Original Article

Bioceramics As Root Canal Sealers: A Literature Review

[1]Aashray Patel, [2]Mona C Somani, [3]Hani Patel, [4]Chintan Joshi, [5]Dr. Maitry Shah, [6]Dr. Dharmil Kansagra

[1]Assistant Professor, Department of conservative Dentistry & Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar-382422, Gujarat, India. E- Mail address: aashray@karnavatiuniversity.edu.in
[2]Associate Professor, Department of conservative Dentistry & Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar-382422, Gujarat, India. E- Mail address: monasomani@karnavatiuniversity.edu.in
[3]Dental Practitioner, Gujarat, India. E- Mail address: hanipatel859@gmal.com
[4]Head of the Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar-382422, Gujarat, India. E- Mail address: chintanjoshi@karnavatiuniversity.edu.in
[5]Assistant Professor, Department of conservative Dentistry & Endodontics,Karnavati School of Dentistry, Karnavati University, Gandhinagar-382422, Gujarat, India
[6]Intern, Karnavati School of Dentistry, Karnavati University, Gandhinagar-382422, Gujarat, India. E- Mail address: dharmilkansagra1434@gmail.com

Corresponding Author:
Aashray Patel
Assistant Professor, Department of conservative Dentistry & Endodontics,
Karnavati School of Dentistry, Karnavati University, Gandhinagar-382422, Gujarat, India
E- Mail address: aashray@karnavatiuniversity.edu.in
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Abstract

The current generation of epoxy resin-based sealers has drawbacks such as mutagenicity, cytotoxicity, inflammatory response, and hydrophobicity. Bioceramic-based sealers containing calcium silicate and calcium phosphate have recently received a lot of attention due to their physical and biological properties like alkaline pH, chemical stability in biological environments, and lack of shrinkage. The addition of calcium phosphate to bioceramic materials improves setting properties and results in a chemical composition and crystalline structure similar to tooth and bone apatite materials, which improves sealer-to-root dentin bonding. Bioceramic sealers were developed to overcome these disadvantages and have been proved to show better clinical performance. As a result, this review focuses on providing detailed insight into individual bioceramic sealers currently in use, as well as their properties.

Key-words: Bioceramic sealer, Biocomaptibility, Bioceramic materials, root canal sealers

INTRODUCTION:

Root canal treatment aims to remove infection from the root canal while also preventing reinfection by filling and sealing the root canal. (1) Despite the fact that chemomechanical preparation significantly reduces the number of microorganisms in the root canal, 40-60% of root canals still test positive for the presence of bacteria after this treatment. (2) Endodontic sealers, as a result, play an important role in controlling endodontic infection and preventing nutrient leakage and root canal reinfection. (3)

The primary functions of root canal sealers are I to seal off voids, patent accessory canals, and multiple foramina, (ii) to form a bond between the core of the filling material and the root canal wall, and (iii) to act as a lubricant while facilitating filling placement. (4)

Zinc oxide eugenol, calcium hydroxide, glass ionomer, silicone, resin, and bioceramic-based sealers are examples of endodontic sealers (5). Bioceramic-based sealers are ceramic products that are designed specifically for medical and dental applications. Alumina, zirconia, bioactive glass, ceramics, hydroxyapatite, and calcium phosphates are used in these sealers (6).

Grossman introduced a non-staining ZOE sealer as a replacement for Rickert's formula in 1958, and this formula was widely used for a long time. Herman introduced calcium hydroxide to endodontics in 1920 for pulpal repair. It is distinguished by its biocompatibility and high pH due to the hydroxyl ion, which induces hard tissue formation and antimicrobial activity. It is widely used as a pulp capping agent for intracanal medicament and as a root canal sealer due to these advantages. However, calcium hydroxide-based sealers are not physically reliable, as evidenced by significant leakage (7,8,9)

The most commonly used clinically available root canal sealers are currently epoxy resin-based sealers. In 1957, Schroeder introduced the AH series prototype, which had excellent physical properties and sealing capability. AH Plus (Dentsply DeTrey, Konstanz, Germany) solved the problem of AH 26 leaching formaldehyde during setting (8,9). AH Plus has been designated as the gold standard for sealers by several studies due to its resorption resistance and dimensional stability (10-13). However, there are some disadvantages, such as the possibility of mutagenicity, cytotoxicity, and an inflammatory response (14-17). Furthermore, because of its hydrophobicity, the hydrophilic canal is not completely filled. Retained dental moisture, in particular, can cause AH Plus adhesion to canal walls to fail. (18)

Bioceramic as a root canal sealers:

The two types of bioceramic sealers are calcium-silicate based sealers (Mineral Trioxide Aggregate (MTA) based and non-MTA based) and calcium phosphate based sealers (5). Bioceramic-based sealers are further classified into two groups based on their interaction with living tissues: bioactive and bioinert materials (19). MTA Fillapex, Endoseal MTA, Total Fill BC Sealer, EndoSequence BC Sealer, iRoot SP, Endo CPM sealer, MTA-Angelus, and ProRoot Endo Sealer are all calcium silicate-based endodontic sealers.

According to current research, bioceramic root canal sealers have different toxic potentials at the cellular and tissue levels. Traditionally, it was used to close dentin tubules and form a uniform interface between the filling material and the dentin walls. According to research, adequate bone healing occurs following adequate endodontic therapy, owing primarily to osteoblast differentiation and contribution. Premix bioceramics sealers (full fill, iroot SP, and endosequence bioceramics seals) are the latest generation of calcium and phosphate silicate-based root canal sealers that do not require cement manipulation. During the setting process, these bioceramics sealers produce more calcium hydroxide, which corresponds to MTA fillapex and explains their high ph and antibacterial properties. Not only that, but their combined effect with the bioceramic nanoparticle-impregnated guttapercha tips ensures void-free intracanal restoration. (20)

CLASSIFICATION OF BIOCERAMIC SEALERS IN ENDODONTICS:

BASIC CLASSIFICATION OF BIOACTIVE MATERIALS (21,22)

Bioinert - Does not interact with biological systems;

Bioactive - Resistant to interfacial interactions with surrounding tissue in tissues.

Biodegradable, soluble, or resorbable - Replace or are incorporated into tissue over time. Broadly classified based on primary constituent as follows:

TABLE 1. CLASSIFICATION OF BIOCERAMIC SEALERS (5)

TYPE	BRAND NAME
Mineral trioxide aggregate (MTA)-based sealers	1.Endo-CPM-Sealers 2. MTA-Angelus 3. MTA Obtura 4. ProRoot Endo Sealer 5. MTA Fillapex.
Calcium silicate-based sealers	1. EndoSequence BC Sealer 2. iRoot SP 3. iRoot BP.
Phosphate-based bioceramic sealers	1. Bio aggregate
Calcium phosphate based sealers	1. Sankin apetite 1 and 2

	2. Capseal 1 and 2.

TABLE 2. OVERVIEW OF PRODUCT DELIVERY AND COMPOSITIONS OF VARIOUS BIOCERAMIC MATERIALS USED IN ENDODONTICS: (23)

Bioceramic sealer	Manufacturer	Composition
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, propylenglycol alginate, propylenglycol
ProRoot Endo Sealer	DENTSPLY Tulsa, OK	Powder: tricalcium silicate and dicalcium silicate, with the inclusion of calcium sulphate as a setting retardant, bismuth oxide as a radio-pacifier and a small amount of tricalcium-aluminate. Liquid: viscous aqueous solution of a water-soluble polymer
MTA Fillapex.	Angelus, Londrina, PR, Brazil	Salicylate resin, diluting resin, natural resin, bismuth trioxide, nanoparticulate silica, MTA, and pigments
EndoSequence BC Sealer	Brasseler USA, Savannah, USA	Zirconium Oxide, Tricalcium Silicate, Dicalcium Silicate, Calcium Hydroxide and fillers
iRoot SP	Innova_veBioceramix, Vancoucer, Canada	zirconium oxide, dicalcium silicate, tricalcium silicate, calcium phosphate monobasic, calcium hydroxide, filler, thickening agents
Bioseal	Ogna Lab Farma, Italy	Powder has Hydroxyapatite, Barium sulphate, Iodothymol and Resin Liquid has eugenol
Bio aggregate	Verio Dental Co. Ltd., Vancouver, Canada	nano particle sized tricalcium silicate, tantalum oxide, calcium phosphate, silicon dioxide
Apetite 1,2,3	Sankin	Powder component of type I ARS contains Tricalcium-phosphate, Hydroxyapatite 30% iodoform is added to Type II Powder in to improve antibacterial property. Type III Powder has 5% Iodoform and 1% Bismuth subcarbonate Liquid: Polyacrylic acid
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
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
Ceraseal	Meta Biomed Co., 270, Chungcheongbuk-do, South Korea	Calcium silicates, zirconium oxide, thickening agent

Tech BioSealer	Endo Isasan SRL, RevelloPorro, Italy	Powder: White Portland cement, bismuth oxide, anhydride, sodium fluoride Liquid: Alfacaine SP solution (4% articaine + 1/100.000Epinephrine
BioRoot RCS	Septodont, Saint-Maur-des-Fossés, France	Powder: tricalcium silicate, zirconium oxide, povidone Liquid: aqueous solution of calcium chloride and polycarboxylate
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 sulphate& gypsum Liquid: Water based gel with thickening agents and water soluble polymers.

Mechanism of action:

Calcium silicate powder and calcium hydroxide are formed when calcium silicate powder hydrates with liquid. When calcium hydroxide reacts with phosphate ions, HAP and water are formed. The newly formed HAP compound is nontoxic and can be used for bone reconstruction and repair. Water continues to react with the calcium silicates, resulting in the formation of more gel-like calcium silicate hydrate. As shown below, the water supplied by this reaction plays a significant role in controlling the hydration rate and setting time: (24,25)

Calcium silicate hydration reactions (A, B) can be approximated as follows:

(A) 2[3CaO. SiO2] + 6H2O --->- 3CaO. 2SiO2 . 3H2O+3Ca (OH)2

(B) 2[2CaO. SiO2]+4H2O --->- 3CaO. 2SiO2 . 3H2O+Ca (OH)2

The precipitation reaction (C) of calcium phosphate apatite is as follows:

(C) 7 C a (O H) 2 + 3 C a (H 2 P O 4) 2 - - - > - Ca10(PO4)6(OH)2+12H2 O

MTA initiates an exothermic reaction, requiring the hydration of its powder in order to produce the cement paste that matures over time.

Calcium silicate hydrates (C-S-H) and calcium hydroxide [Ca (OH) 2] are formed when tricalcium silicate and dicalcium silicate react with water. The hydration of the powder causes Ca+2 dissolution and diffusion, the formation of reaction products (CS-H and Ca[OH]2), and subsequent reactions that result in apatite formation. Calcium chloride accelerates the setting reaction, whereas sodium hypochlorite prevents the formation of calcium hydroxide.

2[3CaO.SiO2] + 6H2 O ---->3CaO.2SiO2 .3H2 O + 3Ca(OH)2

2[2CaO.SiO2] + 4H2 O ---->3CaO.2SiO2 .3H2 O + Ca(OH)2

7Ca(OH)2 + 3Ca(H2 PO4)2 ----> Ca10(PO4)6(OH)2 + 12H2 O.

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

1. Sealer particle tubular diffusion into dentinal tubules to produce mechanical interlocking bonds
2. Mineral infiltration of the sealer's mineral content into the intertubular dentin, resulting in the formation of a mineral infiltration zone after denaturing the collagen fibres with a strong alkaline sealer.
3. Phosphate partial reaction with calcium silicate hydrogel and calcium hydroxide produced by calcium silicate reaction in the presence of dentin moisture, resulting in the formation of hydroxyapatite along the mineral infiltration zone. (26,27)

Properties of Bioceramic based root canal sealers:

Biocompatibility

In vitro cytotoxicity of bioceramic-based sealers was assessed using mouse and human osteoblast cells, as well as human periodontal ligament cells (28.) The majority of bioceramic-based root canal sealers have been found to be biocompatible. The presence of calcium phosphate in the sealer contributes to its biocompatibility.

Setting Time

The ideal root canal sealer setting time should include enough working time. Moisture in the dentinal tubules catalyses the EndoSequence BC Sealer or iRoot SP setting reaction. While the standard setting time is 4 hours, it may be much longer in patients with particularly dry canals.

Both iRoot SP and MTA-Fillapex are highly soluble, with solubilities of 20.64% and 14.89%, respectively, falling short of ANSI/ADA standards. Because both sealers contain hydrophilic nanosized particles, their surface area increases, allowing more liquid molecules to come into contact with the sealer, resulting in high solubility. (30)

Radiopacity

The radiopacity of the EndoSequence BC Sealer is 3.83 mm. The Endo CPM sealer had a radiopacity of 6 mm due to the presence of bismuth trioxide and barium sulphate. Because of the presence of bismuth trioxide, MTA-Fillapex has a radiopacity of 7 mm. (31)

1. Bioceramic materials, such as calcium hydroxide, have a pH of 12.7 while setting, resulting in antibacterial effects. For a longer period of time, BC sealer was found to have a significantly higher pH than AH Plus. An alkaline pH aids in the elimination of bacteria such as Enterococcus faecalis.
2. MTA and EndoSequence Exposure Putty precipitated apatite crystalline structures in phosphate-buffered saline that increased over time, indicating that the materials are bioactive. MTA Fillapex, a salicylate resin-based root canal sealer containing MTA particles, demonstrated significantly lower cytotoxicity and a higher level of cell attachment than iRoot SP. EndoSequence Sealer released more calcium ions than AH Plus but less than BioDentine (Septodont) and White MTA.

ADVANTAGES OF USING BIOCERAMIC SEALERS FOR BASED ON IN VITRO AND CLINICAL STUDIES (31-36)

1. Biocompatible and do not induce any critical cytotoxic effects.
2. When applied inside the root canal, a bioceramic nanocomposite network comprising gel-like calcium silicate hydrate and HAP creates a hermetic seal.
3. Upon hydration, precipitates calcium phosphate with a strength comparable to that of human bone
4. IRoot BP has a good tolerance by subcutaneous tissue, is not mutagenic, and does not have an allergic potential after repeated uses.
5. Both its mineralization process and its bactericidal activities are enhanced by high alkalinity (pH 12.8)
6. Root canal hydration and hydrophilic properties help to produce calcium phosphate, which provides strength.
7. Low contact angle: Because of these properties, they can easily spread over the root canal dentin walls and fill the lateral micro canals.
8. The new bioceramic sealers also form chemical bonds with the canal's dentin walls. As a result, there is no space between the sealer and the dentin walls.
9. They have osseoconductive properties as well.
10 Exceptional radiopacity (3.8 mm Al)
11. Setting time is 3-4 h, allowing enough time for root canal obturaton.
12. Bioceramics do not shrink when they are set. In fact, they actually expand slightly after the setting process is completed.13. Furthermore (and this is very important in endodontics), bioceramics will not result in a significant inflammatory response if an overfill occurs during the obturation.

MTA BASED ROOT CANAL SEALERS:

ENDO CPM SEALER:

CPM sealer was created to combine the root canal sealer's sealing and physiochemical properties with the biological properties of MTA. It is a powder/liquid sealer with the same basic composition as MTA. (37) The presence of a large amount of calcium carbonate, which intends to increase the release of calcium ions and thus offers good sealing properties, adhesion to dentinal canal walls, adequate flow rate, and biocompatibility, is the most significant difference. In 1 hour, it solidifies and forms a hard sealer. After being set to limit surface necrosis

of cells in contact with the material, calcium carbonate was added to reduce the pH from 12.5 to 10.0, resulting in the deposition of mineralized tissue. (38)

MTA-FILLAPEX:

MTA Fillapex (Angelus Solucoes Odontologicas, Londrina, PR, Brazil) is a calcium silicate-based bioceramic sealer that was recently introduced. MTA-fillapex is the first two-paste system: an MTA-based salicylate resin root canal sealing paste with nano-silicate particles that is adaptable to all filling methods. MTA Fillapex was developed to combine the physicochemical properties of a resin-based root anal sealer with the biological properties of MTA. (37,38).

- Flow: Because MTA fillapex has a high flow rate (27 mm) and a thin film, it easily penetrates the other accessory channels. Regardless of the sealing technique, MTA fillapex confidently provides a high level of sealability that is not affected by heat, unlike other seals. [39,40]
- Antibacterial properties: Because the solubility is extremely low (0.1%), it has excellent antibacterial properties and does not erode over time like other sealers. Furthermore, it has a high ph value for a long-lasting antibacterial effect and can maintain a relatively constant calcium release for up to 14 days. (39,40)

ENDOSEAL MTA:

This resin-free sealer's main ingredient is MTA. It does not contain eugenol and will not disrupt root canal adhesion. This premixed, injectable endodontic sealer fills the root canal system, including accessory and lateral canals, due to its exceptional flowability. The radiopacity of endoseal MTA is greater than 3 mm, and the setting time is approximately 12.31 minutes. It expanded less than epoxy resin-based sealers after 30 days in water. However, it is less biocompatible than BioRoot RCS on human periodontal ligament cells (PDL). (41)

MTA OBTURA:

MTA Obtura was created with the goal of creating an endodontic sealer that combines MTA's biological and sealing properties. As expected for an mta-based material, this seal demonstrated very stable leakage values after 15 and 30 days. Its performance mirrored MTA's good sealing ability as a repair material. MTA Obtura, on the other hand, showed a significant increase in leakage after 60 days. According to Bernardes et alresearch, .'s MTA obtura has the lowest flow rate (27.65 mm). Because of this property, MTA obtura is more likely than the other sealers tested to be difficult to penetrate into the ramifications and irregularities of the root canal walls. (42,43)

MTAS EXPERIMENTAL SEALER:

It is composed of 80% white Portland cement, a resin carrier, and zirconium oxide for radiation protection. It has a powder-to-liquid weight ratio of 5:3 that was determined in previous pilot studies. It takes the same amount of time to set up as ah plus sealer. According to a recent study, Mtas released more calcium than MTA and Portland cement except for 14 days. This could be due to the fact that the stamp contains calcium chloride. After 48 hours, the ph of Mtas sealer was statistically similar to that of MTA and Portland cement. This indicates that Mtas has a high capacity for hydroxyl ion release. (44)

F-DOPED MTA CEMENTS

It was recently discovered that fluorine-containing Portland cement expands significantly in both water and pbs. Because there was no expansion when the portland-based cements were immersed in hexadecane oil, the expansion of portland-based cements is a water-dependent mechanism caused by water absorption. Furthermore, fluorine-doped cements hasten the formation of ettringite, which is responsible for expansion. The sodium fluoride in the test cement was older. Fmta is well-known for its expansive properties, long setting time, and activity in bone and pulp cells. (45). Because of the increased expansion, the fluoride-containing cement demonstrated improved sealability. Furthermore, fluoride ions from cementum can penetrate dentin and increase mineralization while also clogging and sealing dentin tubules.

CALCIUM SILICATE-BASED SEALERS

PRO-ROOT ENDO SEALER

The ProRoot ES endodontic sealer is a continuation of the endodontic sealer paradigm shift toward calcium silicates or bioceramics. These new sealers are both sealers and apical fillers. A thin layer of sealer should be present between the gutta percha, dentin, and any exit portal (foramen). A tight fitting gutta percha cone that "fits and fills" the apex or foramen with only a thin layer of sealer in between is preferable in this technique. Pro root ES possesses the following characteristics: It reduces post-operative sensitivity significantly. It has excellent osteogenic/osteoconductive properties and has the ability to stimulate cementum growth. It has antibacterial properties. The initial pH value is 11.6, and the final pH value is 11.7. It binds to dentin and gutta percha.

Bio-C Sealer

The Bio-C Sealer (Angelus, Londrna, PR, Brazil) is a new injectable hydraulic calcium silicate-based material that is pre-mixed and ready for use during root canal treatment. The Bio-C Sealer is a single-use syringe containing calcium silicates, calcium aluminate, calcium oxide, zirconium oxide, iron oxide, silicon dioxide, and dispersing agents (Fig. 18a). Bioceramic particles account for approximately 65% of the material, with polyethylene glycol being used to achieve viscosity and facilitate removal and cleaning following obturation procedures. The manufacturer attributes its bioactivity to the release of calcium ions, which stimulate the formation of mineralized tissue. However, few studies on its effects on periapical tissues and related cells have been conducted to date. The working time is 60 minutes; the average setting time is 120 minutes (maximum up to 240 minutes) after insertion into the root canal and is highly dependent on the moisture level inside the root canal. The material is highly alkaline (pH 12.5). (48)

Well-Root ST

Another tricalcium silicate-based sealer is Well-Root ST (Vericom, Gangwon-Do, Korea) (Fig. 18b). This sealer is a premixed, ready-to-use, injectable, bioactive root canal sealer based on tricalcium silicate, a hydrophilic sealer that sets and hardens in the presence of water. It is intended for long-term root canal obturation. The material is hydrophilic, which means it is activated and completed by moisture in dentinal tubules. The setting time is 25 minutes according to ISO 6876:2012 (100% humidity conditions). (48)

However, the manufacturer claims that the setting time in normal root canals can be more than 2.5 hours. Gutta-percha points should be combined with the Well-Root ST. Well-Root ST has been shown to have good angiogenetic properties, similar biological effects, and low cytotoxicity as compared ProRoot MTA or Biodentine.

CeraSeal

CeraSeal is a hydraulic calcium silicate-based sealer with excellent sealing properties. The chemical reaction between calcium silicate and moisture in the dentinal tubules results in the crystallisation of calcium hydroxide. The material ensures the root canal's hermetic seal and prevents bacteria from entering and multiplying. The material is dimensionally stable, does not shrink or expand in the root canal, and protects against root infractions or fractures by maintaining a constant volume. This material can be obturated using the single-cone obturation technique. The material is highly resistant to washout due to the shorter setting time. CeraSeal causes a significant amount of Ca2+ release. This product cures slowly by absorbing the surrounding water inside the root canal. It is white and aesthetically pleasing. (48)

CeraSeal has a setting time of about 3.5 hours, a pH of 12.73, flowability of 23 mm, and radiopacity of 0. (equivalent to 8 mm of Al). It is supplied in a set of two 2 g premixed syringes with intra canal tips cannulas. CeraSeal's composition and properties, according to the manufacturer, are very similar to those of iRoot®SP, with the exception that CeraSeal uses 1,3-propanediol instead of calcium phosphate monobasic and calcium hydroxide.

BioRoot™ RCS

Septodent's BioRootTM RCS is a new generation of root canal sealer/filler that employs Active Biosilicate Technology. BioRoot RCS is a hydraulic tricalcium silicate-based powder/liquid root filling cement that is ideal for single cone technique or cold lateral condensation root filling. BioRootTM RCS was created to be used in the root canal by manually mixing the powder (1 spoon) with the liquid (5 drops) using simple spatulation; the

working time is approximately 15 minutes, and the setting time is less than 4 hours. BioRootTM RCS also demonstrated a tight seal with dentin and gutta-percha (Fig. 4) as well as adequate radiopacity (5 mm of aluminium). The mixed paste has a smooth consistency and good flow that improves after being placed in the root canal (at body temperature). As shown, the flow rate is 26 mm and the film thickness is 45 m. (48)
BioRootTM RCS was created to simplify root canal obturation techniques by making it easier to mix and use, improving consistency, and eliminating the need for a warm gutta-percha technique. It has been suggested that BioRootTM RCS be used only with cold root canal filling techniques because the heat generated during thermoplastic obturation can negatively affect the material's flowability and film thickness. A single-cone technique has recently been proposed for use with hydraulic calcium silicate cements. (48)

NeoMTA Plus

NeoMTA Plus is a new finer powder tricalcium silicate material with tantalum oxide (Ta2O5) as a radiopacifying agent and good handling properties. The powder to gel mixing ratio can be adjusted to produce a thin mixture for orthograde sealer and a thick mixture for root end filling (49)

iRoot® SP, EndoSequence® BC Sealer™, and TotalFill® BC Sealer™

In 2007, Innovative BioCeramix, Inc. of Vancouver, Canada, developed and launched the first premixed and ready-to-use hydraulic calcium silicate-based material. iRoot SP injectable root canal sealer (iRoot®SP) was introduced. Since 2008, Brasseler USA has sold this premixed sealer under the brand name EndoSequence® BC SealerTM. FKG Dentaire in Switzerland recently marketed this material in Europe as TotalFill® BC SealerTM. The materials are packaged in disposable syringes with pre-loaded tips. All three materials (calcium silicates, zirconium oxide, calcium phosphate monobasic, and fillers) are chemically identical, have identical physicochemical and biological properties, handling characteristics, and are clinically effective. iRoot®SP, EndoSequence® BC SealerTM, and TotalFill® BC SealerTM are injectable white hydraulic cement pastes that have been premixed and are ready to use for permanent root canal filling in the single cone and lateral condensation techniques. They are made of calcium silicate, an insoluble, radiopaque, aluminum-free material that requires water to set and harden filling and sealing. (50, 51, 52, 53)
Working time at room temperature can exceed 4 hours. The timer is set for 4 hours. Setting time can exceed 10 hours in extremely dry root canals.

EndoSequence BC Sealer HiFlow

A new formulation of Endosequence BC Sealer (BCHiF) was modified to create a suitable calcium-silicate-based sealer for use in warm canal filling techniques. BCS and BCHiF had identical elemental compositions. The percentages of carbon, oxygen, and silicon in both sealers were similar, but the amounts of calcium and zirconium varied. However, the manufacturer claims that when heated, it has a lower viscosity and is more radiopaque than Endosequence BCS. BCHiF performed similarly to its predecessor BCS in terms of cytocompatibility, cell migration, cell adhesion, and bioactivity potential. (54)

Nano Ceramic sealer(NCS)

It is cytocompatible, but not as well as Bioroot RCS. These findings show that there are differences between commercially available bioceramics, implying that unknown fillers and thickening agents may be important in biocompatibility. A nanoceramic sealer significantly increased cell viability for 7 days. It promotes cell attachment and proliferation due to its smooth surface. It has a high initial osteoblastic potential, which is beneficial in the early stages of periapical healing. (55)

iRoot BP and iRoot BP Plus

These sealers are insoluble, ready to use, aluminum-free, and radio-opaque, with varying degrees of consistency. iRoot BP is an injectable white paste, whereas iRoot BP Plus has a putty-like consistency. The physical properties of iRoot BP are excellent, and it does not shrink during setting. (56)

PHOSPHATE-BASED BIOCERAMIC SEALERS

BioAggregate

Innovative BioCeramix Inc. (Vancouver, Canada) manufactures BioAggregate, a nanotechnology-based root filling material. It is a fine white hydraulic 10 powder cement mixture that is radiolucent. It produces biocompatible and aluminum-free ceramic biomaterial when it reacts with water. Powder initiates a complex chain of reactions when mixed with BioA Liquid, resulting in the formation of a nano-composite network of gel-like calcium-silicate-hydrate intimately mixed with hydroxyapatite, forming a hermetic seal when applied inside the root canal. It has good handling properties after being mixed with liquid, a quick setting and hardening time, and is simple to work with. Because of these properties, it is an excellent filling material for root canal repairs. This material's main disadvantage is its low radiopacity. (57)

CALCIUM PHOSPHATE BASED SEALERS:

Apatite Root Canal Sealer:

With minor compositional changes, Sankin apatitie root canal sealer I, II, and III were introduced to the market. Polyacrylic acid, which has a low pH and may gradually leak into surrounding tissue during the setting process, causes inflammation in apatite root sealers (ARS). The powder components of type I ARS are tricalcium phosphate, hydroxyapatite, and polyacrylic acid. 30% iodoform is added to Type II Powder to improve antibacterial properties. Iodoform, on the other hand, causes more severe inflammation. Type III Powder contains 5% iodoform and 1% bismuth subcarbonate. The inflammatory response to this sealer is reduced due to the lower iodoform concentration. (58)

Bioseal

It is a hydroxyapatite sealer containing eugenol. The powder is made up of hydroxyapatite, barium sulphate, iodothymol, and resin, while the liquid is made up of eugenol. The powder is delivered in the form of capsules. The ability of hydroxyapatite to seal is unaffected. These sealers perform well in terms of sealing, tissue response, and biocompatibility. Capseal I and Capseal II (56)

Capseal I and II have higher mineralization potential than other sealers, according to Bae et al. The pH and calcium ion release levels of these sealers were higher or equal to those of Sealapex and Appetite root sealer. Jin-Su Kim et al. discovered in 2004 that Capseal I and Capseal II were more biocompatible than Apatite Root Sealers. (56, 59)

CONCLUSION:

The majority of modern commercially available flowable hydraulic calcium silicate materials share many physical, biological, and handling properties as well as a similar chemical composition. These bioceramic sealers are currently being extensively researched, and the clinical effectiveness of the single-cone obturation technique when using these materials has been confirmed. Changing materials and techniques, on the other hand, is a difficult decision for clinicians to make in everyday clinical practise. Based on sound scientific evidence, biocompatible, bioactive, and antibacterial hydraulic calcium silicate materials that slightly expand upon setting and remain dimensionally stable in combination with single-cone obturation can replace lateral condensation as the most effective endodontic sealing technique. The search for newer materials will never end, but the advent of bioceramic technology has the potential to be a game changer in endodontics.

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