrogel and calcium hydroxide, formed through the reaction of calcium silicates in the presence of the dentin's moisture, resulting in the production of hydroxyapatite along the mineral in filtration zone.^[14]

Description of various bio ceramic sealers

Endo-CPM

CPM sealer was developed in 2004, to combine the physiochemical properties of root canal sealer with biological properties of MTA. It is a powder/ liquid sealer and have basically the same composition as of MTA. The most significant difference is the presence of a large amount of calcium carbonate, which increases the release of calcium ions and thus provides good sealing properties, adequate flow rate, adhesion to dentinal canal walls, and biocompatibility. It has an antibacterial effect against *E. faecalis* before setting but it does not maintain it after setting. [15-17]

MTA Fill apex

It is a new MTA based endodontic sealer commercially launched in 2010. It is available as a double paste system. Besides from the basic composition of MTA, it consists of bismuth oxide, resins, silica nanoparticles and pigments.^[15] It was formed to combine the physico-chemical properties of a resin-based root canal sealer with the biological properties of MTA.^[18] The working time is about 30 minutes and the complete setting time is approximately 2 to 4.5 hours. MTA Fill apex has a low film thickness and a high flow rate (27 mm), so it easily

penetrates the accessory and lateral canals.^[19] The significantly higher cytotoxicity of this sealer may be due to the resin component or by other components of the sealer.^[20] It has excellent handling properties so is delivered easily without waste and with an efficient setting time.^[16]

ProRoot Endo Sealer

It is a calcium silicate-based endodontic sealer in which has water soluble polymer is added to MTA so to increase the flow even at high powder to liquid ratio. The major components of the powder component are tricalcium silicate and dicalcium silicate, with the inclusion of bismuth oxide as a radio pacifier, calcium sulphate as a setting retardant and a small amount of tricalcium-aluminate. The liquid consist of viscous aqueous solution of a water-soluble polymer which has more fluidity and thus increases the flow.^[21] It is used in conjunction with root filling material in either warm vertical, cold lateral, or carrier-based filling technique. They are biocompatible when placed in contact with physiologic solution and there is release of hydroxyl and calcium ions from the set sealer liquid which is attributed for its bioactivity.^[22,23]

Endo sequence BC Sealer

It is calcium silicate based, premixed ready-to-use injectable material. It is radiopaque, insoluble and aluminum-free material which set in presence of water. It can be used in the single cone and lateral condensation technique. The working time can be 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.^[24] It is supplied with disposable Intra Canal Tips which are flexible and can be bent to facilitate access to the root canal. For using sealer remove the syringe cap and securely attach an Intra Canal Tip with a clockwise twist to the hub of the syringe. The tip of the syringe is

inserted into the canal in the coronal one third (1/3) and then a small amount (1-2 calibration markings) of sealer is gently and smoothly dispensed into root canal by compressing the plunger of the syringe. Lightly coat the canal walls with the existing sealer in the canal, using a #15 hand file or something comparable. Then master cone is coated with a thin layer of sealer and very slowly insert it into the canal which will carry sufficient sealer to the apex.^[11]

iRoot SP

It is also a premixed, ready-to-use, injectable, calcium silicate, aluminum-free-based root canal sealer with composition similar to White MTA. When compared to Epiphany, MTA Fill apex, and AH Plus, iRoot SP have shown the highest bond strength to root dentin. In a study evaluating the fracture resistance of obturated roots, shows that iRoot SP could potentially strengthen endodontically treated teeth. The high bond strength of this sealer to the dentin walls could be attributed to its difficulty in removal. As concluded in a study evaluating retreatment of canals obturated with this sealer, that conventional retreatment technique could not completely remove this sealer. This sealer has excellent antimicrobial properties especially during the first 24 hours of the setting process due to its high pH (12.8) and was capable of killing *E. faecalis* in an antibacterial investigation. In a filter diffusion test, it was shown that fresh iRootSp had significantly higher toxicity compared to ProRoot MTA.^[25,26]

BioRoot RCS

BioRoot RCS is powder/liquid hydraulic tricalcium silicate- based, composed of a powder consisting of tricalcium silicate and zirconium oxide and a liquid that is water-based and has calcium chloride and polymer additives. It is recommended for single cone technique or cold lateral condensation root filling. It has a

radiopacity more than 3 mm aluminum thickness, film thickness lesser than 50 μm and flow greater than 17 mm. It has a setting time of approximately 5 h. It has a higher calcium ion release than other CSBS and a long-term alkaline activity. Immersion of BioRoot RCS in phosphate buffered saline lead to a surface precipitation of calcium hydroxyapatite in vitro, which is indicate the bioactivity of CSBS. It has shown low toxicity and genotoxicity on PDL cells and have shown to be biocompatible on human PDL cells and gingival fibroblasts.^[27,28]

Cera seal

Cera seal is calcium phosphate-based bio ceramic sealer composed of calcium silicates, zirconium oxide, thickening agent. It is also dispensed using a pre-mixed syringe. It has high pH (12.73) with the setting time of about 3.5 hour and radiopacity of less than 8mm. It shows a high degree of Ca^{2+} release, followed by Endo Sequence BC Sealer and Endo seal. Bioactive cements have the ability to release ions and an acid neutralization capability which favors tissue healing. López-García et al. reported that Cera Seal displayed higher cell attachment, cell viability, ion release rates and cell migration rates, than Endo seal. Furthermore, it has shown significantly more gene expression and mineralization capacity than Endo seal.^[29]

Well Root ST

Well Root ST is also a premixed, injectable sealer which contains zirconium oxide as radio pacifier, calcium silicate and thickening-filling agents. It is delivered to root canals by injection without contaminating the access cavity. It has shown to cause clinically perceptible discoloration in 4 weeks, similar to MTA Fill apex and Dia-Proseal. It showed decreased cell viability by time in fresh media, which might be because of their

high pH in the fresh state and it showed significantly higher cell viability at 3 days.^[30,31]

Advantages

- Excellent biocompatibility properties due to their similarity with biological hydroxyapatite.^[32]
- Intrinsic osteoinductive capacity because of their ability to absorb osteoinductive substances if there is a bone healing process nearby.
- Function as a regenerative scaffold of resorbable lattices which provide a framework that is eventually dissolved as the body rebuilds tissue.
- Ability to form a chemical bond with the tooth structure, achieve excellent hermetic seal and have good radiopacity.^[33]

Limitations

- Higher amount of lead and arsenic released from PC along with reports of its high solubility compared to MTA has raised questions regarding its safety with respect to the surrounding tissues
- Higher solubility may jeopardise the long-term seal of the restoration.
- Excessive setting expansion with PC may lead to crack formation with the tooth
- Bio mineralization with PC is not as effective and as long term as with MTA which is critical for a bioactive material.^[34]

Retreatment of bio ceramics

There has been confusion concerning the retreat ability of bio ceramics. The key is to use bio ceramics as a sealer and not as a complete filler. That is why endodontic synchronicity is so important and again the use of constant tapers makes so much Sense (it reduces the amount of endodontic sealer thereby facilitating retreatment). The key for retreating bio ceramic cases is to use an ultrasonic with copious amount of water. This is particularly important at the beginning of the procedure

in the coronal third of the tooth. Use ultrasonic with lots of water down the canal till approximately half its length. After this add a solvent to the canal (chloroform or xylol) and switch over to an Endo Sequence file (#30 or 35/0.04 taper) at an increased rate of speed (1,000 RPM). Proceed with this file till all the way to the working length, using solvent whenever needed. An alternative is to use hand files for the final 2-3 mm and then remove the gutta-percha with a rotary file to ensure synchronicity.^[25]

Conclusion

Potent antibacterial activity, absolute biocompatibility, Osseo conductivity, ability to achieve excellent fluid tight seal in constantly wet environment, formation of chemical bond with dentin, insolubility in tissue fluids, expansion during time of set, easy handling, very good radiopacity are the features that make bio ceramic-based sealers an up-to-date option to current —golden standard of multi-phase (gutta-percha— epoxy sealer) warm techniques. However, further studies are required to assess the clinical outcomes associated with the use of these sealers.

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