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REVIEW ARTICLE

ROOT END FILLING MATERIALS

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ABSTRACT

One of the keys to successful root canal therapy is adequate obturation of the prepared root canal space. Three dimensional obturation provides hermetic seal to prevent ingress of bacteria and their toxins into the periapical tissues and when this is not achieved by an orthograde approach, then a root end filling technique is used. The purpose of a root-end filling is to establish a seal between the root canal space and the periapical tissues. A number of materials have been suggested for use as root-end fillings, including gutta-percha, amalgam, Cavit, intermediate restorative material (IRM), super EBA, glass ionomers, composite resins, carboxylate cements, zinc phosphate cements, zinc oxide-eugenol cements and mineral trioxide aggregate (MTA). This article reviews different root end filling materials and compare their biocompatibility, sealing ability and microleakage.

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INTRODUCTION

Endodontic treatment is gaining popularity worldwide due to the growing awareness in people regarding the importance of saving the natural teeth. Conventional endodontic treatment has a high success rate of up to 95%, but failures have been noted in 5% to 10% of cases.[1] The main objective of all endodontic procedures is to obtain a hermetic seal between the periodontium and root canal system. When this is not possible by orthograde approach, retrograde approach using root end filling technique with surgical intervention is required.[2] Surgical endodontic therapy involves the exposure of the involved area, preparation of the root end cavity and placement of root end filling material to seal the canal. Although a plethora of materials are available, no material has been found that fulfills all or most of the properties for retrograde filling material.

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The choice of root end filling material thus becomes one of the many factors relevant to the success of the endodontic surgery. The prognosis ultimately depends upon various factors like the correct bevel, adequate access, hemorrhage control, correct retrograde filling and preparation, quality of orthograde filling and individual host responses[3]

However, it led to requirement of a product that would promise a reliable clinical outcome and long-term prognosis. Hence there is a need to review and conclude an ideal material with predictable sealing ability, good biocompatibility, increased tissue fluid sensitivity and healing ability from a bunch of materials.

Indications for Retrograde Filling Procedure

- In cases where canals cannot be negotiated.
- Presence of a well-fitting post and core that might cause root fracture during removal.
- An irretrievable broken instrument.
- In cases where there is no proper apical seal, root end filling has to be done to ensure proper apical seal.[4]

Requirements of an Ideal Root-End Filling Material

Chong &Pitt Ford (2005) summarized the requirements of an ideal root-end filling material which are applicable for any root reparative material to be ideal:

- The material should adhere or bond to tooth tissue and "seal" the root end three-dimensionally
- It should not promote, and preferably inhibit, the growth of pathogenic microorganisms
- It should be dimensionally stable and unaffected by tissue fluids in either the set or unset state
- It should be well tolerated by periradicular tissues with noinflammatory reactions
- It should stimulate the regenera-tion of normal periodontium
- It should be nontoxic both locally and systemically
- It should not corrode or be electrochemically active
- It should not stain the tooth or the periradicular tissues
- It should be easily distinguishable on radiographs

It should have a long shelf life, and be easy to handle Classifications

Root canal filling materials can be broadly classified into two types.

- Orthograde filling materials
- Retrograde filling materials.

Orthograde filling materials are those which are used to fill the root canal during non-surgical endodontic treatment through the canal orifices of the root. Retrograde filling materials are those which are used during surgical endodontic treatment to obtain good hermetic seal of the apex.

Retrograde filling materials can be classified as:

- Metals
- Non-metals

Metals include: Amalgam, Gold Foil, Silver Cones, Gallium Alloys, Lead Points, Tin Foil, Titanium Post, Tin Post, Gold Screws, Silver Points etc…

Non-metals include: Zinc eugenol cement, Glass Ionomer Cement, Cavit, zinc Polycarboxylate cement, IRM, SuperEBA, zinc Phosphate cement, Composite Resins, Gutta-percha, MTA etc [6]

AMALGAM: It is the most extensively used retro-filling material from past seven decades, but one of the first reports of placing it as a root-end filling subsequent to resection is attributed to Farrar (1884). Later Rhein (1897), Faulhaber &Neumann (1912), Hippels (1914) and Garvin (1919) extolled the use of root-end amalgam fillings. Amalgam is easy to manipulate and has good radio opacity. It is non-soluble in tissue fluids and marginal adaptation as well as sealing improves as amalgam ages due to formation of corrosion products. High copper zinc free amalgam is preferred. Use of Amalgambond, a 4-META bonding agent with amalgam significantly reduces the microleakage of amalgam retrofillings[7]. Compatibility studies have demonstrated that freshly mixed conventional silver amalgams are very cytotoxic due to unreacted mercury[8], with cytotoxicity decreasing rapidly as the material hardens. Amalgam has few limitations which include initial marginal leakage, corrosion, tin and mercury contamination of periapical tissues, moisture sensitivity of some alloys, need for retentive undercut preparation, staining of hard and soft tissues and technique sensitivity[9]

Gutta Percha: Thermo plasticized gutta percha has a better sealing ability when compared to amalgam. It absorbs moisture from the periapical region and expands initially, which is later followed by contraction. This contraction leads to poor marginal adaptation and leakage[10]

Zinc Oxide Eugenol (ZOE) and Reinforced ZOE Cements

The use of ZOE as a root-end sealing agent in periradicular surgery has had limited documentation. Newer modifications of ZOE compounds, such as IRM and Super EBA provide a better apical seal. IRM is zinc oxide eugenol cement reinforced by addition of 20%polymethacylate by weight to the powder[11]. Studies reveal that IRM seals better than non zinc amalgam[12]. Super EBA is zinc oxide eugenol cement modified with ethoxybenzoic acid to alter the setting time and increase the strength of the mixture. Super EBA has much better physical properties than ZOE. It showed high compressive strength, high tensile strength, neutral pH, and low solubility. Even in moist conditions Super EBA adheres totooth structure. Super EBA adheres well to itself and can be added incrementally as necessary but IRM does not. Reports showed a good healing response to super EBA with minimal chronic inflammation at the root apex[13]. EBA demonstrates virtually no leakage[14]. Super EBA and IRM showed less leakage as compared to silver amalgam[15].

IRM & Super EBA: Both these materials are modifications of zinc oxide eugenol cement. Both these materials provide a better apical seal[16]. IRM has better sealing than amalgam and leaks lesser than amalgam. Coleman and Kirk in 1965 first recommended the use of EBA as root end filling material. It is a non reabsorbable material. Super EBA has high compressive strength, high tensile strength, neutral pH, adheres to tooth even in moist conditions, minimal leakage and promotes good healing[17].A recent study shows that both IRM and super EBA have less biocompatibility than assumed earlier[18]

Glass Ionomer Cement (GIC): Glass ionomer cement (GIC) consists of aqueous polymeric acids, such as polyacrylic acid, plus basic glass powders, such as calcium aluminosilicate. GIC sets by a neutralization reaction of aluminosilicate, which is chelated with carboxylate groups to cross-link the polyacids; a substantial amount of the glass remains unreacted and acts as reinforcing filler[19]. Glass ionomer cements can be either light or chemically cured. Silver has been incorporated into GIC to improve the physical properties, including compressive and tensile strength and creep resistance. Both forms of GIC have been suggested as an alternative root-end filling material.[20] Light cure, resin reinforced GIC was used as a retrograde filling material by Chong *et al*[28]. It showed least microleakage due to less moisture sensitivity, less curing shrinkage and deeper penetration of polymer into dentin surface. Glass ionomer cements are susceptible to attack by moisture during the initial setting period, resulting in increased solubility and decreased bond strength.[21] Contamination with moisture and blood adversely affected the outcome when GIC was used as a root-end filling material; this occurred significantly more often in unsuccessful cases. The cytotoxicity of chemical- and light-cured GIC does not differ significantly from that of Super EBA or amalgam. The tissue response to GIC is considerably more favorable than to amalgam and similar to that with ZOE-based materials[22].

Composite resin and resin based materials: Composite resin materials have some good desirable properties and can be considered as root end filling materials. They have good sealability. They leak less than amalgam. But moisture and blood contamination reduces bond strength and increases leakage. They may have some cytotoxic potential which is directly proportional to the amount and nature of the leachable materials[23] Rud., *et al*. have reported on several prospective and retrospective human usage studies in an attempt to evaluate the acceptability of composite resin combined with a dentin-bonding agent as a retrograde filling. They applied Gluma in vivo to cases requiring periradicular surgery and compared it to cases treated with root-end amalgam fillings. Gluma exhibited complete healing in 74% of the cases as compared to amalgam healing only in 59% of cases[24] Another study demonstrated excellent long term clinical success with the use of retroplast composite resin and Gluma bonding agent [25]. Using composite resin for retrograde filling allows for more conservative preparation of the root- end cavity. Slightly concave root-end preparations is suggested followed by bonding to the entire resected root end. They are sensitive to moisture than conventional glass ionomer cements.

Retroplast: Retroplast is a dent in bonding composite resin system developed in 1984 specifically for use as a retrograde filling material. The formulation was changed in 1990, when the silver was replaced with Ytterbium tri-fluoride and ferric oxide. There is evidence that retroplast promotes hard tissue formation at the root apex and some have suggested that this is a form of cementum. In a limited number of case reports retroplast retrograde fillings have demonstrated regeneration of the periodontium with a cementum layer over the root end restoration[26].

Mineral Trioxide Aggregate (MTA): It was developed at Loma Linda University, CA, U.S.A in 1993. This cement contains tricalcium silicate, tricalcium aluminate,tricalcium oxide, silicate oxide and other mineral oxides forming a hydrophilic powder which sets in presence of water. The resultant colloidal gel solidifies to a hard structure within 4 hours. Initially the pH is 10.2 which rises to 12.5 three hours after mixing. It is found to be more opaque than EBA and IRM. MTA provides superior seal when compared with Amalgam, IRM and Super EBA[27]. Adamo *et al*[28] compared MTA, Super-EBA, Composite and amalgam and found statistically no significant difference in the rate of microleakage but studies of Torabinejad *et al* and Fischer *et al* proved MTA to be superioras compared to Super EBA and IRM[29]. The marginal adaptation of MTA was better with or without finishing when compared to IRM and Super EBA[30]. MTA, when used as a root-end filling material, showed evidence of healing of the surrounding tissues[31] Most characteristic tissue reaction of MTA was the presence of connective tissue after the first postoperative week[32]. Studies have shown that osteoblasts have favorable response to MTA as compared to IRM and amalgam. With longer duration, new cementum was found on the surface of the material[33]. In a two year follow-up study with MTA as root-end filling material resulted in a high success rate[34]. Such studies support further development of MTA to reduce the long setting time and difficulty inmanipulation for use as a root-end filling material.

Viscosity enhanced root repair material (VERRM): This is a new retrograde filling material which is formulated using Portland cement as the base material. Bismuth oxide and other compounds were added to improve the radio opacity and handling characteristics. Hut Kheng Chng *et al* showed that VERRM's physical properties are similar to MTA and is biocompatible with the periradicular tissues.[35]

Biodentin: It is a calcium silicate based material introduced in 2010 and is used as a material for crown and root dentin repair treatment, repair of perforations, apexifications, resorption repair and root-end fillings[36]. The main component is a highly purified tricalcium silicate powder that contains small amounts of dicalcium silicate, calcium carbonate, and a radioopaquer. The interfacial properties of dentinbiodentine interface were studied under microscope and tag-like microstructures were detected. The flowable consistency of Biodentine penetrates dentinal tubules and helps in the mechanical properties of the interface [37]. Investigation of the bioactivity of Biodentine, MTA and a new Tricalcium silicate cement revealed that all three cements allowed the deposition of hydroxyapatite on the surface. This shows that all three materials are bioactive[38]. An in vitro study to compare the sealing ability of MTA, Calcium phosphate cement and Biodentine MTA showed the highest seal and the least dye absorbance. Biodentine showed a seal slightly less than MTA but, higher than Calcium phosphate cement [39].

Endosequence (ERRM): It is a new bioceramic material consisting of calcium silicates, monobasic calcium phosphate, and zirconium oxide. It is radioopaque, biocompatible, bioactive and its high pH contributes to its antimicrobial activity. ERRM has been shown to have negligible cytotoxicity and capability to induce cytokine expression similar to MTA [40]. The bioactivity was tested in a study by exposing the set material in phosphate-buffered saline. There was precipitation of apatite crystalline structures, which is indicative of its bioactivity[41].

iRoot BP Plus bioceramic putty: iRoot BP Plus (Innovative BioCeramix Inc., Vancouver, Canada) is a fully laboratory-synthesized, water-based bioceramic cement. It claims to be a more convenient reparative material, because it is a ready to-use white hydraulic premixed formula.[42] A current study to verify *in vitro* cytocompatibility of iRoot BP Plus bioceramic putty concluded that iRoot and MTA were biocompatible and did not induce critical cytotoxic effects.[43]

Generex A: Generex A (Dentsply Tulsa Dental Specialties, Tulsa, OK,USA) is a calcium-silicate-based material that has somesimilarities to ProRoot MTA but is mixed with unique gels instead of water used for MTA. Generex A material has very different handling properties in comparison to MTA.[44] Generex A mixes to a dough-like consistency, making it easy to roll into a rope-like mass similar to intermediate restorative material.[45]

Capasio: Capasio (Primus Consulting, Bradenton, FL, USA) is composed primarily of bismuth oxide, dental glass, and calcium alumino-silicate with a silica and polyvinyl acetatebased gel. A recent study found that Capasio and MTA promote apatite deposition when exposed to synthetic tissue fluid thus had the mineralization capacity.[46] The same researchers also concluded that when used as a root-end filling material, Capasio is more likely to penetrate dentinal tubules. Another study compared Generex A, Generex B, Capasio along with Ceramicrete-D (magnesium phosphate based) using primary osteoblasts. Generex A was the only new generation endodontic material that supported primaryosteoblast growth. No material besides MTA facilitated nodule formation. Only Generex A and MTA allowed cell growth and proliferation throughout the experiment.[47]

Endo Binder

EndoBinder (Binderware, Brazil) is a new calcium aluminate cement. During production, free magnesium oxide and calcium oxide are eliminated to avoid expansion of the material and ferric oxide which can cause tooth discolouration is also eliminated. Aguilar., *et al*. evaluated the biocompatibility of a calcium aluminate based-cement (EndoBinder) in subcutaneous tissue of rats, in comparison with the grey version of MTA. After 42 days, EndoBinder presented no inflammatory reaction, however, a mild inflammatory reaction was observed for MTA, in the same period of analysis, which denotes the presence of a chronic inflammatory process[48]. Endobindar tetrasilicate recently cement are being considered. As a good alternative root end filling material. In vitro studies show that their properties are similar to that of MTA[49].

Conclusion

Many different materials have been advocated for use as retrograde filling materials, and each has specific advantages and disadvan-tages. However from the biological perspective of regeneration of periradicular tissues, MTA remains to be the material of choice and is considered the gold standard for all the future root end filling materials. Though retrograde filling materials not much recommended in earlier days, plays a significant role in the success of endodontic surgery. The endodontic surgeon should consider using materials, which have been clinically and biologically evaluated and which give evidence of long-term success. The introduction of ultrasonic tips and micro surgical instruments helps the operator to place the retrograde filling materials with much desired accuracy and precision.

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