Root canal sealers

with love

Proud To Be Dentist

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References

- Pathways of the pulp, Cohen (8th edition)
- Endodontics, Ingle (5th edition)
- Endodontic therapy, Weine (6th edition)
Introduction

The use of sealer during root canal obturation enhances the possible attainment of an impervious seal and serves as filler for canal irregularities and minor discrepancies between the root canal and core filling material.
Requirements of root canal sealer

The ideal root canal cement should (Grossman 1940)

- provide an excellent seal when set
- should be tacky when mixed to provide adequate adhesion among it, the canal walls and the filling material
- be radiopaque so that it can be visualized in the radiograph
- be non staining
- particles of powder should be very fine so that they can mix easily with the liquid
- be dimensionally stable
be easily mixed and introduced into the canal
be easily removed when necessary
insoluble to tissue fluids
bactericidal or discourage bacterial growth
slow setting to ensure sufficient working time
tissue tolerant, that is non irritating to the periradicular tissues
should not provoke an immune response in periradicular tissues
non mutagenic nor carcinogenic
Functions of Sealer

- Cementing the core
- Germicidal
- Fills the discrepancies between the filling material and the dentin wall.
- Form a bond between the filling material and the dentin walls
- Radiopacity which discloses the presence of auxiliary canals, resorptive areas, root fractures and the shape of the apical foramen.
- Lubricant which aids in the seating of GP
Classification

ADA specification No 57 classifies endodontic filling material as follows:

Type I.

Class 1. Metallic
Class 2. Polymeric
Type II:

Class 1. Powder and liquid nonpolymerizing
Class 2. Paste and paste nonpolymerizing
Class 3. Polymer resin system
Type III

Class 1. Powder and liquid nonpolymerizing
Class 2. Paste and paste nonpolymerizing
Class 3. Metal amalgams
Class 4. Polymers
Based on their prime constituent or structure
2. Calcium hydroxide sealers: eg.: CRCS, Apexit
3. Resins: Eg. Diaket, AH26
4. Glass ionomers: Eg. Ketac-Endo
5. Silicones Eg: Lee –Endo fill
6. Gutta percha based: Kloropercha, Eucapercha
7. Dentin adhesive materials: Eg: Cyanoacrylates, dentin bonding agents, polycarboxylates
Based on the addition of medication

**Therapeutic cements**

a) supposed to aid in cementogenesis and dentinogenesis

EG: Calcium hydroxide sealers

b) Suppress post operative pain, contain strong disinfectants & antiphlogistics

Eg: Paraformaldehyde containing sealers
Based on permeability

a) Highly Permeable: Eg: Calcium phosphate, Calcium hydroxide etc

b) Moderately permeable: GIC sealers, Polycarboxylate sealers

Based on Longetivity:

a) Resorbable pastes: Eg: Iodoform pastes, Calcium hydroxide, Biocalex

b) Partially resorbable: Eg: All the other sealers
Zinc oxide – Eugenol sealers

- Chisolm introduced zinc oxide and oil of clove (unrefined eugenol) cement to dentistry in 1873.

Setting reaction:

- combination of chemical process with physical embedding of, zinc oxide in a matrix of zinc eugenolate.
- excess eugenol is absorbed by zinc oxide and eugenolate.
- hardening due to formation of Zinc eugenolate and unreacted eugenol weaken the mass
Factors influencing the setting reaction

- presence of water
- Particle size of zinc oxide
- pH
- additives
- method of preparation
- temp and humidity
- time of spatulation
- presence of unreacted eugenol
General constituents of ZOE sealers

- Mixing vehicle is eugenol
- Zinc oxide is finely sifted to enhance flow
- 1mm of ZnO has a radiopacity corresponding to 4 to 5 mm of aluminium
- Effective antimicrobial
- Cytoprotection to cells

**ROSIN:**
- derived from conifers have 90% resin acid
- Remaining parts volatile & nonvolatile components like terpene alcohol, aldehydes and hydrocarbons
- resin acids are monobasic carboxylic acids
- amphiphilic, carbon groups lipophilic, affecting the lipids in the cell membrane, increases cell membrane permeability
- strong antimicrobial effect and cytotoxicity
- reacts under certain conditions, to form resin acid salt (resinate), this is less soluble in water.

Paraformaldehyde is added for antimicrobial and mummifying action

Germicides like thymol for antimicrobial

Corticosteroids for suppression of inflammatory reactions
Rickert’s formula (Kerr Pulp canal sealer)

Developed in 1931

**Powder**

- zinc oxide powder - 41.21 parts
- precipitated silver – 30 parts
- White resin – 16 parts
- thymol iodide- 12.79 parts

**Liquid:**

- oil of cloves-78 parts
- Canada balsam – 22 parts
**Indications:**

- Vertical condensation of warm gutta percha when large bulk of sealer is needed
- when lateral canals are anticipated, for silverpoints.

**Contraindications**

has staining qualities, needs to be removed from crown.
Advantage:

Disadvantage:

Properties:
- Excellent lubrication.
- Working time of 30 min
- L:P ratio: 1:1
- Germicidal action
  Mixed with a heavy spatula until homogeneity is obtained
  Because of the presence of silver, some granular appearance remains even after spatulation.
Grossman’s formula

-Rapid setting of Rickerts formula lead to development of Grossman’s formula in 1936, known as ProcoSol radiopaque silver cement.

Powder:
- Zinc oxide - 45 parts
- Silver (precipitated) - 17 parts
- Hydrogenated resin – 36 parts
- Magnesium oxide - 2 parts

Liquid:
- Eugenol - 90 parts
- Canada Balsam - 10 parts
Precipitated silver lead to staining, lead to the development of ProcoSol nonstaining root canal cement

**Powder:**
- Zinc oxide, reagent 40 parts
- Staybelite resin 30 parts
- Bismuth subcarbonate 15 parts
- Barium sulfate 15 parts
- Sodium borate, anhydrate 1 part (extends the setting time)

**Liquid**
- Eugenol or oil of pimenta leaf
Advantages:

- Cement hardens in approx. 2 hours at 37 degrees and 100% relative humidity.
- Setting time in canal is less.
- Begins to set in root canal within 10 to 30 minutes because of the moisture present in dentin.
**Tubliseal (Kerr, 1961)**

**Base:**
- Zinc oxide – 57.4%
- Oleo resins – 21.25%
- Bismuth trioxide – 7.5%
- Oils – 7.5%
- Thymol iodide – 3.75%
- Modifier – 2.6%

**Catalyst:**
- Eugenol
- Polymerized resin
- Annidalin
Indications:
- When extreme lubrication is needed, as in slightly short master cone, before apical surgery.

Contraindications:
- Irritating to periapical tissues, not to be used if overfill probable with normal periapical tissue.
- Sets very rapidly when wet

Packaging
- Mixing: mix equal lengths to creamy consistency
Properties:
- Easy to mix
- Non staining
- Allows maximal condensation and packing
- Is white in color with good contrast
- Good lubricating qualities

Advantages:
- Ease of preparation
- High rate of flow, thinner film
Disadvantage:

- Irritating to periapical tissues, causing considerable periapical sensitivity when used on teeth where pulp was vital and the periapical tissue normal before treatment.

- Rapid set in the presence of moisture
Wach’s paste (Wach 1925-1955)

Powder:
- Zinc oxide 10g
- bismuth subnitrate -3.5 g
- bismuth subiodide -0.3 g
- magnesium oxide – 0.5g
- tri calcium phosphate-2 g

Liquid:
- Canada balsam 20 ml
- oil of cloves- 6ml,
- eucalyptol 0.5 ml
- beechwood creosote -0.5 ml.
Indications: all lateral condensation methods, especially when chance of overfilling is present. Adhesive, good for lateral compaction in small canals, softens gutta percha.

Contraindication: when heavy lubrication is needed, as with short master cone.

Advantage: smooth consistency without a heavy body. Canada balsam makes the sealer tacky.

Disadvantage: odor of liquid.
Properties

- medium working time, less lubricating qualities
- Minimal periapical sensitivity
- Increasing the thickness of sealer lessens its lubricating effect, thus when an overfilling appears possible, a maximal degree of thickness should be employed.
- Useful in small curved canals of minimal caliber,
- Has light body, so does not deflect the small master gutta percha cones used to fill these canals.
- Its is very sticky, due to Canada balsam, so paste will remain on reamer until its spun off in the apical portion,
Nogenol:

- Base is zinc oxide, barium sulfate, vegetable oil
- Accelerator is: hydrogenated rosin, methyl abietate, lauric acid, chlorothymol, salicylic acid
- Developed to overcome the irritating quality of eugenol
- Did not set hard, but remained rubbery, water sorption was high.
- More biocompatible than ZOE cements.
PARAFORMALDEHYDE ROOT FILLING MATERIALS

N2(sargenti 1973)

**Powder:**
- Zinc oxide - 69%
- Lead tetroxide - 12%
- Paraformaldehyde 6.5%
- Bismuth subcarbonate 5%
- Bismuth subnitrate 2%
- Titanium dioxide 2%
- Barium sulphate 2%
- Hydrocortisone 1.2%
- Prednisolone 0.21%
- Phenylmercuric borate 0.09%

**Liquid:**
- Eugenol
- Known as RC2B & used in sargenti technique
- Contains lead and mercury which are major systemic poisons
- Loses volume due when exposed to fluid due to presence of paraformaldehyde
- Coagulation necrosis in 3 days time, which can’t undergo repair due to formaldehyde impregnation
- Irreversibly affects nerve endings in tissue area, thereby masking inflammation process
- Paraformaldehyde is included to obtain release of formaldehyde gas for antiseptic and fixative action
- Corticosteroids for suppressing inflammatory reaction
- Lead as an oxide, which by increasing the opacity gives the illusion of the materials compactness, and contribute to the extreme hardness and slow solubility of the final set.
ENDOMETHASONE

Powder
- Di–iodothyiomol 25 g
- Trioxymethylene (paraformaldehyde) -2.2g
- Hydrocortisone acetate – 1 g
- Dexamethasone 0.01g
- Excipient 71.79 g

Liquid
- Eugenol
Riebler’s paste (Riebler)

**Powder**
- Zinc oxide
- Formaldehyde
- Barium sulfate
- Phenol

**Liquid:**
- Formaldehyde
- Sulfuric acid
- Ammonia
- Glycerin
it’s a resorcinol –formaldehyde resin
supplied as powder and two liquids

Powder:
- Zinc oxide – 72.9%
- Barium sulphate -13%
- Titanium dioxide – 6.3%
- Paraformaldehyde – 4.7%
- Hydrocortisone acetate- 2%
- Calcium hydroxide – 0.94%
- Phenyl mercuric borate 0.16%
Liquid (clear)
- Formaldehyde 87%
- Glycerin 13%

Liquid LD (red)
- Glycerin 55%
- Resorcinol 25%
- Hydrochloric acid 20%

- Equal parts of the two liquids mixed with powder.
- Essential reaction to form resin is between resorcinol and formaldehyde
An acidic pH is needed for this reaction, this is provided by HCl.

Large amount of zinc oxide is to control the pH and so prolong the setting time

inclusion of HCl is not harmful, pH at the time of mixing was 5.2 and rose to 6.2 after 2 hrs, due to the neutralizing effects of Zinc oxide

setting time of spad is 24 hrs, during this period there is free unreacted formaldehyde,

solubility of spad is 4 % after 24 hrs.
Tissue response

- Pulpal necrosis, periapical inflammations and necrosis,

Toxicologic studies

- Systemic absorption of lead and paraformaldehyde
- Heavy metal ions- disseminated throughout the body
- Irreversible damage to nerve endings - paraformaldehyde
Gutta percha based materials

Chloropercha (Moyco)
- Mixing white gutta percha 9% with chloroform 91%
- Premixed sealer
- Has no adhesive properties

Kloropercha (Nygard –Ostby)
- Powder liquid mixture
- Powder

Canada balsam -19.6
Resin – 11.8%
Gutta percha – 19.6%
Zinc oxide – 49%

**Liquid:**

Chloroform - 100%

- Zinc oxide is added to reduce shrinkage, also increases radiopacity
- Shrinkage of 7.5% is seen
- Chloroform evaporates leading to loss of volume and “dropping“ of filling into the periapical area
- Chloroform is toxic
**Eucapercha:**

- Eucalyptol is used
- Takes longer than chloroform
- Has antibacterial and anti-inflammatory action
- Segment of gutta percha held over alcohol lamp for 20 to 30 sec
- Eucapercha dissolves and turns into a cloudy mass

**Indications:** ledge formation, perforation, unusual curvatures, in cases in which the apical foramen cannot be successfully sealed
Resin sealers

AH26:
-schroder, 1957

Powder:
- Silver powder – 10%
- Bismuth oxide 60%
- Hexamethylene tetramine -25%
- Titanium oxide – 5%
Liquid:

- Bisphenoldiglyicdyl ether -100%

Packaging

Mixing:

Properties:

- Good flow
- Seals well to dentin walls
- Sufficient working time
- Toxicity in the first 24 hrs due to release of formaldehyde
Strong adhesive & contracts on hardening

Schroder – well tolerated by tissues. Tends to disintegrate into fine granules which are phagocytosed

Hardens slowly at body temperature in 36 to 48 hrs

It's not sensitive to moisture, will set under water.

Will not set if hydrogen peroxide is present
- Sets slowly in 24 to 36 hrs
- Mixed cement should be warmed on glass slab over alcohol flame to make it less viscous
- Sold world wide as therma seal

Disadvantages:
- Allergenic /mutagenic potential
- possible formaldehyde release
- silver containing
AH PLUS:

- Comes in a paste-paste system
- Added new amines to maintain the natural color of tooth
- Working time of 4 hrs, setting time of 8 hrs, half the film thickness, and half the solubility of regular AH26.
- Non mutagenic, no release of formaldehyde, radiopaque, can be used with all techniques
Diaket:

Introduced by Schmidt

**Powder**
- Zinc oxide
- Bismuth phosphate

**Liquid:**
- Dihydroxy dichlorophenylmethane
- Propionylacetophenone
- Triethanolamine
- Caproic acid
- Copolymers of vinyl acetate, vinyl chloride, vinyl isobutylether
Polyketone compound with vinyl polymers that mixed with zinc oxide and bismuth phosphate forms a adhesive sealer
Sets quickly in root canal
Volume stability is good
Solubility is low
Powder liquid ratio : 1:2
Gross overfilling caused modification of apical cementum and alveolar bone
Has a tendency to be encapsulated by fibrous capsule
Adheres well to dentin
Lee – Endo Fill

- Used as a sole material or sealer with GP
- Consists of silicone material, silicone based catalyst plus bismuth subnitrate filler
- Low toxicity
- Sets to pale pink rubbery solid
- Sole filling material: avoid using NaOCl or peroxide as they affect polymerization
Setting time is 8 to 90 min depending on the catalyst used

- Increased catalyst –increased shrinkage
- Decreased bonding to dentin if not used within 20 min of mixing
- Removed with GG drills and peeso reamers

Adv:

Non discoloring, no shrinkage upon polymerization, non resorbable, low viscosity, good adaptation, good penetration of accessory canals
Injection technique of obturating canals

- Greenberg – pressure syringe to extrude cement into a canal
- Krakow and berk popularized the idea

Hydron:
- Goldman introduced
- Rapid setting hydrophilic plastic material used as a root canal sealer without the use of a core.
- Grossman defined it as a polymer of hydroxyl-ethyl methacrylate
- Biocompatible material that conforms to the shape of the root canal because of its plasticity.
Canal must be dry, it sets in the root canal in 10 min

- Requires a special syringe and a needle
- Precaution: it is injected as an unset material and the polymers that hasten its set can cause tissue toxicity resulting in inflammation with macrophage activity.
- Can cause paraesthesia
Resorbable root filling materials:

Def: pastes which does not set after being introduced into the root canal and which is rapidly removed if forced into the periapical region. Eg: iodoform and calcium hydroxide pastes

Mynol Cement:
Powder: Zinc oxide, Iodoform, Rosin, Bismuth sub nitrate
Liquid: Eugenol, Creosote, Thymol
Walkhoff Paste

- Devised by walkhoff in 1928
- consists of 60 parts of iodoform and 40 parts of a solution containing 45 percent parachlorphenol, 49% camphor, and 6% menthol.
- commercially known as Kri paste
- Used in the walkhoff method of treatment, the paste is forced beyond the apex, irrespective of the state of the apex,
- if sinus tract is present, forced paste propelled beyond the canal until it extrudes into the sinus opening.
- in the absence of sinus tract, opening is made in the buccal cortical plate over the root apex
MAISTO’S PASTE
- Zinc oxide – 14g
- Iodoform – 42g
- Thymol-2g
- Chlorophenol  camphor- 3 cc
- Lanolin – 0.50g

VITAPEX
- Iodoform -40.4%
- Calcium hydroxide- 30.3%
- Silicone – 22.4%
Advantages over Zinc oxide eugenol pastes

- Iodoform pastes are easily resorbed from the periradicular region, cause no foreign body reaction, removal of paste occurs due to a combination of leaching, phagocytosis and direct drainage to associated lymph nodes (Barker&Lockett), whereas ZOE causes periradicular irritation.

- Paste disappears from the root canal itself, with the ingrowth of tissue into the canal.

- Bactericidal to microorganism in the root canal and lose only 20% potency over a 10 year period, ZOE – bactericidal only in presence of formaldehyde.

- They don’t set as hard as ZOE, so easy removal from the canal.
Disadvantage:

- yellowish –brown discoloration if not removed from the pulp chamber

- lead to a rise in blood level of iodine, should not be used in patients sensitive to iodine.
Biocalex 6-9, developed and introduced by Bernard under the name of ‘ocalex’.

**Powder**
- Zinc oxide & calcium oxide

**Liquid**
- Ethylene glycol and water
- used as both intracanal medicament and as root filling
- paste expands to more than six times its original volume, penetrating all parts of the root canal system
Mechanism of action:

- Calcium oxide and water react with the tooth to form calcium hydroxide which ionizes to release OH- ions, which has an antiseptic action, in addition it decompose necrotic pulpal tissues to form water and carbon dioxide,
- water combines with residual calcium oxide, leads to further calcium hydroxide formation.
- Carbon dioxide reacts with calcium hydroxide to form calcium carbonate, which is deposited on the root canal walls.
- Chemical incineration of canal contents occurs, with sterilization by the action of hydroxyl ions and sealing of the canal by the deposition of calcium carbonate.
Adv:

- obviates the need for root canal preparation.

Disadvantage:

- doubts regarding the breakdown of necrotic pulpal tissue, so making it doubtful whether the co2 necessary for calcium carbonate formation is formed.
Calcium hydroxide cement

Sealapex:
Base:
Calcium hydroxide : 25%
Zinc oxide : 6.5%

Catalyst:
Barium sulfate : 18.6%
Titanium dioxide : 5.1%
Zinc Stearate : 1.0%
- Osteogenic, possible dissolution, expands on setting
- In 100% humidity takes up to 3 wks to reach a final seal.

**LIFE:** a calcium hydroxide liner is used as a sealer.
CRCS (Calciobiotic root canal sealer)

**Powder:**
- Calcium Hydroxide
- Zinc oxide
- Bismuth dioxide
- Barium sulfate

**Liquid:**
- Eugenol
- Eucalyptol
- Takes 3 days to set fully in dry or humid environments
- Little water sorption
- Stable,
- Softens gutta percha, good for lateral compaction, viscous, adhesive
Apexit

Base:

- Calcium hydroxide: 31.9%
- Zinc oxide: 5.5%
- Calcium oxide: 5.6%
- Silicon oxide: 8.1%
- Zinc stearate: 2.3%
- Hydrogenized colophony: 31.5%
- Tricalcium phosphate: 4.1%
- Polydemethylsiloxane: 2.5%
Activator:

Trimethyl hexanedioldisalicylate : 25%
Bismuth carbonate basic : 18.2%
Bismuth oxide : 18.2%
Silicon dioxide : 15%
1,3-Butanedioldisalicylate : 11.4%
Hydrogenized colophony : 5.4%
Tricalcium phosphate : 5%
Zinc stearate : 1.4%
DENTALIS
ZoE, calcium hydroxide, iodoform, sets rapidly and is very tacky
CH 61
P/L ratio: 1.2g/ml
Powder:
Calcium hydroxide -55%
Bismuth subcarbonate- 30%
Rosin -10
Zinc oxide -5
Liquid:
Fatty acids- 85%
Propylene glycol-15%
Disadvantages:

- to be effective calcium hydroxide must dissolve and the solid consequently lose content.
- Calcium hydroxide may dissolve, leaving obturation voids, which will cause poor seal.
- Have poor cohesive strength
- No proof exists that they have any desirable biologic effects
Calcium Phosphate Paste

- ADA- PAFFENBERG DENTAL RESEARCH CENTER
- Developed a simple mixture of calcium phosphates that sets to become hydroxyapatite
- Two calcium phosphate compounds, one acidic and one basic when mixed with water they set into a hardened mass –hydroxyapatite –the principal mineral in teeth and bones.
- Tetracalcium phosphate is the basic constituent
- Dicalcium phosphate dehydrate or anhydrous dicalcium phosphate is the acidic component.
- Water is neither a reactant nor a product in the reaction but merely a vehicle for dissolution of the reactants.
- Setting time extended by adding glycerin to the mixture.
- Mild phosphoric acid solution speeds the dissolution of the components.
- Final set calcium phosphate cement consists of nearly all crystalline material, and porosity is indirect ratio to the amount of solvent used.
- It is as radiopaque as bone.
- Nearly insoluble in water and is insoluble in saliva and blood.
- There was no dye penetration into the filler canal wall interface.
Tissue reactions: mild irritation after 1 month, new bone formation was observed adjacent to the cement.

Had no toxicity and all tests for mutagenicity and potential carcinogenicity of CPC negative.

G-5 and G-6 are apatite sealers.

BIOSEAL : ZOE to hydroxyapatite
CPC: hydroxyapatite is a naturally occurring product, and that bone grows into and eventually replaces extruded material, makes it biologically acceptable.

Another possibility of using hydroxyapatite relates to the laser: a cross linked collagen hydroxyapatite mixture has been placed in the root canal and melted to place with a laser beam through a fiber optic.
PASTES AS FILLING MATERIALS

- not advocated
- leaching into periradicular tissues
- porosity in paste fills
- most pastes absorb in time – leading to apical leakage, percolation, ultimate treatment failure
- chemical components of paste causes immunologic responses.
- Apical control of paste fills is impossible
Polycarboxylates

- Are effective provided adequate contact is made with the canal wall
- Disadvantage: need for special plastic instruments due to its great adhesiveness to metal
KETAC-ENDO

- Pitt ford recommended use of GIC
- Chemical bonding to dentinal walls of the root canal preventing percolation and bacterial penetration at sealer-dentin interface
- Low toxicity

Disadvantages:
- Difficulty in retrieval
New sealers

- Bis –GMA (difficult to remove)
- Isopropyl cyanoacrylate
- Polyamide varnish
- Dentin bonding agents – good sealers because of their ability to halt microleakage
Problems with dentin bonding agents

- preparation of dentin to remove smear layer
- radiopacity, metal salts need to be added, which can affect polymerization
- placement to ensure total, porosity free placement
- removal in the event of failure
Root canal cement is mixed on a sterile glass slab with a sterile spatula.

Slab is sterilized by an alcohol scrub and is dried until the spatula is passed through an open flame two of three times. Small increments of powder are added to the liquid while one spatulates it to a smooth creamy mix. Spatulation time depends on the number of drops of liquid used, a min per drop.
Completed mix can be tested for proper consistency by raising the flat blade of the spatula up from the mixed mass. The cement should “string out” for at least an inch before breaking.

Another test is the suspended mix should cling to the inverted spatula blade for 10 to 15 sec before dropping from the spatula.
Placement of sealer

- Reamer: is twirled counterclockwise, pumped and wiped against the walls
- Absorbent paper points or gutta percha: pumping
- Lentulo spiral: in a handpiece
  Disadv: locking in canal, “whipping up” of cement in canal causing it to set prematurely
- Ultrasonic file without use of a coolant
Sealer efficacy:

- Hovland and Dumsha
  - “Although all root canal sealers leak to some extent –there is probably a critical level of leakage that is unacceptable for healing and therefore result in endodontic failure. This leakage may occur at the interface of the dentine and sealer, at the interface of the solid core and sealer, through the sealer itself, or by dissolution of the sealer.”
  - All sealers leak. Some leak more than others mostly through dissolution.
  - The greater the sealer/periradicular tissue, the faster dissolution takes place.
Tissue tolerance:

Zinc oxide and Eugenol:
- All ZoE sealers dissolve in fluid releasing eugenol which is irritating.
- Zinc oxide is also toxic due to the effect of zinc ions.
- CRCS was the least cytotoxic followed by AH26,
- Prraformaldehyde most toxic
- Ketac Endo most biocompatible.
In vivo tissue tolerance examination:

- Erausquin and Muruzabal – found that ZOE was highly irritating to the periradicular tissues and caused necrosis of bone and cementum.
- Least irritating was Diaket and AH-26.
- Diaket becomes encapsulated
- AH-26 was resorbed
Conclusion

The selection of a sealer is based on amount of lubrication needed, the length of working time estimated, and the filling material to be used.