Review Article on Recent Advances of Root canal sealers

[1]Dr Qurat ul ain, [2]Dr Durga Devi Dasari, [3]Dr Shari Devarajan,
[4]Dr Aditya Narayanan, [5]Dr Ritika Pundir

The oxford dental college
Bangalore

Abstract- **Root canal sealers are the binding agents used to fill the gaps between the root canal walls and the obturating materials. A hermetic seal cannot be obtained without the use of a sealer which forms a fluid tight seal and barrier between the dentin and core material apically, laterally and coronally. All sealers are required to possess certain physical and biological properties. These properties include biocompatibility, strength, sealing ability, adequate working and setting time, flow, solubility and various other characteristics. However, no sealer has been shown to be totally satisfactory for clinical use. This article reviews the Desirable properties, functions, classification and recent advances of root canal sealer.**

INTRODUCTION:

A basic concept is that sealer is more important than the core obturating materials. sealer accomplishes the object of providing a fluid tight seal; the core occupies space, serving as vehicle for the sealer. Sealer must be used in conjunction with the obturating material used. This makes the physical properties and placement of the sealer important. Gutta-percha is universally accepted as the "Gold standard" for the obturating materials. It is nontoxic, biocompatible, thermoplastic, retreatable but it presents no adhesiveness to tooth structure and thus it requires a sealer to provide a seal at the canal gutta-percha interface.

Desirable properties:

Grossman outlined the criteria for an ideal sealer. None of the sealers currently available possesses all these ideal properties, but some have more than others. His criteria are as follows.

Tissue tolerance:

The sealer and its components should cause neither tissue destruction nor cell death. All commonly used sealers used sealers shows a degree of toxicity. This toxicity is greatest when the sealer is unset but tends to diminish after setting and with time.

No shrinkage with setting:

Sealer should remain dimensionally stable or even expand slightly on setting.

Slow Setting Time:

Sealer should provide adequate working time for placement and manipulation of obturating material, then set reasonably soon after obturation is complete.it is desirable to have sealer unset if post space is made immediately.

Adhesiveness:

Adhesiveness is a most desirable property. A truly adhesive material would form an absolute bond between the core material and dentin, closing off any spaces. Zinc Oxide Eugenol based sealers have no adhesion, plastics have some.

Radiopacity:

Sealer should be readily visible on radiographs, however the more radiopaque the sealer, the more it obscures voids in the obturation. Some clinicians prefer a highly radiopaque sealer to mask discrepancies.

Absence of staining:

Remnant should not cause future staining of the crown. Currently all tested sealers particularly zinc oxide eugenol or those containing heavy metals stain dentin

Sealer as a Lubricant:

When used with solid/semisolid obturation materials, sealers act as a lubricant thereby aiding in easy seating of obturation material in the apical area.

Sealer as an Antibacterial agent:

Sealers should be able to control or restrict bacterial growth. Zinc oxide eugenol, Calcium hydroxide and Calcium silicate-based sealers have significant antibacterial properties.

Bioactivity:
Sealers might influence the host response by actively interacting with the local tissue environment. Calcium hydroxide and MTA based sealers can be considered as bioactive sealers with bioactivity.

Insolubility to oral and tissue fluids:
Sealers should not disintegrate with when in contact with tissue fluids. Sealers are somewhat soluble particularly when in contact with oral fluids.

GROSS MAN' S IDEAL REQUIREMENT OF ENDODONTIC SEALER
1. It should be sticky when mixed and also provide better adhesion.
2. It should provide fluid tight hermetic seal.
3. It should be radiopaque so it can be easily seen on radiographs.
4. It should have small particle size so that it can be easier for mixing.
5. It should not shrink on setting.
6. It must not discolour the tooth.
7. It must have an antibacterial activity.
8. It should not be easily soluble in tissue fluids.
9. It supposed to be not be cytotoxic or mutagenic in nature.
10. It supposed to be biocompatible and non-irritating to periapical or periodontal tissue.
11. It supposed to be easily soluble in routine solvents so that it can be easily removed in retreatment cases

FUNCTIONS OF SEALERS
Antibacterial Property of Root Canal Sealer
Lubricating Property of Endodontic Sealer
Sealing Capability of Endodontic Sealers to Root Dentin
Bond Strength of Root Canal Seale
Biocompatibility of Endodontic Sealer

Recent advances in root canal sealer
Adaptability of a sealer to the dentin is the primary factor influencing microleakage and reinfection of the root canal. Many endodontic sealers are used in clinical practice, including the recently-introduced calcium silicate-based sealers. The EndoSequence BC sealer (Brasseler USA, Savannah, Georgia, USA; also named the iRoot SP; (Innovative. BioCeramix Inc, Vancover, Brtish Columbia, Canada) has been introduced as an ideal premixed and injectable biomaterial in the clinical, exhibiting excellent radiopaque, zero-shrinkage, insoluble, and hydrophilic characteristics.
RESIN-BASED ROOT CANAL SEALERS
Researchers have mainly focused on finding an ideal root canal sealer to use in combination with GP. Polymeric resin-based root canal sealers were introduced to overcome shortcomings associated with conventional zinc oxide eugenol (ZOE) sealers.
Those shortcomings include inability to strengthen root structure, lack of bonding to dentin, microleakage, and the high solubility, all of which may compromise the longevity of root canal therapy Polymeric root canal sealers, such as silicon-based sealers and resin-based sealers were introduced to the market to overcome limitations associated with conventional sealers. AH Plus (Dentsply DeTrey, Konstanz, Germany) is an epoxy-resin based paste-paste sealer system and is widely accepted in root canal therapy. It consists of an epoxide paste and an amine paste that consists of three different types of amines.
AH Plus has demonstrated low solubility and good dimensional stability in solutions. It can adhere to root dentin due to its creep properties and long setting times. Regarding the antimicrobial properties, epoxy-resin based sealers have shown to produce some antibacterial properties but mainly before their setting due to the release of some of the constituents like formaldehyde. Many efforts have been made to prolong the antimicrobial properties of epoxy-resin sealers through the addition of antibacterial agents, such as silver, quaternary ammonium compounds, chlorhexidine, calcium hydroxide and many more, which have shown improved antimicrobial activity and minimal adverse effects on physicochemical and biological properties.
Methacrylate-resin based root canal sealers were introduced to provide the concept of a "mono-block" by bonding the core filling material to the canal wall and forming a single unit. They were developed to provide a better seal and mechanically reinforce compromised roots, which have been suggested to reduce bacterial ingress pathways and strengthen the root structure. Methacrylate-based sealers are meant to infiltrate the partially demineralized collagen matrix and create micromechanical retention to root dentin. Despite the desirable concept of the mono-block, the lack of relief of polymerization shrinkage stresses associated with these sealers that occur as a result of the unfavorablecavity configuration of the root canal, result in the pulling out of the resin tags from the dentinal tubules. This can compromise the sealer-dentin bond and result in micro-gaps that can act as a source for micro-leakage. For these specific reasons, efforts have been made to improve the bond and antibacterial properties of methacrylate-resin based root canal sealers

Bio ceramic based sealers:
Bio ceramic based sealers were introduced in endodontics due to their superior physico-chemical and biological properties over the traditional endodontic sealer. Bio ceramic, a term introduced for an important subset of biomaterials includes materials that can be classified as bioinert, bioactive or biodegradable according to the interaction with surrounding tissues.Bio ceramic-based sealers have only been available for use in endodontics for the past thirty years, their rise to prominence corresponding to the increased use

of bio ceramic technology in the fields of medicine and dentistry. Bio ceramics are ceramic materials designed specifically for medical and dental use. They include alumina, zirconia, bioactive glass, glass ceramics, hydroxyapatite, and calcium phosphates.
The classification of bio ceramic materials into bioactive or bioinert materials is a function of their interaction with the surrounding living tissue. Bioactive materials, such as glass and calcium phosphate, interact with the surrounding tissue to encourage the growth of more durable tissues. Bioinert materials, such as zirconia and alumina, produce a negligible response from the surrounding tissue, effectively having no biological or physiological effect. Bioactive materials are further classified according to their stability as degradable or nondegradable. Bio ceramics are commonly used for orthopaedic treatments, such as joint or tissue replacements, and for coating metal implants to improve biocompatibility. Additionally, porous ceramics, such as calcium phosphate-based materials, have been used as bone graft substitutes. Calcium phosphate was first used as bio ceramic restorative dental cement by LeGeros et al. However, the first documented use of bio ceramic materials as a root canal sealer was not until two years later when Krell and Wefel compared the efficacy of experimental calcium phosphate cement with Grossman's sealer in extracted teeth, finding no significant difference between both sealers in terms of apical occlusion, adaptation, dentinal tubule occlusion, adhesin, cohesion, or morphological appearance..

Calcium phosphate cement has subsequently been used successfully in endodontic treatments, including pulp capping, apical barrier formation, periapical defect repairs, and bifurcation perforation repairs There are two major advantages associated with the use of bio ceramic materials as root canal sealers. Firstly, their biocompatibility prevents rejection by the surrounding tissues. Secondly, bio ceramic materials contain calcium phosphate which enhances the setting properties of bio ceramics and results in a chemical composition and crystalline structure similar to tooth and bone apatite materials, thereby improving sealer-to-root dentin bonding. However, one major disadvantage of these materials is in the difficulty in removing them from the root canal once they are set for later retreatment or post-space preparation. 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. Infiltration of the sealer's mineral content into the intertibular dentin resulting in the establishment of a mineral infiltration zone produced after denaturing the collagen fibres with a strong alkaline sealer. 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

(2) Infiltration of the sealer's mineral content into the intertubular 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

Classifications of bio ceramic sealers

Type and Brand name

Calcium silicate based sealer (CSBS)

iRoot SP
EndoSequence BC Sealer

MTA-based sealer

MTA Fillapex
Endo CPM sealer,
MTA-Angelus,
ProRoot Endo Sealer

Calcium phosphate-based sealer

Sankin apatite root canal sealer (I, II, and III),Capseal (I and II)

BIO-C® SEALER is a ready-to-use bio ceramic endodontic cement. In addition to the benefits of its bio ceramic formulation such as stimulating tissue regeneration, bactericidal action and inhibiting bacterial infiltration, it presents a great advantage over traditional filling cements, not requiring mixing. Its ready-to-use presentation makes it easy to apply to the canal, simplifying the procedure with great time saving.

INDICATION

The use of BIO-C® SEALER in filling procedures has shown excellent results. In addition to the physical seal provided by the expansion of the cement, it promotes a biological seal by the formation of an intermediate layer of mineralization. In cases of non-communicating internal resorptions, the high pH of BIO-C® SEALER neutralizes the acidity of the medium, preventing the resorption to progress

TECHNIQUES OF USE

A. **Root canal filling of permanent teeth**

Traditional Technique - Lateral Compression

1. Anesthetize, install rubber dam insulation and do biomechanical preparation of the canal;

2. Dry the canal with paper tips only without causing excessive drying; 3. Position the applicator tip and fill the canal with BIO-C® SEALER; 4. Insert the main gutta percha cone covered with BIO-C® SEALER and later the accessory gutta percha cones;
5. X-ray to verify the correct filling of the canal;
6. Cut the cone at the desired height with heated instruments followed by vertical compaction;
7. Remove excess material from the canal walls with water, perform coronary sealing and restoration. Single Cone Technique or Hydraulic Compression
1. Anesthetize, install rubber dam insulation and do biomechanical preparation of the canal;
2. Dry the canal with paper tips only without causing excessive drying; 3. Position the applicator tip and fill the canal with BIO-C® SEALER; 4. Insert the selected gutta percha cone covered with BIO-C® SEALER;
5. X-ray to verify the correct filling of the canal;
6. Cut the cone at the desired height with heated instruments followed by vertical compaction;
7. Remove excess material from the canal walls with water, perform coronary sealing and restoration.

Single Cone Technique or Hydraulic Compression

1. Anesthetize, install rubber dam insulation and do biomechanical preparation of the canal;
2. Dry the canal with paper tips only without causing excessive drying;
3. Position the applicator tip and fill the canal with BIO-C® SEALER;
4. Insert the selected gutta percha cone covered with BIO-C® SEALER;
5. X-ray to verify the correct filling of the canal;
6. Cut the cone at the desired height with heated instruments followed by vertical compaction;
7. Remove excess material from the canal walls with water, perform coronary sealing and restoration.

B. Internal resorption treatment

1. Anesthetize and install rubber dam insulation;
2. Remove granulation tissue from the resorption area with sharp curettes;
3. Neutralize the medium with calcium hydroxide paste;
4. Remove the calcium hydroxide in the next session;
5. Dry the canal with paper tips only without causing excessive drying;
6. Insert BIO-C® SEALER with the applicator tip into the entire canal, prioritizing the resorption site;
7. Fill the canal according to the selected technique;
8.Cuttheconesontopoftheresorptionwithheatedinstruments.Performverticalcompaction for better cement flow at the resorption site;
9. X-ray to verify the correct filling of the resorption site and the canal;
10. Fill the rest of the canal with gutta percha;
11. Perform coronary sealing with glass ionomer or other material of your choice
12. X-ray and follow for at least two years.

COMPOSITION	***FUNCTION***
Tricalcium Silicate (C3S)	Mechanical resistance over time Calcium ions release
Dicalcium Silicate (C2S)	Mechanical resistance over time Calcium ions release
Tricalcium Aluminate	Initial setting
Calcium Oxide	Calcium ions release
Zirconium Oxide	Radiopacity
Silicon Oxide	Rheology agent
Polyethylene	Dispersing agent
Glycol Iron Oxide	Pigmentation

MTA Fillapex

MTA Fillapex is an endodontic sealer based on MTA, developed by Angelus (Londrina/Parana/ Brazil) and launched commercially in 2010. It is a new product that combines the proven advantages of MTA with a superior canal obturation product. Its formulation in the paste/paste system allows a complete filling of the entire root canal, including accessory and lateral canals. MTA, present in the composition of MTA Fillapex, is more stable than calcium hydroxide, providing constant release of calcium ions for the tissues and maintaining a pH which elicits antibacterial effects. The tissue recovery and the lack of inflammatory response are optimized by the use of MTA and disalicylate resin. The product is eugenol free and will not interfere with adhesive procedures inside the root canal. Also, it does not cause discoloration of the tooth structure.

MAIN FEATURES AND ADVANTAGES

A. Presence of MTA in the formula: allows the formation of new tissue, including root cementum;

B. Biocompatibility: rapid recovery of tissues without causing inflammatory reaction;
C. High Radiopacity: perfect radiographic visualization;
D. Excellent Flow: the flowable consistency of MTA Fillapex is engineered to penetrate and also to fill lateral canals;
E. Setting expansion: provides excellent sealing of the root canal, avoiding the penetration of tissue fluids and/or bacterial recontamination;
F. Calcium ion release: induces rapid tissue regeneration in sites with bone lesion and microbial activity;
G. System paste x paste: easy handling and insertion
H. Working time: allows adequate working time to be used by specialists and/or general practitioners;
I. Easy removal: allows easy removal for retreatment, particularly when used with GP points.

Composition

Paste A:
Salicylate resin, Bismuth Trioxide Fumed Silica.
Paste B:
Fumed Silica Titanium Dioxide
Mineral Trioxide Aggregate (40%)
Base resin

Endo-CPM-Sealer

This was introduced in 2004, to combine the physicochemical properties of a root canal sealer with the biological properties of MTA. End-CPM had an antibacterial effect against E. faecalis before setting but it did not maintain antibacterial activity after setting. Calcium carbonate was added to reduce the pH from 12.5 to 10.0 after being set so as to restrict the surface necrosis of cells in contact with the material, resulting in the deposition of mineralized tissue. Addition of calcium chloride to MTA reduces setting time, improves sealing ability and facilitates the insertion into cavities without interfering with its biocompatibility.

iRoot SP

iRoot®SP Injectable Root Canal Sealer (iRoot® SP) is a convenient premixed ready-to-use injectable white hydraulic cement paste developed for permanent root canal filling and sealing applications. iRoot® SP is a next generation and revolutionary bioceramic material which is user-friendly highly biocompatible non-toxic aluminum-free anti-bacterial hydrophilic and provides outstanding sealing properties.

Packing:
1 x 2g Syringe
15 x Mixing Tips

Convenient and User-Friendly

iRoot® SP requires no mixing saves time and delivers a consistent homogeneous product for every application. Just apply iRoot® SP directly from the syringe into the root canal using the disposable tips provided.

Hydrophilic No Additional Curing Agent Required

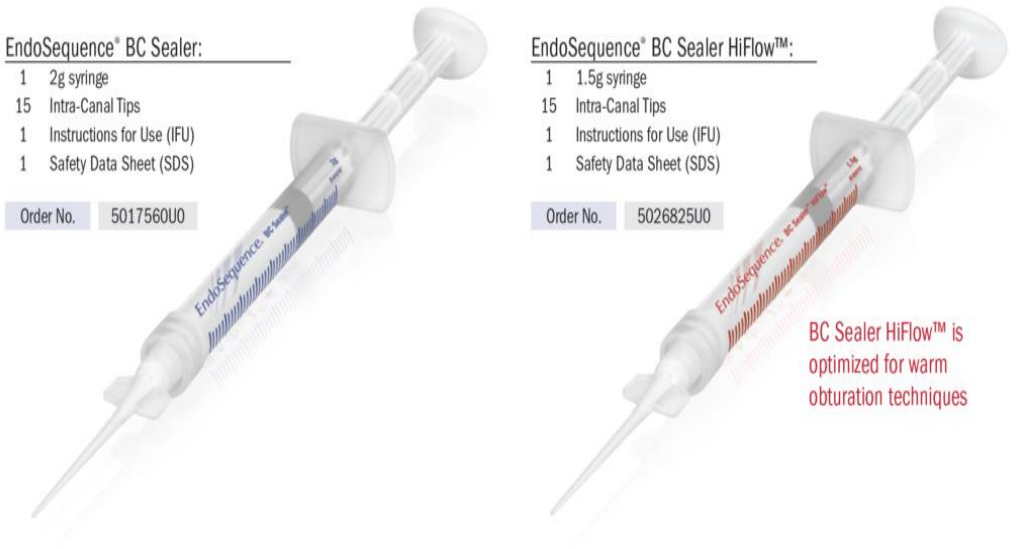
Utilizing the moisture naturally present in the dentinal tubules to initiate and complete its reaction. iRoot® SP is hydrophilic therefore you don't have to be concerned about the moisture in the root canal in fact the presence of moisture helps the setting reaction of iRoot® SP.

Biocompatible and Anti-Bacterial

The unique formula of iRoot® SP is biocompatible non-toxic and aluminum-free. In addition, because Root® SP setting reactions result in a highly alkaline pH therefore provides an environment detrimental for bacterial growth

EndoSequence® BC Sealer

The "State-of-the-Art" in Endodontic Obturation



BC Sealer

Introducing a revolutionary premixed and injectable root canal sealer utilizing new bioceramic nanotechnology! EndoSequence BC Sealer's nano particle size allows it to flow readily into canal irregularities and even dentinal tubules and unlike traditional sealers; EndoSequence BC Sealer has absolutely no shrinkage! This highly radiopaque and hydrophilic sealer chemically bonds to both dentin and to our bioceramic gutta percha. It uses the moisture naturally present in dentin to initiate and complete its setting reaction and it is anti-bacterial during setting due to its highly alkaline pH.

HOW DOES YOUR CURRENT SYSTEM COMPARE?

What makes BC Sealer different from other "bioceramic" sealers? Our nano-particulate premixed bioceramic contains Calcium Silicates, Calcium Phosphate, Calcium Hydroxide and Zirconium Oxide – a patented formula that cannot be copied.

Patented premixed calcium silicate, calcium phosphate bioceramic sealer
Biocompatible and Osteogenic
Bonds to dentin and BC Points
100% Hydrophilic
Zero Shrinkage

BC Sealer Hi Flow

Clinicians now have two distinct formulations of the same proven pre-mixed bioceramic sealer to choose from. Compared to standard BC Sealer, BC Sealer HiFlow exhibits a lower viscosity when heated and is more radiopaque, making it optimized for warm obturation techniques.

Standard gutta percha can be used with BC Sealer, but for a true, gap-free seal, BC Points are recommended. BC Points are impregnated and coated with bioceramic particles to allow for bonding with BC Sealer. The benefit of using BC Sealer and BC Points is that three-dimensional bonded obturation can be achieved at room temperature. However, if a warm vertical technique is preferred it is recommended to use BC Sealer HiFlow with BC Points 150 Series along with BC Pellets at 150ºC – 220ºC.

- Condensation-based technique
- Optimal for warm obturation
- Lower viscosity when heated
- Higher radiopacity

HIGHLY ANTIBACTERIAL

BC Sealer is alkaline (+12pH) making it highly antibacterial. A recent study showed that BC Sealer killed Enterococcus faecalis within 2 minutes of contact.

EXCELLENT FLOW

BC Sealer's extremely small particle size and hydrophilic nature allow it flow into all aspects of the canal anatomy.

SUPERIOR BIOCOMPATIBILITY

BC Sealer is essentially a root repair material with a flowable consistency. The unique osteogenic properties of BC Sealer make it particularly effective on non-vital cases with extensive bone loss or apical periodontitis

SUPERIOR BONDING

BC Sealer's hydrophilic/hydroxyapatite producing formula and excellent flowability allow it bond readily to both dentin and to bio ceramic filling materials (BC Points™)

ProRoot Endo Sealer (Dentsply Tulsa Dental Specialities):

ProRoot Endo Sealer is calcium silicate-based endodontic sealer to be used in conjunction with root filling material in either cold lateral warm vertical or carrier-based filling technique. The major components of the powder of ProRoot Endo Sealer are tricalcium silicate and dicalcium silicate, with inclusion of calcium sulphate as setting retardant, bismuth oxide as radio pacifier and a small amount of tricalcium aluminate. The liquid component consists of viscous aqueous solution of water-soluble polymer. It exhibits biocompatibility when in contact with physiologic solution (Huffman et al., 2009). There is also release of calcium and hydroxyl ions from the set sealer liquid (Tay et al., 2007). Similar to other calcium silicate containing biomaterial, MTA sealer produce calcium hydroxide on reaction with water. These phenomena may account for in vitro bioactivity of Pro Root MTA sealer. Microleakage studies of Pro Root MTA sealer showed similar sealing ability to epoxy resin-based sealer superior to zinc oxide eugenol-based root canal sealers when evaluated using fluid filtration system (Torabinejad et al., 2010)

CONCLUSION

With the advent of ZOE based sealers in 1980s there has been lot of advancements in various types of sealers and its aspects such as biocompatibility, antimicrobial property, setting reaction, achieving Monoblock concept and so on. However, till date no sealer has achieved all IOS ideal requirements. The inclusion of novel, biocompatible and bioactive agents into dental products to achieve strong antibacterial and tissue-remineralization functions is highly desirable. These strategies are highly promising to improve the endodontic treatment outcomes and can potentially prevent and control endodontic diseases.

REFERENCES:

1. Mishra P., Gupta S., Nikhil V, Jaiswal S., Raj S. Root canal sealers: An review. IP Indian J Conserv Endod 2018;3(3):69-74
2. Torabinejed -Endodontic principle and practice.
3. J. I. Ingle, L. K. Bakland, and J. C. Baumgartner, Ingle's endodontics, BC Decker, Hamilton, Ont, 2008
4. Rathi CH, Chandak M, Nikhade P, et al. Functions of root canal sealers- a review. J. Evolution Med. Dent. Sci. 2020;9(17):1454- 1458, DOI: 10.14260/jemds/2020/317
5. International Journal of Biomaterials Volume 2016, Article ID 9753210, 10 pages http://dx.doi.org/10.1155/2016/9753210
6. Rathee G, Cheema J, Thapak G, Chauhan P, Kumar AV. Recent advancements in root canal sealers. Int J Res Health Allied Sci 2020; 6(4):46-49.