ROOT-END FILLING MATERIALS - REVIEW

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ABSTRACT

The aim of this study is to describe different root-end filling materials according to the literature and to compare their antibacterial activity, sealing ability, biocompatibility and microleakage. 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).

Keywords: *root-end filling materials, sealing ability, microleakage*

INTRODUCTION

The purpose of root-end filling material is to hermetically seal the apex (1,2). It has to prevent the residual irritants and oral contaminants from exiting the root canal system and entering the periradicular tissues. The ideal root-end filling material would have the following characteristics (1,3,19):

- Adhere and adapt to the walls of the root preparation
- Prevent leakage of microorganisms and their products into the periradicular tissues
- Be biocompatible
- Nonresorbable
- Unaffected by moisture
- Easy to prepare and place
- Radiographically visible
- To have anticaries activity
- To be non-toxic, non-carcinogenic, dimensionally stable
- It should not cause paresthesia
- It should not cause additional pigmentation
- It should not corrode or be electrochemically active
- It should have bactericidal or bacteriostatic effect
- It should stimulate cementogenesis
- It should be well tolerated by periradicular tissues with no inflammatory reactions

Surgical endodontic therapy is the treatment of choice when teeth have responded poorly, when inadequate instrumentation is met and teeth cannot be treated nonsurgically. When the root-end preparation has been completed, the proper root-end filling material is inserted. There are numerous root-end filling materials but no material has been found to fulfill all the properties for ideal retrograde filling. The materials which are most commonly used are given below.

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One of the materials which is very often used is the amalgam. Other metals such as gold-foil, silver posts, tin posts, titanium screws and gallium alloy are also commonly used.

Cements such as Super EBA, IRM, glass iono-mers, carboxylate cements, zinc phosphate cements, Diaket, zinc oxide-eugenol cements and mineral tri-oxide aggregate (MTA) are also used for retrograde filling.

Other materials which are widely used are composite resins and gutta-percha.

Root-end filling materials which are used rarely are laser, citric acid demineralization, teflon, ceramic inlay.

A wide variety of materials have been used for retrograde fillings (Tabl.1).

Tabl.1.

Plastic materials	Rigid materials
Amalgam	Titanium inserts
GIC	Ceramic inserts
Zincoxide eugenol cements (IRM, super EBA, Cavit)	Silver points
Composite resin/dentine adhesive	Gold-foil
Biodentine	Gallium alloy
MTA	Ceramic inlay
Gutta-percha	
Diaket	
Bioaggregate	
Zinc phosphate	

AMALGAM

Silver amalgam is one of the most commonly used root-end filling material. It remains as a standart to which other materials are compared. One of the first reports of placing amalgam as a root-end filling is attributed to Farrar (1884). Clinical and histopathological studies show that amalgam, implanted subcutaneously and adjacent to bone is well tolerated by periapical tissues (22,38). Amalgam is easy to manipulate, has good radioopacity and is nonsoluble in tissue fluids, because of the formation of corrosion products. The preferred amalgam is high copper-zinc free.

Anderson et al. (8) reported that using a bonding agent (4-META) with the amalgam significantly reduces the microleakage of the amalgam retrograde fillings.

Zhu et al. (58) suggested that amalgam had a higher cell toxicity to human periodontal ligament cells and human osteoblast-like cells than IRM and Super-EBA. Makkawy HA et al. found (29) that use of resin-modified glass ionomer cement as a root perforation repair material initially (<24 h) may result in a more favorable response by PDL cells than the tested dental amalgam.

Studies by Tronstad et al. (51) and Abdal et al. (4) have found that the apical seal is significantly improved when varnish was applied to the cavity prior to the placement of a retrograde amalgam filling. Other comparative studies (52) showed that freshly mixed conventional amalgams are very cytotoxic due to unreacted mercury with cytotoxicity decreasing as the material hardens. Georgiev et al. (24) reported a clinical case of paresthesia due to disseminated amalgam retrograde filling in the upper jaw and soft tissues.

The problems with amalgam are:

1. It produces corrosive by-products (15,28,43).
2. As a result of metal's primary shrinkage it initially leaks.
3. There is a possibility of mercury and tin contamination.
4. It is moisture sensitive.
5. A retentively designed cavity preparation is required for retention.
6. It may cause tissue tattooing (15,29).
7. Scattered particles are not resorbable and may be difficult to retrieve.
8. It does not seal the root end three-dimensionally and does not prevent the leakage of microorganisms and their products in the periradicular tissues (15,24,40).

9. Many surveys based on clinical studies have reported poor outcomes with amalgam used as a root-end filling material (15,40).

ZINC OXIDE

The most commonly used zinc oxide cements are Super EBA and IRM. IRM is 80% zinc oxide, 20% polymethylmethacrylate, with the liquid being 99% eugenol. Super EBA is 60% zinc oxide, 30% alumina, 6% natural resin, with the liquid being 37.5% eugenol and 62.5% orf/ 70-ethoxybenzoic acid. These cements have excellent sealing capability and are non toxic after setting.

The use of Super EBA of root-end filling material was suggested by Oynick and Oynick (39) in 1978. They reported that collagen fibers grew over Super EBA root-end fillings and claimed the material to be biocompatible.

Baek et al. (10) compared the periapical tissue responses and cementum regeneration in response to three widely used root-end filling materials, amalgam, SuperEBA, and Mineral Trioxide Aggregate (MTA) and found that Super EBA was superior to amalgam as a root-end filling material.

Torabinejad M et al. (47) examined the tissue reaction of implanted Super-EBA and MTA in the mandibles of guinea pigs. Two bony cavities without implanted materials were left to heal and used as negative controls. The presence of inflammation, predominant cell type, and thickness of fibrous connective tissue adjacent to each implant was recorded. Based on these results, it seems that both Super-EBA and MTA are biocompatible.

Pitt Ford TR et al. (41) examined the effect of Super-EBA cement as a root-end filling placed in eight molar roots in monkeys. The tissue response to Super-EBA was very mild, with only a few inflammatory cells being observed at the root end of 3 of the 8 roots filled. It is concluded that the tissue response to Super-EBA as a root-end filling is acceptable and considerably more favorable than that to amalgam.

Pitt Ford TR et al. (42) examined also the effect of IRM root end fillings on healing after replantation in 21 molar teeth in monkeys and concluded that the tissue response to root-end fillings of IRM in replanted teeth was less severe and less extensive than that to amalgam.

Harikaran et al. (27) evaluated the sealing ability of tree different materials for retrograde filling and revealed that the dye leakage scores were lowest in IRM. The sealing ability of IRM was significantly better than amalgam and glass-ionomer.

Trope et al. (53) in a histological study confirmed the good tissue response to both EBA and IRM.

Super EBA adheres well to itself and can be added incrementally as necessary but IRM does not. Reports (39) showed a good healing response to super EBA with minimal chronic inflammation at the root apex. EBA demonstrates no leakage (10, 26).

These zinc oxide cements have the following disadvantages:

1. They are moisture sensitive.
2. They cause initial tissue irritation.
3. Resorbability is questionable.

GLASS IONOMER CEMENT

Glass ionomers are formed by the reaction of calcium–aluminosilicate glass particles with aqueous solutions of polyacrylic acid. It bonds physicochemically to dentine. These cements are easy to handle and does not cause any adverse histological reaction in the periapical tissue (13,32). Chong et al. (14) used light cure, resinreinforced GIC as a retrograde filling material. It showed least microleakage due to less moisture sensitivity, less curing shrinkage and deeper penetration of polymer into dentin surface. According to MacNeil K et al. (34) sealing ability of GIC was adversely affected when the root end cavities were contaminated with moisture at the time of placement of cement.

It is reported that newer glass ionomer cements containing glass-metal powder have less leakage and showed no pathologic signs (57).

The glass ionomers have the following disadvantages:

1. The root preparation must be absolutely dry.
2. The seal is adversely affected by moisture and low PH.

GUTTA-PERCHA

Gutta-percha is the most commonly used material for retrograde and orthograde filling. It has to obtain a hermetic seal coronally and apically. Orthograde gutta-percha root canal obturation that is associated with apical surgery is burnished after apicoectomy with either cold or hot burnisher. Abdal and Retief (4) in their study observed that heat sealed gutta-percha provides a better seal as compared to Amalgam, IRM and Super EBA. It is reported that a better seal can be obtained with thermo-plasticized gutta-percha than amalgam with and without varnish (35 55,56).

Although this nonresorbable, biocompatible material has good handling characteristics it has the following disadvantages:

1. It is moisture sensitive.
2. The apical seal depends on the structure of the gutta-percha, its degree and condensation, and the nature and amount of root canal sealer used.
3. There is a tendency for its margins to open when the canal root interface is cut, heated or burnished.

CAVIT

It is a Zinc oxide based temporary filling material. Cavit is soft when placed in the tooth and subsequently undergoes a hygroscopic set after permeation with water, giving a high linear expansion (18%). This rationalizes its use as a root-end filling material. Cavit has been shown to exhibit greater leakage than IRM (23). It is not proved that it is toxic or non-toxic that is why using Cavit is not recommended as retrograde filling (6,54).

COMPOSITE RESIN

Composite resins are used with a bonding agent as a retrograde filling. Rud et al.(44) 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. In another study Rud et al. (45) demonstrated excellent long term clinical success with the use of retroplast composite resin and Gluma bonding agent.

Using composite resin for retrograde filling allows for more conservative preparation of the root-end cavity. Rud et. al (45) have suggested a slightly concave root-end preparations followed by bonding to the entire resected root end.

Some authors have reported that some composite resins have cytotoxic effect that may persist 30 days or longer (7).

MINERAL TRIOXIDE AGGREGATE (MTA)

It was developed by Torabinejad at Loma Linda University, CA, USA in 1993. The main molecules present in MTA are calcium and phosphorous ions, derived primarily from tricalcium silicate, tricalcium aluminate, tricalcium oxide and silicate oxide. Its pH when set is 12.5 and its setting time is 2 hours and 45 minutes. The compressive strength of MTA is reported to be 40 MPa immediately after setting and increases to 70MPa after 21 days (48).

MTA has been extensively evaluated for microleakage, marginal adaptation and biocompatibility. MTA sealing ability has been shown to be superior to that of super EBA and was not affected by blood contamination.

Several dye leakage studies have demonstrated the fact that MTA leaks significantly less than other root-end filling materials. Fischer et al. (21) determined the time needed for *Serratia marcescens* to penetrate a 3 mm thickness of zinc-free amalgam, Intermediate Restorative Material (IRM), Super-EBA, and MTA when these materials were used as root-end filling materials. The number of days required for *S. marcescens* to penetrate the four root-end filling materials and grow in the phenol red broth was recorded and analyzed. They reported that most of the samples filled with zinc-free amalgam leaked bacteria in 10 to 63 days. IRM began leaking in 28 to 91 days. Super-EBA began leaking in 42 to 101 days. MTA did not begin leaking until day 49. At the end of the study, four of the MTA samples had not exhibited any leakage. Statistical analysis of the data indicated Mineral Trioxide Aggregate to be the most effective root-end filling material against penetration of *S. marcescens*.

Apaydin et al. (9) compared the effect of fresh MTA with set MTA on hard-tissue healing after periradicular surgery in the root canals of 24 mandibular premolars in four 2-yr-old beagle dogs . They found that there is no significant difference in the quantity of cementum or osseous healing associated with freshly placed or set MTA when used as root-end filling material.

Lindeboom et al. (33) performed a randomized clinical prospective study to evaluate the application of MTA and IRM as retrograde sealers in surgical endodontics. One hundred single-rooted teeth were surgically treated. After randomization, MTA or IRM was used as a retrosealer. Radiographs were taken 1 week, 3 months, and 1 year postoperatively. Complete healing was observed in 64% of the MTA-treated teeth vs 50% of the IRM-treated teeth. Incomplete healing was seen in 28% (MTA) vs 36% (IRM), and unsatisfactory in 6% (MTA) vs 14% (IRM). Only 1 failure was seen (MTA). No statistically significant differences were found between the 2 retrofilling materials.

The marginal adaptation of MTA was better with or without finishing when compared to IRM and Super EBA (25). MTA, when used as a root-end-filling material, showed evidence of healing of the surrounding tissues (46,49,50). Most characteristic tissue reaction of MTA was the presence of connective tissue after the first postoperative week (20).

CONCLUSION

Nowadays no material has been found that meets all of the requirements of an ideal root-end filling material. The authors have successfully used Super EBA and IRM for over 30 years. Based on the literature and dental studies, dental amalgam should no longer be used because of its poor marginal adaptation, cytotoxic effect and inadequate sealing. MTA remains to be the material of choice because it is non-toxic, non-carcinogenic, biocompatible, dimensionally stable and has high radioopacity, good tissue tolerance and possible induction of mineral tissue (49).

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