

Insight into bio ceramic sealers - A Review

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Introduction

With the advent of new materials and technical advancements, the field of endodontics is constantly changing. The exponential growth of endodontics is greatly aided by developments in the field of endodontic material sciences. One of the most recently developed endodontic materials that has altered the field is bio-ceramics. When raw minerals are heated to high temperatures, they become inorganic, non-metallic materials known as ceramics. (1)

In the last two decades, cements based on a calcium and silicate composition, such as mineral trioxide aggregate (Pro Root MTA, Dentsply Sirona, York, USA) or Bio dentine (Septodont, St. Maur-des-Fosses, France), have been launched and are now well-established in modern dentistry. These cements are being used for numerous clinical applications because of their high sealing ability and biocompatibility, including pulp capping in primary and permanent teeth, root-end filling, perforation repair, and apical plug for teeth with open apices. Endodontic sealers based on calcium silicate compositions have been introduced over the past few years in response

to the positive attributes of calcium silicate-based cements.

The term "bio ceramic" has been used to describe a significant subgroup of biomaterials that can be categorised as bio inert, bioactive, or biodegradable depending on how they interact with the tissues around them. Bio ceramics are made of alumina and zirconia, bio active glass, glass ceramics, calcium silicates, hydroxy apatite, resorbable calcium phosphates and radio therapy glasses and can be implanted into the body without triggering a foreign body reaction. (2)

Sealers are a radiopaque dental cement used, usually in combination with a solid or semisolid core material, to fill voids and to seal root canals during obturation. (3) The major purposes of the root canal obturation are managed by the sealers: sealing off the root canal system, encapsulating any remaining germs and filling imperfections in the prepared canal. (4)

The main functions of root canal sealers are.

- (i) sealing off voids, patent accessory canals and multiple foramina
- (ii) forming a bond between the core of the filling material and the root canal wall and

(iii) acting as a lubricant while facilitating the placement of the filling core and entombing any remaining bacteria Sealers are categorised according to their main chemical constituents: zinc oxide eugenol, calcium hydroxide, glass ionomer, silicone, resin, and bio ceramic-based sealers. Bio ceramics are ceramic materials designed specifically for medical and dental use. They include alumina, zirconia, bioactive glass, glass ceramics, hydroxyapatite and calcium phosphates. (5) All these materials can be produced in porous or dense form in bulk, as granules or as coatings. (6)

When Krell and Wefel compared the effectiveness of experimental calcium phosphate cement with Gross man's sealer in extracted teeth two years later, they found no appreciable differences between the two sealers in terms of apical occlusion, adaptation, dentinal tubule occlusion, adhesion, cohesion or morphological appearance.

However, compared to Gross man's sealer, the experimental calcium phosphate sealer did not successfully produce apical sealing.

The effectiveness of calcium phosphate as a root canal sealer in adult dog teeth was later examined by Chohayeb et al. They claimed that as compared to gutta-percha, the calcium phosphate-based sealer produced even more and precise adaptation to the dentinal walls. (5)

When using bio ceramic materials as root canal sealers, there are two key benefits. Firstly, these are bio compatible, non-toxic, less shrinkage, and are chemically stable in a biological context. Second.

whether a root is repaired or an overfill occurs during the obturation process, bio ceramics do not cause an inflammatory reaction. (7) Drawback of bio ceramic sealer includes difficulty in removing the sealer during retreatment or post-space preparation when needed.

The exact mechanism of bio ceramic-based sealer bonding to root dentin is unknown; however, the following mechanisms have been suggested for calcium silicate-based sealers:

- (1) Diffusion of the sealer particles into the dentinal tubules (tubular diffusion) to produce mechanical interlocking bonds.
- (2) Infiltration of the sealer's mineral content into the intratubular dentin resulting in the establishment of a mineral infiltration zone produced after denaturing the collagen fibres with a strong alkaline sealer.
- (3) Partial reaction of phosphate with calcium silicate hydrogel and calcium hydroxide, 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. (5)

Classification of bio active sealers in endodontics

Broadly classified based on 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 MTA-based sealers

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

Calcium silicate-based sealers

1. Endo Sequence BC Sealer
2. I Root SP
3. I Root BP

Phosphate - based bio ceramic sealers

1. Bio aggregate

Calcium phosphate-based sealers

1. San kina petite 1 and 2
2. Cap seal 1 and 2

Based on dispensing

1. Powder and liquid systems
2. Paste systems
3. Premixed syringe systems ⁽³⁾

The biological and physical properties of bio ceramic-based root canal sealers were reviewed based on the ideal root canal sealer properties as described by Grossman as 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 particles of powder should be very fine so that they can mix easily with liquid.
- (5) It should not shrink upon setting.
- (6) It should not discolour tooth structure.
- (7) It should be bacteriocidal 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. ⁽⁵⁾

Endo-CPM-Sealer

Introduced in 2004 to combine the biological qualities of MTA with the physical-chemical properties of a root canal sealer. Before setting, Endo-CPM had an antibacterial impact on *E. faecalis*, but it did not continue to have an antibacterial effect after setting. ⁽⁸⁾ 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 had been set. ⁽⁹⁾ This caused

the deposition of mineralized tissue. The addition of calcium chloride to MTA decreases the amount of time needed for it to set, increases its ability to seal, and makes it easier to place into cavities without affecting its biocompatibility. ⁽¹⁰⁾

MTA Fill apex

MTA Fill apex is a sealer made of resin MTA and Nano silicate particles. ⁽¹¹⁾ 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 Fill apex due to its high flow rate (27 mm) and thin film thickness. ⁽¹²⁾ MTA Fill apex has a noticeably increased cytotoxicity, which may be due to the resin component or other sealer ingredients. ⁽¹³⁾

Endo seal-MTA

MTA serves as the principal component as it lacks resin. It doesn't contain eugenol and it will not prevent 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. Endo seal MTA has a setting time of 12 minutes and it is radiopaque. After 30 days in the water, it expanded less than epoxy resin-based sealers. On human periodontal ligament cells (PDL), it has less biocompatibility than Bio Root RCS. ⁽¹⁴⁾

Pro Root Endo Sealer

A water-soluble polymer has been added to MTA in Pro Root Endo Sealer, a calcium silicate based endodontic sealer, to enhance flow even at high powder to liquid ratios. It must be used in conjunction with root filling material when using a carrier-based filling technique or a cold lateral warm vertical filling approach. It displays biocompatibility when in contact with physiological solution and ⁽¹⁵⁾ there is release of calcium and hydroxyl ions from the set sealer liquid which is responsible for its bio activity. ⁽¹⁶⁾ When it is extruded through the apical

constriction, it has a favourable cytotoxicity and causes little tissue irritation. ⁽¹⁷⁾

I Root SP

The root canal sealer iRoot SP has a similar composition to White MTA and is an injectable, premixed calcium silicate-based material (CSBS) that is free of aluminium. In an antibacterial examination, it was able to kill *E. faecalis* and displayed an alkaline pH up to 7 days after setting. ⁽¹⁸⁾ It is more radiopaque than 3 mm of aluminium thickness. ⁽¹⁹⁾ iRoot SP has a higher solubility than other BC materials. In a filter diffusion test, it was discovered that fresh iRoot SP was much more hazardous than ProRoot MTA, and that iRoot SP had more residual filler after retreatment than epoxy resin- and zinc oxide-eugenol-based sealers. ⁽²⁰⁾ Additionally, it has greater push-out bond strength compared to other CSBS, deeper dentinal tubule penetration, and higher resistance to fracture than epoxy resin-based sealers. ⁽⁸⁾

Endo sequence BC Sealer

Endo sequence BC Sealer (BCS), a calcium silicate-based material that is insoluble, radiopaque and aluminium-free, needs 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. ⁽²¹⁾ It is used in the single cone and lateral condensation techniques.

At room temperature, the working period can last up to four hours or longer. It takes four hours to set. However, in extremely dry root canals, the setting time may exceed 10 hours.

Endo sequence BC Sealer Hi Flow

Endo sequence BC Sealer Hi Flow (BC HiF) is a modified version of the original Endo sequence BC sealer formulation to create a sealer with a calcium-silicate basis that is appropriate for warm canal filling methods. BC HiF and BCS shared the same elemental

composition. Carbon, oxygen, and silicon percentages in both sealers were similar, while calcium and zirconium content varied. However, the manufacturer claims that it is more radiopaque than Endo sequence BCS and has a reduced viscosity when heated. In terms of cytocompatibility, cell migration, cell adhesion, and bioactivity potential, BC HiF performed similarly to its predecessor BCS. ⁽²²⁾

Total Fill BC Sealer

A pre-mixed bio ceramic paste called as Total Fill BC sealer was introduced to be used as a permanent root canal filling and sealing application. It is a calcium silicate-based substance which is insoluble, radiopaque and aluminium free. Compared to AH Plus or MTA Fill apex, it showed more cell proliferation and collagen type I adhesion. ⁽¹³⁾ Compared to AH-Plus, Total Fill documented more observations of complete apical healing. ⁽²³⁾

Bio Root RCS

Bio Root RCS is powder/liquid hydraulic tricalcium silicate-based cement recommended for single cone technique or cold lateral condensation obturation techniques. The chemical structure of Bio Root RCS was unaffected by heating it to 250 °C for 30 or 60 seconds to mimic the effect of warm vertical compaction techniques, however heating it to this temperature for 11 min caused Bio Root RCS to lose 15% of its weight. ⁽²⁴⁾ It has a flow more than 17 mm, radiopacity greater than 3 mm aluminium thickness and a film thickness less than 50µm. It has a setting time of approximately five hours. ⁽²⁵⁾ It releases more calcium ions than other CSBS and exhibits long-lasting alkaline activity. ⁽²⁶⁾ When applied using the single-cone approach, Bio Root RCS's Push out bond strength (POBS) was lower than AH Plus. ⁽²⁷⁾ The POBS of Bio Root RCS was negatively impacted by the application of EDTA as a final irrigants, but

chlorhexidine improved dislodgement resistance. ⁽²⁸⁾

When tested on human PDL cells and gingival fibroblasts, Bio Root RCS was found to be bio compatible and to have low toxicity and genotoxicity. ⁽¹⁴⁾

Neo MTA Plus

Neo MTA Plus is a new finer powder tricalcium silicate material and has tantalum oxide (Ta₂O₅) as a radiopacifying agent which is mixed with a water-based gel that imparts good handling properties. A thick combination can be used for root end filling while a thin mixture can be utilised as an orthograde sealer. The powder to gel mixing ratio can be adjusted. ⁽²⁹⁾

Cera seal

Cera seal is a bio ceramic sealer made of calcium phosphate. Available as pre-mixed syringe. With a setting time of 3.5 hours and a radiopacity less than 8 mm. Cera Seal has a high pH 12. It showed a significant release of calcium ion, has increased cell viability, and enables faster migration rate than endo seal. ⁽³⁰⁾

Cera Fill RCS

Cera fill RCS root canal filling material available as injectable premixed form. filling and its sealing ability is based on bio ceramic technology. It is an alumina free radiopaque calcium silicate-based material with excellent handling characteristics and superior physical properties which requires water to set and harden.

Well Root ST

Well Root ST is an injectable, premixed sealer, injected into root canals without contaminating the access cavity. Zirconium oxide serves as a radio-opacifier in Well Root ST and it also contains calcium silicate and thickening-filling agents. Like MTA Fill apex and Dia-Proseal, Well Root ST generated clinically noticeable discoloration in 4 weeks. [31 Well Root ST was found to be most effective for attaching human periodontal ligament stem cell on the set surface. ⁽³²⁾

Nano Ceramic sealer (NCS)

Compared to Bio root RCS, Nano Ceraic Sealer has a lower level of cytocompatibility. These findings demonstrate that commercially available bio ceramics differ from one another, indicating that unidentified thickening and filler agents may be crucial to the biocompatibility of these materials. ⁽¹⁴⁾ Cell viability is dramatically enhanced in 7 days while using nano-ceramic sealer. Due to its flat surface, it exhibits advantageous cell adhesion and proliferation. It has good initial osteoblastic potential, which is better for periapical healing at the beginning. ⁽³³⁾

Conclusion

Potent antibacterial activity, complete biocompatibility, Osseo conductivity, the ability to achieve a fluid-tight seal in a constantly moist environment, the formation of a chemical bond with dentin, insolubility in tissue fluids, expansion during the setting process, excellent radiopacity, and ease of handling are the characteristics that make bio ceramic-based sealers a modern alternative to the current "gold" standard sealers. However, additional research is needed to evaluate the clinical results connected to the use of these sealers.

References

1. Raghavendra SS, Jadhav GR, Gathani KM, Kotadia P. Bio ceramics in endodontics - a review. J Istanbul Univ Fac Dent. 2017 Dec 2;51(3 Suppl 1): S128-S137.
2. Donner Meyer D, Bürklein S, Dammaschke T, Schäfer E. Endo dontic sealers based on calcium silicates: a systematic review. Odontology. 2019 Oct; 107 (4) :421-436.
3. Teja, Kavalipurapu & Ramesh, Sindhu. (2020). An update on bio ceramic sealers. Drug Invention Today. 14. 17-20.

4. Ørstavik DA. Materials used for root canal obturation: technical, biological and clinical testing. *Endo dontic topics*. 2005 Nov;12(1):25-38.
5. Al-Haddad A, Che Ab Aziz ZA. Bio ceramic-Based Root Canal Sealers: A Review. *Int J Bio mater*. 2016; 2016:9753210.
6. Best SM, Porter AE, Thian ES, Huang J. Bio ceramics: Past, present and for the future. *Journal of the European Ceramic Society*. 2008 Jan 1;28(7):1319-27.
7. Koch K, Brave D. The increased use of bio ceramics in endodontics. *Dental town*. 2009 Apr; 10:39-43.
8. Morgen Tal RD, Vier-Pelisser FV, Oliveira SD, Antunes FC, Cogo DM, Kopper PM. Antibacterial activity of two MTA-based root canal sealers. *International endodontic journal*. 2011 Dec;44(12):1128-33.
9. Vasconcelos BC, Bernardes RA, Cruz SML, et al. Evaluation of pH and calcium ion release of new root-end filling materials. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009; 108:135-39.
10. Camilleri J. Hydration mechanisms of mineral trioxide aggregate. *Int Endod J* 2007; 40:462-70.
11. Nagas E, Uyanik MO, Eymirli A, Cehrelil ZC, Vallittu PK, Lassila LV, Durmaz V. Dentin moisture conditions affect the adhesion of root canal sealers. *Journal of Endodontics*. 2012 Feb 1;38(2):240-4.
12. Rawtiya M, Verma K, Singh S, Munuga S, Khan S. MTA-based root canal sealers. *Journal of orofacial research*. 2013:16-21.
13. Rodríguez-Lozano FJ, García-Bernal D, Onate - Sánchez RE, Ortolani - Seltenerich PS, Forner L, Moraleda JM. Evaluation of cyto compatibility of calcium silicate-based endodontic sealers and their effects on the biological responses of mesenchymal dental stem cells. *International endodontic journal*. 2017 Jan; 50 (1):67-76.
14. Collado-González M, García-Bernal D, Onate-Sánchez RE, Ortolani-Seltenerich PS, Lozano A, Forner L, Llena C, Rodríguez-Lozano FJ. Bio comp atibility of three new calcium silicate-based endodontic sealers on human periodontal ligament stem cells. *International endodontic journal*. 2017 Sep;50(9):875-84.
15. Weller RN, Tay KCY, Garrett LV, 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. *Int Endod J* 2008; 41:977-86.
16. Tay FR, Pashley DH, Rueggeberg FA, Lou shine RJ, Weller RN. Calcium phosphate phase transformation produced by the interaction of the Portland cement component of white mineral trioxide aggregate with a phosphate-containing fluid. *J Endod* 2007; 33:1347-51.
17. Bryan T, Khechen K, Brackett MG. In vitro osteogenic potential of an experimental calcium silicate-based root canal sealer. *J Endod* 2010;36(7):1163-69.
18. Zhang H, Pappen FG, Haapasalo M. Dentin enhances the antibacterial effect of mineral trioxide aggregate and bio aggregate. *Journal of Endodontics*. 2009 Feb 1;35(2):221-4.
19. Candeiro GT, Correia FC, Duarte MA, Ribeiro-Siqueira DC, Gavini G. Evaluation of radio pacity, pH, release of calcium ions, and flow of a bio ceramic root canal sealer. *J Endod*. 2012; 38:842-5.
20. Zhang J, Zhu LX, Cheng X, Lin Y, Yan P, Peng B. Promotion of dental pulp cell migration and pulp repair by a bio ceramic putty involving FGFR-mediated signaling pathways. *Journal of Dental Research*. 2015 Jun;94(6):853-62.
21. Hess D, Solomon E, Spears R, He J. Retreat ability of a bio ceramic root canal sealing material. *Journal of endodontics*. 2011 Nov 1;37(11):1547-9.

22. Rodríguez-Lozano FJ, López-García S, García - Bernal D, Tomás-Catalá CJ, Santos JM, L Lena C, Lozano A, Murcia L, Forner L. Chemical composition and bioactivity potential of the new Endo sequence BC Sealer formulation Hi Flow. *International Endodontic Journal*. 2020 May 15.
23. Atteia MH. Apical healing, Resorbability, and digital radiodensity after apical extrusion of total fill versus ah-plus sealers (one- year retrospective study). *Egyptian Dental Journal*. 2017 Oct 1;63(4-October (Fixed Prosthodontics, Dental Materials, Conservative Dentistry & Endodontics)):3717-23.
24. Atmeh AR, Al Shwaimi E. The effect of heating time and temperature on epoxy resin and calcium silicate-based endodontic sealers. *J Endod*. 2017; 43: 2112–8.
25. Yang DK, Kim S, Park JW, Kim E, Shin SJ. Different setting conditions affect surface characteristics and microhardness of calcium silicate-based sealers. *Scanning*. 2018; 2018:7136345.
26. Kebudi Benezra M, Schembri Wismayer P, Camilleri J. Influence of environment on testing of hydraulic sealers. *Sci Rep*. 2017; 7:17927
27. Donner Meyer D, Dornseifer P, Schäfer E, Dammaschke T. The push-out bond strength of calcium silicate-based endodontic sealers. *Head Face Med*. 2018; 14:13.
28. Donner Meyer D, Vahdat-Pajouh N, Schäfer E, Dammaschke T. Influence of the final irrigation solution on the push-out bond strength of calcium silicate-based, epoxy resin-based and silicone-based endodontic sealers. *Odontology*. 2019 Apr;107(2):231- 236
29. Siboni F, Taddei P, Prati C, Gandolfi MG. Properties of Neo MTA Plus and MTA Plus cements for endodontics. *International endodontic journal*. 2017 Dec; 50: e83-94.
30. Lopez-Garcia S, Myong-Hyun B, Lozano A, Garcia-Bernal D, Forner L, Llena C, Guerrero-Girones J, Murcia L, Rodriguez-Lozano FJ. Cytocompatibility, bio activity potential, and ion release of three premixed calcium silicate-based sealers. *Clinical Oral Investigations*. 2019 Aug 9:1-1.
31. Demiral M, Keskin C, Uzun I. In Vitro Assessment of the Tooth Discolouration Induced by Well Root ST, Dia-Proseal and MTA Fill apex Root Canal Sealers. *Sch J Dent Sci*. 2017 Jan;4(1):27-30.
32. Lee JK, Kim S, Lee S, Kim HC, Kim E. In vitro comparison of biocompatibility of calcium silicate-based root canal sealers. *Materials*. 2019 Jan;12(15):2411.