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ROOT END FILLING MATERIALS – A REVIEW

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ABSTRACT The aim of a root end filling is to prevent irritants from the root canal from leaking into the periapical region and to improve the apical seal created by nonsurgical endodontic care. Various restorative materials that have been used for coronal restorations have been tried and tested as root end filling materials, as well as the creation of restorative materials designed specifically for root end filling. In the past, amalgam was the preferred material for root end filling. MTA, a recently established material that meets almost all of the criteria for an ideal root end filling material, has become the gold standard against which newer materials are measured. This article examines traditional endodontic root end materials and provides an overview of recent advancements in root end filling

KEYWORDS : Root End Filling Materials; Sealing Ability; Fluid Tight Seal; Microleakage; Biocompatibility.

INTRODUCTION

When a traditional endodontic retreatment is not possible, or when nonsurgical retreatment fails to treat the infection, surgical endodontics is used to treat the tooth. Root resection, apical curettage if necessary, and reconstruction of the resected root end with a suitable root end filling material are all part of endodontic surgery. The aim of root end filling is to prevent irritant leakage from the root canal into the periapical region while also improving the apical seal created by nonsurgical endodontic therapy. Various restorative materials that have been used for coronal restorations, as well as the development of restorative materials designed specifically for root end filling, have been tried and tested as root end filling materials.. The aim of this article is to provide a thorough review of the literature for various root end materials that are currently available, with a focus on recent developments in root end materials.

IDEAL REQUIREMENTS OF A ROOT END FILLING MATERIL[1]

1. The most important requirement of a root end material is that it should be biocompatible and non-toxic, as it placed in direct contact with vital soft tissue. 2. It should provide a biological seal. i.e. It should promote cementum deposition on the cut root surface.
3. It should adhere to tooth structure.
4. It should be insoluble in tissue fluids.
5. It should be dimensionally stable.
6. It should be non resorbable.
7. It should be radio opaque

Orthograde filling materials are those that are used to fill the root canal through the canal orifices of the root during nonsurgical endodontic therapy.

Retrograde filling materials are those that are used to achieve a strong hermetic seal of the apex during surgical endodontic procedure.

AMALGAM

Rhein in 1897 used amalgam to close the pulp canal following root resection. For many years, amalgam has been the preferred material for root end fillings due to its workability, self-sealing ability, radio opacity, and tissue fluid insolubility. However, studies show that freshly mixed amalgam is toxic due to the presence of free mercury[2], and that toxicity decreases as the material hardens. Scientists are concerned about the amount of free mercury in the environment and its possible toxicity. In vitro experiments have also shown that amalgam has a weak ability to seal.

According to a few reports, amalgam combined with Amalgabond has a stronger sealing capacity[3]. As a result of these factors, amalgam is no longer a common material for root end filling.

GUTTA PERCHA

Gutta percha was introduced by bowman in 1867 it is a trans-isomer of polyisoprene, existing in alpha and beta crystalline forms[4].

Until the development of thermoplasticized gutta-percha, the placement of gutta percha as a root-end filling material was not advocate.

In comparison to amalgam, IRM, and super EBA, heat sealed gutta-percha produces a stronger seal, according to a study. It is reported that a better seal can be obtained with thermo-plasticized gutta-percha than amalgam with and without varnish[5-7].

Due to it's porous nature, it absorbs moisture from surrounding periapical tissue and expands initially, which is followed by contraction at a later stage. This could lead to a lack of marginal adaptation and increase in micro leakage.

ZINC OXIDE EUGENOL

The most commonly used and preferred root-end filling materials are zinc-oxide eugenol cements.

Various changes were made to ZOE cements in order to enhance their physical properties.

SUPER EBA:

Alumina is added to the powder and a portion of the eugenol liquid is replaced with ortho-ethoxybenzoic acid (EBA).

Super-EBA was developed in the 1960s and was first manufactured in England by Staines..

This contained
Powder ;Zinc oxide, 60%,Silicon dioxide, 34%,Natural resin, 6%
Liquid ;Ortho-ethoxy benzoic acid and 62.5%, Eugenol. 37.5%

The harry.j.bosworth co. used the same liquid component and

34%alumina[8] in place of silicon dioxide in the powder. Strong compressive strength, high tensile strength, neutral pH, and low solubility characterise Super EBA.

In a comparative study of the solubility of some root-end filling materials performed by Poggio et al in 2007, Irm, superEBA, and MTA showed no signs of solubility in water. It has also been shown to have good sealing properties.

In vitro microleakage testing by Yaccino et al in 1999 revealed that different consistencies of fast set or standard set super-EBA could be suitable as root-end fillings. Also in wet weather, it adheres well to tooth structure. Super-EBA seems to have a successful healing response, with limited chronic inflammation at the root apex, according to reports.. But, super-eba is radioluscent and technique sensitive. The eugenol content of super-eba may be a source of irritation to the tissues[9].

IRM is a zinc oxide eugenol cement that has been altered by adding 20% polymethyl methacrylate to the powder. Pitt Ford et al observed the impact of irm as a root-end filling inserted in teeth prior to replantation.

Composition:
Powder; Zinc oxide 80%, Polymethylmethacrylate 20%
Liquid;Eugenol 99%,Acetic acid 1%

Eugenol in irm may have an affinity for poly methyl methacrylate which reduces its release into the tissues, thereby reducing the cytotoxicity[10].

In 2008, al-aseed et al investigated the release of zinc and eugenol from zinc oxide eugenol cements, irm, and super-eba.Because of the comparatively higher content of eugenol, eugenol release from irm by this leached element study was obviously higher than from super-EBA.

However, the increased eugenol release did not increase cytotoxicity; super-EBA was more toxic. As a result zinc release may be the primary cause of toxicity caused by ZOE cements.. IRM has been shown to seal better than amalgam or super-EBA. IRM showed good anti-bacterial activity against s.aureus, e.faecalis, p.aeruginos[11].

CAVIT

Cavit is a temporary filler made up of zinc oxide, calcium sulphate, zinc sulphate, glycol acetate, polyvinyl chloride-acetate, triethanolamine, and red pigment. Cavit is soft when inserted in the tooth, but after being permeated with water, it takes on a hygroscopic set, giving it a high linear expansion (18%). This property has been cited as rationale for its use as a root end filling materials.

Biocompatibility studies with cavit are in conflict, showing it to be both toxic and nontoxic which emphasizes potential problems with comparing diverse experimental conditions. Cavit is harmful to subcutaneous tissue and bone, according to tissue toxicity reports.

The sealing capacity of amalgam, cavit, and glass ionomer cement was tested, and it was discovered that although cavit had a better seal than amalgam, it was inferior to amalgam[12].

Based upon the above studies, the use of cavit as a root-end filling material is questionable. Further studies or alteration in the compound to enhance its tissue biocompatibility and sealing ability are required, if cavit is to be considered as a viable material to seal the root system.

GIC

The reaction of calcium–aluminosilicate glass particles with aqueous polyacrylic acid solutions produces glass ionomers.

It bonds physico-chemically to dentine. These cements are easy to handle and does not cause any adverse histological reaction in the periapical tissue[13,14]. According to mac neil k., et al. When the root end cavities were filled with moisture at the time of cement placement, the sealing capacity of GIC was compromised[15].

As a retro-grade filling material, light cure, resin reinforced GIC was used in a sample. It showed least microleakage due to less moisture sensitivity, less curing shrinkage and deeper penetration of polymer into dentin surface[16].

It is reported that newer GIC containing glass-metal powder have less leakage and showed no pathologic signs[17]. One of the disadvantages of glass ionomers is that the root preparation must be completely dry, and moisture and low PH negatively affect the seal.

COMPOSITE RESINS

Composite resins have earned little interest as root-end filling materials due to their cytotoxic or irritating effects on pulp tissue. The cytotoxic effects are a function of the evaluative methods employed, and, when the agents are properly used, the cytotoxic effects were substantially decreased or eliminated[18].

When composite with dentin bonding agent, composite alone, cavit, amalgam, hot burnished gutta percha, and cold burnished gutta percha were put directly on resected root surface, Mcdonald and dumsha discovered that composite with dentin bonding agent showed the least amount of leakage, followed by composite alone[19].

These results indicate that preparing a root-end cavity may be unnecessary. Light cure composite resin showed significantly lower apical leakage than amalgam and ketac-silver[20]. Rud et al[21] applied gluma in vivo to cases requiring periradicular surgery and compared it to cases treated with root-end amalgam fills. Gluma showed complete healing in 74 percent of cases, while amalgam showed complete healing in just 59 percent of cases.

The proper application of dentin bonding agents and composite resin will help improve the final root-end filling and the advantages of their use should be investigated further.

DIAKET

Diaket is a root canal sealer that is also used as a root-end filling agent in thicker consistency.

When compared to amalgam as a root-end filling, diaket has been shown to have superior sealing qualities[22].

Diaket also shows a good healing response characterized by bone apposition, reformation of periodontal ligament and deposition of new cementum[23].

GOLD FOIL

Schuster and Lyons were the first to record the use of gold foil as a root-end filling material in 1913 and 1920. Its marginal adaptability, surface smoothness, and tissue biocompatibility are all excellent. Gold foil implants[24] cause just a minor tissue reaction. In terms of improving biting [25] force, gold foil was discovered to be the best apical sealing material. Goldfoil was the least toxic of the four materials tested: IRM, composite resin[26], amalgam, and glass ionomer. Gold foil as a root-end filling material appears to be impractical because it necessitates a moisture-free setting, as well as careful placement and finishing.

MTA

Torabinejad invented mineral trioxide aggregate (MTA) in 1993 at Loma linda University in California.Grey and white varieties of MTA cement are commercially available. The major difference between the two versions is that the grey MTA contains the highest concentration of iron oxide, which, according to many reports, is the primary cause of staining of dental tissues when the substance is used[27].

Tricalcium silicate, tricalcium aluminate, tricalcium oxide, and silicate oxide are the main sources of calcium and phosphorous ions.It has a PH of 12.5 when set, and it takes 2 hours and 45 minutes to set. MTA is stated to have a compressive strength of 40 mpa immediately after setting, increasing to 70 mpa after 21 days[28]. MTA leaks much less than other root-end filling materials, according to many dye leakage reports. Fischer., et al[29]. When these materials were used as root-end filling materials, the time it took for Serratia marcescens to penetrate a 3 mm thickness of zinc-free amalgam, intermediate restorative material (IRM), super-EBA, and MTA was determined.

The number of days required for .The ability of S. Marcescens to penetrate four root-end filling materials and grow in phenol red broth was measured and analysed.In 10 to 63 days, bacteria leaked from the zinc-free amalgam samples. In 28 to 91 days, IRM started to leak.

Super-EBA began leaking in 42 to 101 days. MTA did not begin leaking until day 49. At the conclusion of the analysis, four of the mta samples showed no signs of leakage.According to statistical analysis of the results, mineral trioxide aggregate is the most effective root-end filling material against s. Marcescens penetration. Apaydin., et al[30]. In four 2-year-old beagle puppies, the effect of fresh mta versus set MTA on hard-tissue healing after peri-radicular surgery in the root canals of 24 mandibular premolars was compared. 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[31]. Analysed the use of MTA and IRM as retrograde sealers in surgical endodontics in a randomised clinical prospective trial.

One hundred single-rooted teeth were surgically treated. As a retrosealer, MTA or IRM is used after randomization. 1 week, 3 months, and 1 year after surgery, radiographs were taken. Sixty-four percent of MTA-treated teeth healed fully, compared to fifty percent of irm-treated teeth[32]. Incomplete healing was seen in 28% (MTA) vs. 36% (IRM), and unsatisfactory healing was seen in 6% (MTA) vs. 14% (IRM) (IRM).

Only 1 failure was seen (MTA).Between the two retrofilling materials, no statistically significant variations were discovered. When compared to IRM and super EBA, MTA's marginal adaptation was stronger with or without finishing[47].When MTA was used as a root-end filling material, the underlying tissues showed signs of healing[33,34]. Most characteristic tissue reaction of MTAwas the presence of connective tissue after the first postoperative week.

POLYCARBOXYLATE CEMENT

It was introduced by smith in 1968. The zinc polycarboxylate cement consists of a powder having modified zinc oxide with fillers and a liquid comprising of aqueous solution Of polyacrylic acid which, when mixed and hardened, forms a cement of zinc oxide particles dispersed in a cross linked structureless matrix of zinc polycarboxylate.

The ph of the cement is approximately 1.7, which rapidly increases as the cement sets. Despite their initial acidic nature, minimal irritation has been reported to the dental pulp when placed on adjacent dentin[35] or used as a direct pulp cap[36]. Polycarboxylates placed in root canal systems or beyond the confines of root apex show a varied periradicular tissue response.

Polycarboxylates, when used as root-end fillings, leak at slightly higher levels than amalgam or gutta-percha, according to apical leakage tests. The use of polycarboxylate as a root-end filling material is highly questionable due to their poor sealing capacity and uncertain periradicular tissue reaction. It's possible that further research is needed.

TITANIUM SCREWS

A comparison of titanium screws as retrograde fillings with amalgam was conducted. Bacterial penetration was visible in the amalgam fillings on the first day, but bacteria only penetrated the titanium screw seals after 2 to 7 days. Titanium screws appeared to produce a tighter seal than amalgam[37]

BIOAGGREGATE

Is a modified version of MTA. It's a new bioceramic root repair and filling material made up of a powder component composed of Tricalcium silicate,Dicalcium silicate, Tantalum pentoxide, Calcium phosphate monobasic And amorphous silicon oxideLiquid component of Deionized water.

The effect of bioaggregate on human pulp and pdl cell growth was determined by examining the cells grown on this cement using a phase microscope.

In the pulp and pdl cell culture grown with mta, an inhibition zone was discovered. Bioaggregate showed no inhibition zone around the material. Bioaggregate was found to be non-toxic to human pulp and PDL cells[38].

The cytotoxicity of bioaggregate and its impact on mineral-associated gene expression in osteoblast cells were investigated in a report. The cytotoxicity of proroot mta and diaroot bioaggregate was compared in a sample., Inflammatory and foreign body reactions were substantially higher in the bioaggregate group than in the MTA group.

Bioaggregate appeared to be more biocompatible than MTA[39]. Using the methylene blue dye penetration technique, an in vitro comparison of the sealing capacity of diadent bioaggregate and other root-end filling materials (gutta-percha, amalgam, IRM, white MTA) was conducted.

When compared to amalgam, irm, and white MTA[40], the findings showed that bioaggregate had substantially less microleakage.

Bioaggregate has been shown to be non-toxic to osteoblast cells and to increase the expression of genes associated with mineralization in osteoblast cells, such as collagen type 1, osteopontin, and osteocalcin[41].

BIODENTINE

It's a calcium silicate-based substance that was first developed in 2010 and is used for crown and root dentin repair, perforation repair, apexification repair, resorption repair, and root-end fillings[42].

A highly purified tricalcium silicate powder with tiny quantities of dicalcium silicate, calcium carbonate, and a radioopaquer is the main component. Under a microscope, the interfacial properties of the dentinbiodentine interface were investigated, and tag-like microstructures were discovered.

The flowable consistency of Biodentine penetrates dentinal tubules and helps in the mechanical properties of the interface[43]. The bioactivity of Biodentine, MTA, and a new Tricalcium silicate cement was investigated, and it was discovered that all three cements permitted the formation of hydroxyapatite on the surface..

This shows that all three materials are bioactive[44]. An in vitro comparison of MTA, Calcium phosphate cement, and Biodentine MTA revealed that MTA had the best seal and the least dye absorbance.. Biodentine showed a seal slightly less than MTA but, higher than Calcium phosphate cement[45].

CERAMICRETE

hydroxyapatite powder and cerium oxide radioopaque fillers are used in this material. This material is biocompatible and radiopaque and is also known to release calcium and phosphate ions during setting[46].It's a self-setting phosphate ceramic that forms a potassium magnesium phosphate hexahydrate ceramic matrix phase via an acid-base reaction.. Its mechanical properties were improved by adding calcium silicate whiskers to produce a phosphosilicate ceramic material[47].

To investigate the prevention of glucose penetration, researchers compared the root-end seal achieved with ceramicrete, bioaggregate, and White MTA.. Both bioaggregate and ceramicrete showed similar sealing ability, with ceramicrete showing significantly better results than Bioaggregate[48].

Ceramicrete An in vitro study was done to evaluate the ceramicrete based material as a root-end sealing material.

A ceramicrete-based powder was mixed with deionized water in this experiment. Ceramicrete had a radioopacity comparable to root dentin in this analysis, and its sealing capacity was superior to that of SuperEBA and ProRoot MTA. This excellent apical seal was attributed to its impervious nature and also the use of an acidic MgH2 PO4 .H2O solution was used as a conditioner to eliminate the smear layer, which is thought to have increased ceramicrete's adaptation to the dentin.

The surface of the set ceramicrete material formed Dicalcium phosphate dihydrate (DPCD) or hydroxapatite after immersion in a Phosphate containing fluid (PCF). This is due to the reaction of the ceramicrete material's calcium disilicate with the PCF's phosphate. As a result, ceramicrete has the potential to be bioactive[49].

ENDOSEQUENCE (ERRM)

It's a new bioceramic made 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[50]. 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[51].

IROOT BP PLUS

IRoot BP Plus is a synthetic water-based bioceramic cement. It comes in a ready-to-use premixed form and is biocompatible. Calcium silicates, zirconium oxide, tantalum pentoxide, calcium phosphate monobasic, and filler agents are some of the materials used.

It must be set and hardened in the presence of water, and it takes at least 2 hours to set, according to the manufacturer. It has excellent physical properties[52] and does not shrink during the setting phase.

GENEREX A

Generex A (Dentsply Tulsa dental, USA) is a calcium silicate based cement and is similar to MTA but the handling properties are different. The cement is mixed with a special gel instead of water. The final consistency is similar to IRM like dough and easy to manipulate[53]

CAPASIO

Capasio (Primus Consulting, Bradenton, FL) is a calcium-phospho-aluminosilicate–based cement with a novel setting reaction that has similar or enhanced physical characteristics like setting time, radiopacity, compressive power, pH, and washout resistance.[53] .Capasio is a potential root-end filling material because of its favourable properties.

EPOXY RESIN AND PORTLAND CEMENT (EPC)

EPC is an epoxy resin and Portland cement blend. In vitro studies show that it has a good radio opacity, short setting time, low microleakage, and low cytotoxicity and can be used a root end filling material[54].

ENDOBINDER

EndoBinder (Binderware, Brazil) is a calcium aluminate cement that is new to the market. Free magnesium oxide and calcium oxide are removed during processing to prevent material expansion, as well as ferric oxide, which can cause tooth discoloration. Aguilar et al. compared the biocompatibility of a calcium aluminate-based cement (EndoBinder) to the grey version of MTA in subcutaneous tissue of rats. EndoBinder showed no inflammatory response after 42 days, but MTA showed a mild inflammatory response during the same time span, indicating the existence of a chronic inflammatory process[55].

Tetrasilicate cements have recently been proposed as an alternative root end filling material. Their properties are identical to those of MTA[56], according to in vitro studies.

CONCLUSION

After analysing the numerous tests, MTA has the most favourable properties of all the recent root end filling materials and is considered the gold standard for all possible root end filling materials.

However, the future appears bright since many new materials are being investigated. However, since there isn't enough evidence to back up these new root end filling products, they can't be used in clinical practise. The quest for a better root end filling material will continue until then.

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