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Review

*Corresponding author
Harpreet Singh, MDS
Associate Professor
Department of Conservative Dentistry & Endodontics
Gian Sagar Dental College and Hospital, Ramnagar, Patiala-140401
Punjab, India
Tel. 91-9815493618
E-mail: hsgentledental@gmail.com

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"Endodontic Sealers": Current Concepts and Comparative Analysis

Harpreet Singh[1*], Sheenam Markan[1], Mandeep Kaur[1] and Gaurav Gupta[2]

[1]*Department of Conservative Dentistry & Endodontics, Gian Sagar Dental College and Hospital, Patiala, India*

[2]*Department of Prosthodontics, Guru Nanak Dev Dental College, Sunam, India*

ABSTRACT

The main aim of root canal therapy is the removal of microbial contaminants in conjunction with the total closure of the root canal system. Root canal sealers along with solid core material plays a major role in achieving the three dimensional sealing of the root canal system. These sealers are binding agents which are used to adapt the rigid gutta-percha to canal walls and to fill up the voids, accessory canals and irregularities within the canal. Root canal sealers, although used only as adjunctive materials in the obturation of root canals, have been shown to influence the outcome of endodontic treatment. A perfect combination of sealing ability and biocompatibility is what an ideal root canal sealer should possess. This article discusses the current concepts in the usage of different sealers in endodontic therapy and their comparison in order to draw some clinical inferences.

KEYWORDS: Endodontics; Root canal treatment; Sealers.

INTRODUCTION

Root canal therapy depends on integrally related root canal treatment phases: microbial control, cleaning and shaping, and effective sealing of the root canal system. The success of each depends on the execution of the final phase.[1] Endodontic filling materials may be considered true implants as they touch and are based in vital tissues of the body.[2] The main components of a root filling are: a solid core material and a sealer. The most commonly used core material is Gutta-percha, which occupies bulk of the canal space while the root canal sealer fills the interface between the core material and the dentin wall, the voids inside the core material and the accessory canals and also serves as a lubricant, thus helping to obtain a fluid tight seal.[3]

Ideally, the root canal sealer should be capable of creating an effective bond between the core material and the dentine of the root canal thus preventing leakage. It should also be non-toxic and preferably have a positive effect on the healing of periapical lesions.[4]

A great variety of endodontic sealers are available commercially and they are divided into different groups according to their chemical composition. It is a well known fact that three dimensional impervious obturation of the root canal system is of prime clinical importance for the long-term success of endodontic treatment.

At present epoxy resins based sealers possess very good physical properties, excellent apical sealing and ensure adequate biological performance. However, the creation of most desired 'Three dimensional obturation' seems to get hampered by the general lack of chemical union between the polyisoprene component of gutta-percha cone and the components of endodontic sealer.

Although predictable clinical results have been reported with the use of these non-

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bonding root canal sealers, there has been a continuous quest for alternative sealers or techniques that bond simultaneously to canal wall dentin as well as filling materials. These bondable root canal sealers are getting popular these days because of their property of creating monoblocks within the root canal space.[5]

The term monoblock refers to the scenario wherein the canal space becomes perfectly filled with a gap-free, solid mass that consists of different materials and interfaces, which improves the seal and increases the fracture resistance of the filled canals. The most recently introduced self-adhesive type bondable root canal sealers are also associated with the additional benefits of reduced application steps and being user friendly.[5]

This review article attempts to compile information on various new generation root canal sealers which are advocated to be superior to their contemporary counterparts and also compare their properties.

CLASSIFICATION OF SEALERS

Before we discuss the new generation of sealers, let us have an overview of the ones available to us for clinical use. Endodontic sealers have been historically classified in various ways such as: according to eugenol content; usage; absorbance, etc.[6-12] A comprehensive categorization of the endodontic sealers has been provided in table 1 according to their composition.

ROOT CANAL SEALERS	BRAND NAME
1. Zinc Oxide Eugenol based sealers	Roth sealer Kerr PCS Procoseal Endomethasone
2. Epoxy resin based sealers	AH Plus AH 26 Top Seal 2- Seal
3. Silicon based sealers	RoekoSeal Gutta flow
4. MTA based sealers	Endo-CPM-Sealer MTA Obtura ProRoot Endo Sealer MTA fillapex
5. Calcium-silicate-Phosphate based bioceramic sealers	Endosequence/iRoot SP iRoot BP Bioaggregate
6. Methaacrylate resin based sealer	First generation- Hydron Second generation- EndoREZ, Realseal Third generation- Epiphany, Fibrefill Fourth generation- Realseal SE, Metaseal SE, Smartseal
7. Calcium-phosphate based sealers	Capseal I Capseal II

Table 1: Categorisation of Endodontic sealers according to their composition.

RECENT ENDODONTIC SEALERS

ProRoot Endo Sealer

It is an experimental calcium silicate-based root canal sealer that is designed to be used in conjunction with a root filling material in either the cold lateral, warm vertical or carrier-based filling techniques. The major components of the powder component are tricalcium silicate and dicalcium silicate, with the inclusion of calcium sulphate as a setting retardant, bismuth oxide as a radiopacifier and a small amount of tricalcium aluminate. The liquid component consists of a viscous aqueous solution of a water soluble polymer. Similar to other tricalcium silicate and dicalcium silicate-containing biomaterials, the sealer produces calcium hydroxide on reaction with water.[13]

Herbal Sealer (Biosealer)

It is an experimental root canal sealer based on Copaifera multijuga oil-resin. Trees belonging to the genus Copaifera are distributed around northern South America, mainly in the Amazon Rainforest. It is one of the most popular and promising phytomedicines used in Brazil. The powder is composed of zinc oxide, calcium hydroxide, bismuth subcarbonate, natural resin (rosin) and borax, and the liquid is purified Copaifera multijuga oil-resin.[14]

Nanoseal plus root canal sealer

A common cause of failure of root canal treatment is due to the inability to seal the accessory canal in most cases. One of the newest update in endodontics is the development of the first endodontic sealer based on nanotechnology which actively seals the tiny gaps thereby reducing the infection. It is made up of calcium phosphate hydroxyapitite nanoparticles range from 40-60 nm. The rod shaped active nanoparticles can penetrate the dentinal tubules & enter accessory canals to ensure that all the spaces are effectively sealed.[15]

Hybrid root seal

It is a commercially available fourth generation self-adhesive dual-cure sealer, available in the powder-liquid form. It is an insoluble, radiopaque material that can be used either with resilon or Gutta-percha. The liquid comprises of 4-META, monofunctional methacrylate monomers and photo-initiators, while the powder consists of a mixture of zirconia oxide filler, silicon dioxide filler and polymerization initiators. 4-META is able to promote monomer diffusion into the acid-conditioned and underlying intact dentin and produces functional hybridized dentin with polymerization.[16,17] The formation of the hybrid dentin is the major mechanism of bonding and also the high quality hybridized dentin resists acidic challenges.[18] However, polymerization shrinkage is inherent to methacrlyate resin-based sealers that tend to produce debonding at the resin-dentin interface.

Gutta flow 2 sealer

This is a modification of the original Gutta flow sealer which was available in the cartridge form. The excellent flow of this material made it the sealer of choice. However, the larger armamentarium required was a drawback. Of late, Gutta Flow 2 has been introduced which is available in the syringe form and has an excellent property of slight expansion after mixing which helps in better sealing.

iRoot SP/EndoSequence BC sealer

The manufactures of these sealers claim the ability to form hydroxyappetite during the setting process and ultimately create a chemical bond between dentinal wall and the sealer.[19,20] These are convenient, premixed, ready-to-use, injectable white cement paste developed for permanent root canal filling and sealing applications. These are insoluble, radio opaque and aluminium free material based on a calciumsilicate composition, which requires the presence of water to set and harden. Dentin is composed of approximately 20% (by volume) of water and "iRoot SP" uses this water to initiate and complete its setting reaction.[21] It exhibits potent antimicrobial action, excellent biocompatibility, and significant stimulation of periodontal regeneration and is osteoconductive. These sealers are also termed as Bioceramic sealers in general.

THE CONCEPT OF MONOBLOCK

The term monoblock literally means a single unit. Franklin R. Tay first described the concept of monoblock in endodontics.[22]

Primary monoblock

It has only one interface that extends circumferentially between the material and the root canal wall. A classic example of primary monoblock would be obturating the root canals with gutta percha, without using the sealer. Use of Hydron sealer alone is another example of this concept. The lack of sufficient strength and stiffness is the major drawback and this led to the development of Secondary monoblocks.

Secondary monoblock

Secondary monoblocks are the ones having two circumferential interfaces, such as one between the cement and dentin and the other between the cement and the core material. A classic example would be the use of sealer for obturation, wherein one interface is between Gutta Percha point and sealer and the the second one between the sealer and root canal wall.

Interest in utilizing the monoblock concept for reinforcing the root canal space was got resurfaced in around 2004 with the advent of bondable root filling materials that were launched as alternatives to conventional gutta-percha as obturating materials.

Resilon, a bondable root filling material which falls into this category, may be used for either lateral or warm vertical compaction techniques. As Resilon is applied using a methacrylate-based sealer to self-etching primer treated root dentin, it contains two interfaces, one between the sealer and primed dentin and the other between the sealer and Resilon, and hence may be classified as a type of secondary monoblock.

Tertiary monoblock

Tertiary monoblocks are the ones having an additional third circumferential interface between the bonding substrate and the abutment material. Fiber posts that contain either an external silicate coating or those that contain unpolymerized resin composite for relining root canals that are too wide or not perfectly round for the fitting of conventional fiber posts may be considered as tertiary monoblocks. Tenax Fibre post (Coltene) have a specific resin coating on its surface, which when cured with dual cure resin ParaCore (Coltene) forms a typical Teriary monoblock: with one interface between the fibre post and the resin coating; the second one between the resin coating and the luting cement; and the third one between the luting cement and the root canal wall.

Another product that falls into this category is the EndoRez system (Ultradent), in which the conventional gutta-percha cones are coated with a proprietary resin coating.

EVALUATION AND COMPARISON OF VARIOUS ENDODONTIC SEALERS

Orstavik has listed the various evaluation parameters for testing endodontic sealers. They include technologic tests standardized by the ADA/ANSI in United States, and the ISO internationally. These technological tests include flow, working time, setting time, radio opacity, solubility and dimensional change following setting.[2]

Leakage

Leakage continues to be a major reason for failure in root canal therapy. Ideally, a root canal filling material should provide a barrier that prevents bacterial ingress from the oral cavity.[23] Compared with zinc oxide-eugenol sealers, methacrylate based resin sealers were found to be more effective in sealing.[24] Using a fluid-transport method, Tunga and Bodrumlu concluded that Epiphany and Resilon leaked significantly less than gutta-percha and AH-26.[25] In bacterial leakage tests Epiphany and Resilon were superior to gutta percha and various other sealers.[26] The Resilon/Epiphany system is reported to establish an immediate coronal seal after light curing of the dual-cured sealer at the canal orifices.[27] An immediate coronal seal is clinically advantageous because there are situations in which filled root canals might be exposed to the oral environment and subject to

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bacterial recontamination.

Weller et al suggested that the newly introduced calcium silicate based Pro Root Endo Sealer is comparable in sealing quality to the epoxy resin-based sealer and seals better than the ZOE-based sealer after immersion in phosphate containing fluid.[28] Moreover, Pro Root Endo Sealer exhibits amorphous calcium phosphate-like phases that spontaneously transform into apatite-like phases after immersion in the phosphate- containing stimulated body fluid. This phenomenon probably accounts for the *in vitro* bioactivity of this calcium silicate-based sealer (Huffman et al).[13]

Biocompatability

One of the principal requirements of an endodontic root canal sealer is that it should be non-cytotoxic and immunologically compatible with peripheral tissue.

The biocompatibility and antimicrobial activity of a specific root canal sealer remains one of the principal considerations for selecting an appropriate sealer for a dental restoration.[29] It has been demonstrated that sealer material based on zinc oxide-eugenol release potentially cytotoxic concentrations of eugenol. Calcium hydroxide-based sealers promote calcification but tend to dissolve overtime and compromise the endodontic seal. A new calcium hydroxide-based sealer, Acroseal appears to have lower solubility than other calcium hydroxide sealers, probably because of its epoxy resin component. Glass ionomer sealers may bond tooth structure but also may activate the release of prostaglandins in periapical tissues.[30]

Spangberget et al noted that the AH26 releases formaldehyde following component mixing that reaches a maximum rate two days after mixing. Formaldehyde release from curing endodontic material has been recognized for many years, formaldehyde being reputed to act as a disinfectant.[31] The disinfective agent in AH26 is methenamine, which is hydrolyzed to ammonia and formaldehyde.[32] The efficacy of long-term disinfection of canal by formaldehyde released from a root canal sealer has previously been shown to be low.[33] There have been case reports of adverse reactions such as paraesthesia of the inferior alveolar nerve attributed to the formaldehyde released from root canal sealers.[34]

Scarparo et al found that Methacrylate resin-based sealers brought about greater quantities of macrophages.[35] Studies have shown that the Epiphany root canal sealer was the only material that presented intraosseous biocompatibility among the resin based sealers.[36]

Newer generation of sealers such as iRoot SP have shown a promising biocompatibility owing to their composition.

Flow

It has been found that the flow depends on particle size, temperature, on the internal diameter of the tubes and the rate of insertion of materials.[2] Orstavik rated the flow of Tubliseal to be better than that of Kerr sealer, which was better than Diaket and Kloroperka NO. He also stated that flow properties may be affected by changes in the powder to liquid ratio.[2] Studies have shown that Tubliseal EWT had a thinner film thickness among the conventional zinc oxide eugenol sealers. Increased strain rate gave a significant increase in the flow rate of all sealers. Other studies concluded that among the medicated sealers Endomethasone did not confirm to ISO specification.[37]

Sealers such as Gutta flow 2 have an excellent flow which helps in better sealing. On the other hand improvements are still going on to make the flow of Bioceramic sealers better for clinical usage.

Bond strength

Root filled immature roots or roots that are otherwise weakened internally run a greater risk of fracture. With the introduction of adhesive filling techniques, attempts have been made to strengthen such teeth through reinforcement of the coronal part of the root by composite cements and fillings. More recently, this concept has been taken further by attempting to reinforce the whole root canal system *via* an adhesive filling and integrated resin core (Resilon).[38]

Souza SFC et al concluded that Epiphany had higher flow, polymerization stress and lower bond strength values to dentine than AH Plus.[39] Other study concluded that the 980 nm diode laser irradiation of root canal dentin increased the bond strength of AH Plus sealer, but did not affect the adhesion of Epiphany sealer. Among the methacrylate based sealers the self adhesive sealers exhibited higher push out bond as compare to the non-etching sealer.

Newer Bioceramic sealers such as Endosequence possess very high bond strength with the dentin walls. This, to begin with, seems highly advantageous but can serve to be a limitation in the long run as retreatment in such cases would be highly difficult.

Antibacterial activity

Current concepts of root canal sealer functions do not emphasize on its antimicrobial activity as its primary function, but it is well recognized that most sealers in current use exhibit some such properties. With increased emphasis on improving procedures for disinfecting the root canal system, this particular property may be more appreciated in the future. Studies have concluded that among the resin based sealers EndoRez did not show any antimicobial activity. Kayaoglu G et al found that AH

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Plus and Grossman's sealer were effective in reducing the number of cultivable cells of E. faecalis while Calcium hydroxide-based sealers, Sealapex and Apexit were ineffective.[40]

The new generation sealers are also claiming their antimicrobial efficacy of a broader spectrum. However, higher levels of research are required to evaluate the long term antibacterial activity of these sealers, *in vivo*, before any final conclusions can be drawn.

CONCLUSION

The degree of endodontic success is directly proportional to a clinician's knowledge of the root canal anatomy and the techniques selected while performing treatment. Properly performed endodontic therapy is the cornerstone of restorative and reconstructive dentistry. Three-dimensional sealing of the root canal is one of the main goals of endodontic treatment to prevent the reinfection of the canal and for preserving the health of the periapical tissues, thereby ensuring the success of root canal treatment. Thus, several types of endodontic sealers have been recommended to achieve this goal. It is important to note that not only the apical seal of the root canal but the coronal seal is of equal importance for the success of endodontic treatment. Ideally, further directions should focus on materials that penetrate the patent dentinal tubules, bind intimately to both organic and inorganic phases of dentin, neutralize or destroy microorganisms and their products, predictably induce a cemental regenerative response and strengthen the root system.

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