Review Article

Root Canal Sealers & its Role in Successful Endodontics- A Review

Joe D’souza Leslie Henston, Sharma Nitin, Chander Subhash, Singh Shamsher, D’ Souza Raina

Abstract

In endodontic practice, the success of root canal therapy mainly depend on achieving a compact fluid tight seal of the apical end of the root canal, so as to prevent the ingress and accumulation of irritants causing biological breakdown of attachment apparatus leading to failure. Root canal sealers along with solid core material play a major role in achieving the fluid tight seal.

Several types of root canal sealers are used in endodontic practice with each one having own merits and demerits. Sealers are basically selected based on their sealing ability, adhesive properties, biocompatibility & antimicrobial efficacy.

Keywords:
Root canal therapy, Root canal sealer


Correspondence to
Dr Nitin Sharma
Dept. of Pedodontics and Preventive Dentistry
Vyas Dental College, Jodhpur, Rajasthan.
Email: nitinsharma4u@gmail.com
Phone: +91 9413552698

Copyright: © 2012 Henston et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
**Introduction**

Three dimensional sealing of the entire root canal space with a bio-compatible filling material is a challenging task to be achieved for the success of endodontic treatment. Filling the root canal space is achieved by two main components: Gutta Percha core filling material and root canal sealer. Gutta Percha is the most favorable bio-compatible filling material that can be used to fill the radicular space. But, this material alone is not enough to produce and ensure tight seal of the root Canal system, it is only adapts to the adjacent dentinal walls. However, root canal sealer is necessary to fill the irregularities and minor discrepancies between gutta percha and canal wall.

**Classification of Root Canal Sealers:**

A. Classified according to the chemical composition – Ingle\(^1\)
   1. Zinc oxide-eugenol based cements.
   2. Calcium hydroxide containing cements.
   3. Resin based cements.
   5. Experimental Sealers.

B. According to Clark:
   1. Absorbable.
   2. Non-absorbable.

**Grossman’s Ideal requirements of Root Canal Sealer\(^2\):**

1. Tacky which helps for good adhesion between it and the canal wall when set.
2. Provide a hermetic seal.
3. Radiopaque to be seen in the radiograph.
4. Easy to manipulate.
5. No shrinkage on setting.
6. No staining to tooth structure.
7. Bacteriostatic.
8. Set slowly.
9. Insoluble in tissue fluids.
11. Soluble in a common solvent.
12. Neither mutagenic nor carcinogenic.
13. Not provoke an immune response in periradicular tissue.

**Functions of root canal sealers:**

1. As antimicrobial agent
2. Helps in filling the discrepancies between the filling material and the dentin walls
3. As a binding agent between the filling material and the dentin walls.
4. As a lubricant and gives radiopacity.

**Types of Root Canal Sealers:**

1. Zinc oxide-eugenol based cements:
   (a) Rickert sealer: can cause tooth staining (silver particles). The silver is added for radiopacity, so removing all cement from the access cavity would prevent this unfavorable property\(^3\).
   (b) Roth’s Sealer: Non-staining formula developed by Grossman in 1958\(^4\).
   It meets most of Grossman’s requirements for sealers.
   (c) TubliSeal: Non-staining sealer marketed as a 2 paste systems.
It is quick and easy to mix.
(d) Wach's Cement: Smooth mix, but the liquid gives an odor of an old-time dental office.

Medicated Variations of ZOE Cements:
(a) In USA: N2, RC2B, While in Europe: SPAD, Endomethasone.
These sealers contain formaldehyde as an antibacterial agent.
(b) Nogenol: was developed to overcome the irritating quality of eugenol.

2. Calcium hydroxide containing cements:
First advocated by Luebke & Ingle in 1976:
(a) CRCS: (Calcobiotic Root Canal Sealer) CaOH has been added to ZOE sealer for its osteogenic effect; it takes 3 days to set fully.
(b) SealApex: 2 paste systems, it takes 3 weeks to reach a final set.
(c) Life: It is a liner and capping material & suggested to be used as a sealer.
(d) Apexit: Seals better than SealApex.
(e) Vitapex: It contains 40% iodoform (bactericide)
(f) MCS: (Medicated root canal sealer) It is an Iodoform containing sealer.

3. Epoxy resin based cements:
(a) Diaket: It is first introduced in 1951 as a resin reinforced chelate. It is very tacky material.
In a recent dye penetration study, showed the sealing ability of Diaket was similar to Apexit but better than Ketac Endo.
(b) AH-26: It is epoxy resin, radiopaque, low solubility, slight shrinkage and less biocompatible, but it stains the tooth structure. It is also sold as Therma Seal.
(c) AH-Plus: 2 paste systems, less tooth staining and less toxic than AH-Plus and is highly biocompatible.
(d) Methacrylate-dual cured resin sealer: Final rinse with 17% EDTA is recommended

4. Glass ionomer based cements:
(a) Ketac Endo: It is a GIC modified in its properties by a group at Temple University to be used as cement into the canal. It was introduced in Dentistry by Wilson and Kent in 1971 as a restorative material. In 1991, it was introduced as root canal sealer. It provides favorable biological, chemical & physical properties.

5. Experimental Sealers:
1. Bis GMA Unfilled Resin was tested as a sealer. It is Biocompatible but impossible to remove.
2. Pit & Fissure Sealants (low viscosity resin) have also been tried as root canal filling materials.
Removal of smear layer is a must.
3. Isopropyl Cyanoacrylate has been found adequate in sealing canals. Not accepted by the FDA.
4. Polyamide Varnish, Barrier has also been tried as a sealer. It is less effective than ZOE.
5. Dentin Bonding Agents: at the University of Minnesota, the efficacy of four different dentin bonding agents used as root canal sealers was tested.
No leakage was measurable in 75% of the canals sealed with Scotchbond, in 70% of canals sealed with Restodent, in 60% of canals sealed with DentinAdhesant and in only 30% of canals sealed with GLUMA. It seems quite probable that dentin bonding agents will play a major role in sealant endodontics.

Sealer Efficacy (Sealing):

Leakage is considered a common reason for the clinical failure of endodontic therapy. Therefore, leakage studies on sealers remain important and necessary to determine the most suitable materials and to gain more understanding of the factors influencing the sealing properties.

Hovland and Dumsha (19) stated “Although all root canal sealers leak to some extent, there is probably a critical level of leakage that is unacceptable for healing, and therefore results in endodontic failure”.

Location of Leakage:

This leakage may occur at the interface of the dentin and sealer, at the interface of the gutta percha and sealer, through the sealer itself, or by dissolution of the sealer.

Leakage studies:

Test items: radioisotopes, India ink, methylene blue or bacteria.

In choosing a sealer, factors other than adhesion must be considered: setting time, ease of manipulation, antimicrobial affect, particle size, radiopacity, tendency to staining, dissolvability and cytotoxicity.

All presently available sealers leak, but some leak more than others, mostly through dissolution.

The greater the sealer/periapical tissue contact, such as in open apex or apical perforation, the faster dissolution takes place.

1. Zinc oxide-eugenol based cements:

ZOE sealers continue to be the most popular root canal sealers, but they are just sealers and any attempt to depend on them wholly or in great part reduces long term success. Bou Degher, et al. found no significant difference in microleakage between the original Kerr pulp canal sealer and the newer EWT (Extended Working Time) pulp canal sealer.

Yared GM and Bou Degher found that pulp canal sealer gave better sealing result than Roth 801 and AH26.

2. Paraformaldehyde containing sealers: (N2, RC2B, Spad and Endomethasone)

Helps in sealing & disinfection. Sargenti claims that N2 is not resorbed from the canal but is slowly absorbed from the periradicular tissues.

Yates and Hembree found N2 is the least effective sealer when compared with Tubliseal or Diaket after 1 year. Block and Langeland reported 50 failed cases treated with N2 or RC2B.

3. Ca(OH)2 based cements: (Apexit, SealApex, Vitapex)
Helps in Sealing, & has Osteogenic , Antibacterial properties. It is postulated that CaOH as the sealer may stimulate for a sterile biological closure of the apical region.


AH26 was found to have better sealing than three other sealers; SealApex, Apexit and TubliSeal(7).

Ray and Seltzer 25 found Ketac Endo was superior to Grossman's sealer but it difficult to remove.

Ketac Endo is superior in sealing to AH26.

Roth's sealer & AH26 superior to Ketac Endo.26

Apexit & Diaket superior to Ketac.10

Friedman et al, reported a high success rate of using GIC sealer in endodontic therapy, after 6 to 18 months recall (78.3%).27

5. Dentin Bonding Agents: (Scotchbond, Metabond, All bond and GLUMA).

Mannocci and Ferrari 28 claimed sealing root canals with a combination of dentin bonding agent & AH26 were superior to AH26 alone.

Anic, et al, 29 obtained favorable sealing results when canals apexes sealed with a resin bond, followed by obturation with a composite resin condensed laterally as it was being photopolymerized in the canal with an argon laser.

Adhesive Properties of Endodontic Sealers: (Bonding to Dentin & GP)

Adhesion of endodontic sealers to dentin and gutta-percha offers clues into their interaction with the wall of the root canal and the filling material. An ideal endodontic sealer should, in part, adhere firmly both to dentin and to gutta-percha. No specific interaction either with dentin or gutta-percha is expected from the setting reaction of calcium hydroxide-based sealers and the epoxy-based sealers.

In contrast, the zinc oxide-eugenol sealer should firmly bond to dentin and gutta-percha. The setting reaction of the zinc oxide-eugenol mixtures is a chelation reaction occurring with the zinc ion of the zinc oxide. In addition, eugenol is a solvent of gutta-percha that may soften it during the setting reaction and increase bonding of sealer to gutta-percha.30

The glass ionomer sealer is known to bond to dentin but may also bond to gutta-percha, because the polycarboxylic acid of the glass ionomer may react with the zinc component of gutta-percha in a manner similar to the polycarboxylate cements that have already been used as endodontic sealers.31

1. ZOE sealers showed low bond strength to dentin (0.068 Mpa), but it gave a higher value with gutta percha (0.99 Mpa) the eugenol in the sealer reacts with ZnO in the gutta percha to create chelate bond. Also, eugenol can soften gutta percha to increase the interaction between the gutta percha and sealer (chemical union).31

2. CaOH based cements (SealApex) displayed no bonding on both dentin and gutta percha.32
3. Resin based cements (AH 26) reacted strongly with both dentin (2Mpa) and gutta percha (2.9Mpa). \(^{32}\)

4. GIC sealers (Ketac Endo) bonded to dentin (0.74 Mpa) more strongly than to gutta percha (0.14 Mpa) multiple carboxylate groups in GIC can chelate with dentin calcium. \(^{32}\)

**Mechanism of Sealing (Adhesion):**

Adhesion of a root canal sealer means its capacity to attach to the dentinal walls of the root canal provide bonding between it gutta percha. Bonding of root canal sealer is carried out through 2 mechanisms:

1. **Mechanical interlocking:** Sealer penetration (resin based) into the dentinal tubules resin tags.

2. **Chemical reaction between sealer and dentin:** The polyacrylic acid matrix of GIC contains multiple ionized carboxylate groups than can chelate with calcium in the mineral phase of dentin. \(^{32}\)

**Factors Affecting Sealing:** \(^{26}\)

1. Adequate flow properties.

2. Low sealer film thickness to reduce volumetric shrinkage during sealer setting.

Wu and Gee concluded: sealer’s film thickness is an influencing factor in the sealing quality of the root filling material.

3. No shrinkage on setting.

**Removal of smear layer:**

During the chemo-mechanical preparation of the root canal, a smear layer is produced, which is a negative factor in root canal obturation, because it is constituted by organic and inorganic material located on the interface between the root canal walls and the sealing material and weakly attached to them. Thus, it interferes in the adhesion of the sealing material to the root canal walls. \(^{34}\)

Removal of smear layer enhances adhesion of endodontic sealers to root canal walls. \(^{33}\)

Conditioning solutions and/or weak organic acids are required to get clean dentin surface for higher bond strength of the cement to the root canal walls.

Eg: 15% EDTA, 35% Phosphoric acid, 6% citric acid. \(^{35}\)

Recently: Er: YAG laser: Takeda et al (37) showed the capacity of Er: YAG laser in removing smear layer. Sousa-Neto (38) reported that after Er: YAG application on dentin surface, the adhesion of Sealer 26 increased.

Bio Pure MTAD: It’s a new root canal irrigant.

Functions: 1. Smear layer removal

2. Disinfection of the root canal system.

Composition: Tetracycline, Citric Acid and Detergent.

Detergent: reduces surface tension, to allow liquid to flow deeper into the dentin of the root canal.
Citric acid: helps in removal of smear layer and Tetracycline: helps in disinfection of the root canal.  

**Tissue Tolerance (Biocompatibility):**

A biocompatible sealer should neither prevent nor hinder tissue repair, but should aid or stimulate the regeneration of injured tissues. All of commercial root canal sealers were toxic, causing extensive to moderate tissue damage, when they escape through the foramen. Some sealers are toxic when mixed; others continue to ooze noxious elements (dissolution of sealer).  

1. **Zinc oxide-eugenol based cements:**

Chisolm introduced zinc oxide and oil of clove cement to dentistry in 1873.  

Classifying the ZOE sealers from worst to best:

Grossman's and Rickert are followed by Watch's and TubliSeal, SealApex, CRCS, and finally Nogenol.  

While at Loma Linda University, TubliSeal was found the least toxic followed by Wach’s and Grossman’s.  

At the University of Connecticut, researches found TubliSeal to be non-toxic at all experimental levels.  

In marked contrast, a Greek group reported in vivo studies showing TubliSeal exhibited severe inflammation and necrosis.  

Erausquin J, Muruzablal M. concluded pure ZOE cement was highly irritating to the periradicular tissue and caused necrosis of the bone and cementum. The same authors reported Grossman's sealer and N2 provoked severe inflammatory reactions, and Rickert's sealer caused moderate cell infiltration.  

The irritating potential of zinc oxide eugenol based cements is referred to the unique chemical composition of such sealers. Eugenol is a major cause of toxicity, but it is not the only irritating factor.  

Das found zinc oxide to be quite toxic. Meryon reported that the cytotoxicity of ZOE based sealers may be attributed more to the possible toxic effect of zinc ions. Eugenol is not only toxic but neurotoxic as well. Adding CaOH to the mixture decreases the irritating effect. Excluding Eugenol (Nogenol) helps in reducing toxicity.  

2. **Calcium hydroxide based sealers:**

An extensive study in Venezuela found that CRCS was the least cytotoxic against human gingival fibroblasts, followed by Endomat and AH26. Another study of calcium hydroxide based sealers found that with SealApex no inflammatory occurred, whereas with CRCS a moderate inflammatory infiltrate occurred. Inflammation of the severe type accompanied Apexit.  

3. **Paraformaldehyde containing sealers:**

(N2, RC2B, SPAD and Endomethasone)  

It contain 6.5% paraformaldehyde which is considered to be highly toxic.  

Recently, Septodent (France) developed Endomethasone N (no Paraformaldehyde), the cytotoxic effect of this product is 30 times lower than the classic product, and it is less toxic than AH26, TubliSeal or CRCS.
4. Resin based sealers:
AH 26 & Diaket: both were less toxic than ZOE sealers. AH 26 found to be the most toxic of resin tested. While US Navy study found AH26 the least toxic. AH26 was found to have a moderate toxic effect and Diaket a markedly toxic effect.
AH Plus was compared with its original product. AH-26, in an in vitro test, caused only slight or no cellular injuries, and did not cause any Genotoxicity or mutagenicity.

5. Glass Ionomer based sealers:
Ketac Endo demonstrated a very biocompatible material.

Antimicrobial Activity:
It is mainly attributed to the contents of some sealers (Paraformaldehyde, Eugenol and thymol) helps in destroying bacteria, but causes damage to the periradicular tissue. This activity plays an important role in the antimicrobial efficacy of such sealers.

Grossman tested 11 root canal sealers and he concluded: all sealers showed antibacterial activity to a varying degree. Initially it is potent, and then starts to diminish gradually. Grossman's sealer had the greatest antibacterial activity, but AH 26 was very effective against Bacteroids.

AH 26 was also found to have strongest antibacterial activity. The Dundee University demonstrated a descending order for sealers according to their antibacterial activity, Grossman's sealer, Ketac Endo, TubliSeal, Apexit and SealApex.

Mickel and Wright also found Roth Sealer to be more bactericidal than the calcium hydroxide sealers and attributed the effect to the concentration of eugenol.
N2 containing formaldehyde and eugenol proved to be the most effective against microorganisms. The extreme antimicrobial potency of this root canal sealer must be weighted against its pronounced tissue toxic effect. CaOH containing cements provide an alkaline medium which inhibit bacterial growth.
Recently Iodoform has been added to the content to double the antibacterial effect (Vitapex).

Conclusion:
In choosing a sealer, find a sealer can: Seal the canal totally. Well tolerated by periradicular tissue. Inhibit microbial growth.

References
6. Crane DL, Heuer MA, Kaminski EJ, Moser JB. Biological and physical properties of an


45. Kolokuris I, Beltes P, Economides N, Viemmas L. Experimental study of the biocompatibility of a new glass ionomer


50. Mickel AK. Wright ER. Growth inhibition of Streptococcus anginosus by three calcium hydroxide sealers and one zinc oxide eugenol sealer. JOE 1999; 25:34.


Citation: D’Souza L Henston, Sharma N, Chander S, Singh S, D’Souza R. Root canal sealers and its role in successful endodontics – A review. Annals of Dental Research 2012; 2 (2):68-78