RESIN BASED ENDODONTIC SEALERS - CURRENT CONCEPTS.

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Abstract:

Ever since the introduction of resin bonding in dentistry, researchers are in the quest of alternatives to conventional techniques of obturation to attain a fluid-tight seal. In the recent years several resin based root canal sealers have been introduced as an alternative to conventional gutta-percha and zinc oxide eugenol based techniques to bring in a simplified obturation technique. The objective of this review is to provide information about epoxy resin based sealers and the recently introduced methacrylate resin based sealers on the basis of currently available data.

***Key words**: Periapical lesions, Ultrasound, Color Doppler, Vistascan, Diagnosis*

Introduction:

Complete filling of the prepared root canal system is an important component of successful root canal treatment. It is well understood that when filling root canals with a solid core material, some form of cement is required for a fluid tight seal that fills the minor gaps between the core material and the dentinal walls of the canals to prevent leakage. Sealers play an important role in sealing the root canal system with entombment of remaining microorganisms and filling of inaccessible areas of prepared canals.

Synthetic resins have been used as root filling materials for many decades. The most successful resin-based sealers are the AH series, which was developed more than 50 years ago.[1] Even though predictable clinical results have been achieved with the use of non-bonding root canal sealers, there has been a quest for alternative sealers or techniques that bond simultaneously to canal wall dentin as well as filling materials.

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Methacrylate based resin sealers are new in Endodontics and are derived from polymer chemistry technology initially developed for adhesive restorative dentistry, albeit in modified formulations and viscosities as determined by specific demands in endodontics.[2] This genre of bondable root canal sealers have been aggressively promoted with the highly desirable property of creating monoblocks within the canal space.

The term monoblock refers to a scenario wherein the canal space becomes perfectly filled with a gap-free, solid mass that consists of

different materials and interfaces with the

purported advantages of simultaneously improving

the seal and fracture resistance of filled canals[3].

Classification of Resin Based Sealers:

Resin based sealers can be classified as:

- Ketac resin based sealers
- Epoxy resin based sealers
- Methacrylate resin based sealers

Ketac Resin Based Sealers:

- Diaket:

It is a polyvinyl resin (polyketone) introduced in Europe by Scheufele in 1952. The sealer consists of a fine, pure white powder and a viscous, honey-colored liquid. Two drops of liquid are mixed with one scoop of powder.

Properties:

1. It is difficult to manipulate
2. It has got good adhesion
3. It has got low solubility and superior tensile

strength

Disadvantages:

1. Setting is adversely affected in the presence of small amounts of camphor or phenol intracanal medicaments
2. It is highly toxic and causes extensive tissue necrosis.
3. When gross overfilling was present, “modification of the apical cementum and alveolar bone occurred.
4. Diaket showed a tendancy towards fibrous encapsulation if extruded.

Epoxy based resin sealers:

- AH-26
- AH-Plus
- EZ-Fill

Epoxy resin sealers have an established record in endodontics, especially in the form of AH-26 and its successor AH Plus. This group of sealers is well established as effective root canal sealers, displaying acceptable biocompatibility, insolubility and dimensional stability. AH 26 and AH Plus are classic examples with proven track records over many years of clinical use.[4, 5]

AH-26:

AH-26 is a bis-phenol epoxy resin recommended by Schroeder in 1957. The sealer derives its name from:

A-Aethoxylinharz (German) for ethoxyline base

H-Hexamethylene tetramine

26-Test/Batch Number

Powder	Liquid
Bismuth Oxide Hexamethylene Tetramine Silver Powder Titanium Oxide	Bisphenol diglycidyl ether

Table 1:

The setting time of the sealer is 36 to 48 hours at body temperature and 5-7 days at room temperature.

The methenamine present on the sealer for polymerization will give off some formaldehyde as it sets, this being one of its drawbacks. The highest amount of formaldehyde is in the freshly mixed sealer, and the amount of formaldehyde released goes down after 48 hours and after two hours the amount is insignificant.

AH 26 produces greater adhesion to dentin especially when smear layer is removed.

AH Plus:

AH Plus is an Epoxide-Amine resin pulp canal sealer, developed from its predecessor AH 26.

The amines present in the sealer allow for polymerization without the unwanted formulation of formaldehyde but with all the advantages of AH 26 such as increased radiopacity, low solubility and slight shrinkage upon setting as well as outstanding long-term dimensional stability, good sealing properties and tissue compatibility.

AH Plus sealer is known for its excellent sealing properties and is considered as the gold standard against which all new sealers and bondable root canal obturation materials must be compared.6

AH Plus comes as a two paste system, unlike the powder liquid system if AH 26.

Paste A	Paste B
Bisphenol-A epoxy resin Bisphenol-F epoxy resin Calcium tungstate Zirconium oxide Silica Iron oxide pigments	Aminoadamantane Dibenzyldiamine Tricyclodecane-diamine Calcium tungstate Zirconium oxide Silica Silicone oil

Table 2:

The addition of 5 percent calcium hydroxide led to the development of a low viscosity material, as well as it provide more alkaline pH and calcium release which lead to improved biological and microbiological behavior, as a more alkaline pH favors the deposition of mineralized tissue and exerts an antimicrobial action.7

AH Plus has a working time of 4 hours and a setting time of 8 hours.

AH Plus sealers are generally placed in the canal without any dentin preparation or dentin adhesive

and can be used with any obturation technique. Their popularity has been due, in part, to the fact that they contain no eugenol, which inhibits the polymerization of resins and can interfere with bonding.

Is a noneugenol epoxy resin sealer that is placed with a bidirectional spiral, rotating in a handpiece, used with a single gutta-percha point technique. The spiral is designed to spread the sealer laterally in the apical region of the canal. It is reportedly non-shrinking on setting and is hydrophobic in nature, making it resistant to fluid degradation. [5]

Important Properties	AH 26	AH PLUS
Adhesion	Good	Good
Flow	Good	Slightly thixotropic
Antibacterial property	Good, mainly due to the presence of formaldehyde	Moderate, due to the presence of bisphenol diglycidyl ether and minimal amounts of formaldehyde
Dimensional stability	High	High
Sealability	Good	Good
Radioopacity	Good	Better than AH 26 Due to the addition of new fillers such as zirconium oxide and iron oxide[8]

Table 3

Methacrylate Resin Based Sealers:

To date, Four Generations of methacrylate resin-based sealers have been introduced.[2]

- First Generation Methacrylate resin-based sealers- Hydron
- Second Generation Methacrylate Resin Based Sealer- EndoREZ
- Third Generation Methacrylate Resin Based Sealer- FibreFill, Epiphany
- Fourth Generation Methacrylate Resin Based Sealer- MetaSEAL

First Generation Methacrylate Resin-based Sealers

The first generation Hydron, appeared in the mid 1970's when scientific foundations behind dentin bonding where at their infancy stage of development.

The use of poly [2-hydroxyethyl methacrylate] (poly [HEMA]) as the major ingredient rendered the sealer very hydrophilic. Hydron was designed to be injected into a root canal and to be polymerized in situ for an en masse root filling.

The sealer came to a disastrous end and became obsolete in the 1980's because discrepancies occurred between the manufacturer's claims and laboratory/ clinical findings on its physical/chemical properties and biocompatibility. The sealer caused severe inflammatory reaction, absorption of the material, severe leakage as well as water sorption and swelling.

Second Generation Methacrylate Resin-based Sealers

The second generation of a bondable sealer is non etching and hydrophilic in nature and does not require the adjunctive use of a dentin adhesive.

EndoREZ (Ultradent Products Inc, South Jordan) is a dual- cured radioopaque hydrophilic methacrylate sealer that might be used in a wet environment of the root canal system and is very effective in penetrating the dentinal tubules and adapting closely to the canal walls.

EndoREZ:

EndoREZ (ER) is a hydrophilic, two component (base and catalysts), dual-curing self-priming sealer. The formulation can be described as follows:

Composition

	Catalyst Paste
A bismuth compound as the radio opaque filler, small amounts of other fillers, di urethane methacrylate triethylene glycol dimethacrylate, a peroxide initiator and a photo initiator	A bismuth compound as the radiopaque filler, small amounts of other fillers, diurethane dimethacrylate and triethylene glycol dimethacrylate.

Table 4:

Important Properties:

- Adhesion:

Coating of Guttapercha cones with a polybutadiene-diisocyanate methacrylate adhesive ensures the presence of a hydrophobic portion that is chemically compatible with the hydrophobic polyisoprene substrate and a hydrophilic portion that is chemically compatible with a hydrophilic methacrylate resin.

With the use of this adhesive resin coating, a strong chemical union is achieved between

the gutta-percha and the methacrylate resin–based sealer. This thermoplastic resin-coated gutta-percha cone is recommended for use with the EndoREZ system.

When considering that the interface between the gutta-percha resin coating and the resin sealer is the only truly bondable interface in this system, this interface is a weak link that failed during polymerization shrinkage of the sealer.

The chemical union between the polyisoprene component of the gutta-percha and the polybutadiene end of the resin coating molecule appears to be stronger than the coupling between the methacrylate end of the molecule to the resin sealer.

Removal of the oxygen inhibition layer from the surface of the resin-coated gutta-percha cones during packaging has been hypothesized for their weak adhesion to the methacrylate resin-based sealer, resulting in the frequent delamination of the sealer after root canal obturation.

Hirashi et al attempted to improve the shear strength of the resin coated gutta-percha to the EndoREZ sealer by generating active free radicals for chemical coupling via in situ application of a dual cured dental adhesive to the resin-coated guttapercha. They observed a 5 fold increase in the shear strength after adhesive application, with complex interfacial failures instead of complete sealer delamination from the resin coating.[9]

The use of dual cure self etch adhesive helps create both intertubular hybridization and intratubular retention which improves the adhesive strength of EndoREZ to dentin. An intracanal brush can be used to coat the walls of the canal, followed by wetting of the canal space with the master cone.

This technique enables simultaneous coating of the proprietary resin coated master cone with the bonding component of the adhesive to generate “Active Free Radicals” for chemical coupling of the cones to the EndoREZ sealer.[9]

- Antibacterial property:

EndoRez demonstrated strong antibacterial effect against E. faecalis throughout the 7-day testing period, and all bacteria were killed during 5–20 minutes of contact with the sealer. Slow setting, elution of non reacted monomers, and the lowest pH (below 4) are probably important for the continuing antibacterial effect of EndoRez.[10]

Third Generation Methacrylate Resin Based Sealers

- FibreFill Root Canal Sealers:

Third generation methacrylate resin-based sealer that is designed for filling canals with fiber-reinforced obturators that are attached to thermoplastic root filling material tip.

Composition
UDMA, PEGDMA, HDDMA, Bis-GMA resins with silane-treated barium borosilicate glasses, barium sulphate, calcium hydroxide and initiators.[2]

Table 5:

The Fiberfill obturator is a resin and glass-fibre post with a terminal gutta-percha tip.

The resin sealer is used in combination with a self-cured, self-etching primer (Fibrefill Primer A and B). Bonding between adhesive systems and dentin depends on the penetration of monomers into the conditioned dentin surface to create micromechanical interlocking between the dentin collagen and resin, forming a hybrid layer.[11]

Fibrefill is reported to have good sealing and adhesion properties to radicular dentin.[12]

Epiphany Sealer: [Real Seal]

Epiphany (Pentron Clinical Technologies) or Real-Seal (Sybron Endo) is a sealer that contains designed for use with polycaprolactone core materials.

Urethane dimethacrylate (UDMA), Poly(ethylene glycol) dimethacrylates (PEGDMA), Ethoxylated bisphenol-A-glycidyl-dimethacrylate (EBPADMA), Bisphenol-A-glycidyl-methacrylate (BisGMA) resins Silane-treated barium borosilicate glass Barium sulfate, Silica, Calcium hydroxide, Bismuth oxychloride with amines, Peroxide, Photoinhibitor and Pigments.

Table 6:

Sodium Hypochlorite may negatively affect the bond strength of the primer, so after the use of sodium hypochlorite for irrigation, one should irrigate with ethylenediaminetetraacetic acid (EDTA) and sterile water. The use of sodium hypochlorite will leave an oxygen rich surface layer in the root canal which results in reduced bond strength.

Peroxide containing lubricants might also have a retarding effect on the resins, so a final rinse with EDTA and sterile water is recommended after using these lubricants.

Chlorhexidine does not affect the bond strength. When obturation is completed, the coronal surface may be light cured for 40 seconds to create a coronal seal.

Important Properties:

- Antimicrobial property:

Epiphany Sealers showed minimal antimicrobial activity. Due to the hydrophilic nature of the sealer it absorbs water and releases free (unreacted) monomers which might stimulate the growth of bacteria.[13] However, in recent times it has also been shown that Epiphany has got some amount of antibacterial activity.[14]

- Toxicity:

The toxicity of Epiphany may be explained by the presence of unpolymerised hydrophilic monomers (such as HEMA) that can easily diffuse into the cell-culture medium and elicit significant toxicity. Epiphany requires body temperature and total elimination of air contact to polymerise.15

The extrusion of a methacrylate resin based sealer through the periapical foramen would create an uncured surface layer for extended time periods which might alter the toxicity profile of the sealer as it hinders tissue repair.[12]

- Sealing ability:

Epiphany has got excellent sealing ability which may be attributed to its integrity which is provided by the adhesion of Resilon core material to the epiphany sealer and in turn the Epiphany sealer's adhesion to the dentinal walls in the root canal system.

Fourth Generation Methacrylate Resin Based Sealers

- MetaSEAL:

MetaSEAL is a fourth generation self-adhesive dual cure sealer. The inclusion of an acidic resin monomer, 4-methacryloyloxyethyl trimellitate anhydride (4-META), makes the sealer self-etching, hydrophilic, and promotes monomer diffusion into the underlying intact dentin to produce a functional hybridized dentin with the polymerization.

The formation of hybridized dentin is the major mechanism of bonding and high quality hybridized dentin resists acidic challenges. The sealer purportedly bonds to thermoplastic root-filling materials as well as radicular dentin via the creation of hybrid layers in both substrates.

A recent report on MetaSEAL reported the identification of a 'hybrid layer-like structure' along the gutta-percha sealer interface.[6] The self-etching property of the sealer hybridizes the canal wall preventing leakage and bonds to gutta-percha and Resilon.

The cytotoxicity profile of MetaSEAL revealed that it remained severely cytotoxic during the first week, and eventually became non-cytotoxic.[16]

Comparative Evaluation of Methacrylate Resin Based Sealers

Due to the poor physical and chemical properties and biocompatibility problems of Hydron [First Generation Methacrylate Resin Based Sealer], it is no longer being used as a sealer.

Properties	Second Generation	Third Generation	Fourth Generation
1. Radioopacity	Good[17]	Good[17]	Good
2. Shrinkage, Solubility & Expansion	High shrinkage values of 7.81%, Solubility-3.72% and Expansion-6.84% [18]	Shrinkage values of 4.47% and 3.57%, Solubility- 4.02% and Expansion-8.1% [18]	
3. Setting Time	20-25 minutes	23-26 minutes	8-10 minutes
4. Flow and Film Thickness	Confirmed to ADA standards	Confirmed to ADA standards	Confirmed to ADA standards
5. Adhesion	Good, can be improved by coating the cones with an adhesive	Good	Bonds well to the filling material as well as radicular dentin via the creation of hybrid layer in both the substrates[6]
6. Antibacterial property	Strong antibacterial effect against certain microorganisms[13]	Good antibacterial property[10]	

Table 7:

Conclusion:

It is anticipated that Methacrylate based-resin sealers will continue to appeal to the dental profession.

Bonding in endodontics is gaining recognition and the goal of being able to bond a canal from the minor constriction to the canal orifice to the occlusal surface is definitely a desirable one.

After a thorough review of the available data and despite the contradicting ex vivo and in vivo tests, it seems that MBRS are here to stay. EndoREZ and Resilon are now being used successfully, about 10 years after their inception. The only conclusive evidence is long-term clinical success. Therefore more long-term data are needed to determine whether they will eventually replace conventional sealers or will be used in parallel as an alternative choice when filling root canals.

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