Root-end Filling Materials : Review Literature

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Abstract

The aim of a root-end filling is to fill the apical canal space and to obtain a hermetic seal between the periodontium and the root canal system. When non-surgical root canal treatment fails or if retreatment is not feasible surgical intervention is recommended, which includes apical resection, retro preparation and root-end filling to seal the root canal. Numerous materials have been suggested for root-end filling. This article reviews on the suitability of various root end filling materials from past to present.

Keywords : Root-end filling, Apical resection, Retro preparation, Periapical surgery, Biocompatibility.

Introduction

The success of endodontic treatment depends on thorough debridement of the inherently complex, irregular root canal systems and sealing the portals of communication with the periapical tissues. Three-dimensional obturation of the root canal is essential to the long-term success of endodontic treatment, so the root canal system should be sealed apically, coronally and laterally.[1] The preferred treatment for failing endodontic cases is non-surgical retreatment.[2] However, because of the complexity of root canal systems, inadequate instrumentation and presence of physical barrier (anatomical, post and core restorations, separated instruments etc) it may be difficult to achieve success with a non surgical approach. Then, endodontic surgery becomes the first alternative.

Periapical surgery can be defined as surgery of the root apex and the periapical tissues, to eliminate the periapical lesion and to ensure good root canal sealing, in order to avoid leakage of bacteria and their toxins from the tooth towards the surrounding tissues.[3] Management of root end during periapical surgery includes apical resection, retro preparation and root-end filling to seal the root canal.

The influence of the degree of the apical root resection on the apical seal was reported that increasing the slope of the bevel from a horizontal plane of 90 degree- 45 degree, the dye penetration was greater. Therefore, a root apex resected perpendicular to the long axis of the root is preferred.[4]

The ideal retro preparation should be parallel to the long axis of root, 3mm deep and centered as supported by Peter Gilheany et al.[5] As the depth increases the leakage decreases because of the occlusion of apical dentinal tubules by the root-end filling material.

Ultrasonics used for retro preparation offers improved access, alignment, depth and quality of seal.[6,7]

Apical resection and retro preparation opens up the root canal system to the periapical region, thereby necessitating the placement of a root-end filling material. According to Gartner and Dorn[8], an ideal root-end filling material should prevent leakage of microorganisms and their byproducts in to the Periradicular tissues, non toxic, non carcinogenic, insoluble in tissue fluids, dimensionally stable, easy to use, radiopaque and biocompatible to the host tissues.

A myriad of dental materials have been evaluated as root-end filling material. These include silver amalgam, gold foil, cavit, super EBA, Intermediate Restorative Material (IRM), gutta percha, hydroxy apatite, titanium screws, glass ionomer cements, composites and more recent like mineral trioxide aggregate, bone cement, lasers, calcium phosphates, castor oil polymer and most recently introduce material biodentine.

Based on review of literature on scientific evaluation and clinical usage, the following are commonly used root-end filling materials.

Amalgam

The first report of placing amalgam as a root-end filling subsequent to resection is attributed to Farrar (1884). Tanzilli et al[9] suggested that dental amalgam gives a poor seal when used as a retrograde filling material. Use of Amalgambond, a 4-META bonding agent with amalgam significantly reduces the microleakage of amalgam retrofillings.[10] Satoshi Inoue et al, have reported that application of cavity varnish over amalgam significantly decreased apical leakage.[11] Compatibility studies[12] have demonstrated that freshly mixed conventional silver amalgam are very cytotoxic due to unreacted mercury with cytotoxicity decreasing as material hardens.

Though amalgam is easy to manipulate, readily available, well tolerated by soft tissues and radio opaque, its inherent shortcomings are slow setting time, staining of overlying soft tissues and it eventually leaks from corrosion.[13] Major problem in long term follow up is related to the fact that the root tip undergoes continuous resorption and apposition of cementum, which alters marginal integrity resulting in loss of seal.

Reinforced Zinc Oxide & Eugenol Cements

As early as 1962, Nicholls showed preference for zinc oxide eugenol cements. But these cements showed increased solubility and tissue irritation. To overcome these problems Intermediate Restorative Material (IRM) and Super EBA was introduced. IRM is zinc-oxide eugenol cement reinforced by addition of 20% polymethacrylate to the powder. Super EBA is zinc-oxide eugenol cement modified with ethoxybenzoic acid to alter the setting time and to increase the strength of the mixture. The use of super EBA as root-end filling material was suggested by Oynick and Oynick[14] in 1978. They reported that collagen fibers grew over EBA root end fillings and claimed the material to be biocompatible. Both the cements induce mild to moderate toxicity when they are freshly mixed probably because of the eugenol component. Cytotoxicity diminishes rapidly as the cement sets and long term inflammatory potential appears to be minimal. 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 to tooth structure. Super EBA adheres well to itself and can be added incrementally as necessary but IRM does not. Bondra et al[15], in their study reported that IRM provided a better seal than Amalgam or Super EBA. On clinical and radiographic examination in a clinical retrospective study a success rate of 75%- Amalgam, 91%-IRM and 95%-Super EBA was documented.[16]

Glass Ionomer Cement

Glass ionomers are formed by reaction of calciumalumino silicated glass particles with aqueous solution of polyacrylic acid. Easy to handle, chemically bonds with tooth structure and does not cause adverse histological reaction in the periapical tissues. Mac Neal and Beatty[17] demonstrated that the apical seal of glass ionomer cements is adversely affected by moisture. Marginal adaptation and adhesion of glass ionomer cements to dentin have been shown to improve with the use of acid conditioners and varnishes.[18] Light cure, resin reinforced GIC was used as a retrograde filling material by Chong et al.[19] It showed least microleakage due to less moisture sensitivity, less curing shrinkage and deeper penetration of polymer into dentin surface. Newer glass ionomer cements containing glass-metal powder have been reported to have less leakage[20] and showed no pathologic signs.

Composite Resin

Used in combination with a dentin bonding agent, composite resin is another example of material borrowed from restorative dentistry and adapted to endodontic surgery. A dry field is compulsory for the dentin bonding agent and Retroplast composite resin root-end fill. In cases where there was poor hemostasis during surgery, there was an absence of complete healing, possibly because of bond failure between the Retroplast and root dentine.[21] Rud et al[22] have demonstrated excellent long term clinical success with use of retroplast composite resin and Gluma dentin bonding agent. The biocompatibility of selected dentin bonding agents and composite resin appears favorable in terms of reattachment of periodontal ligament fibres.[23] McDonald and Dumsha compared composite with a dentin bonding agent, composite alone, cavit, amalgam, hot burnished gutta percha, and cold burnished gutta percha and found that composite with dentin bonding agent showed least amount of leakage followed by composite alone when both of these were placed directly on resected root surface.[24] Light cure composites have shown significantly lower apical leakage than Amalgam and Ketac silver.[25] The proper use of dentin bonding agents and composite resins play a significant role in enhancing the root end filling.[26]

Newer Materials

Bone cement

Bone cement has shown to permit tissue reattachment, wherein the outer cement layer is progressively incorporated in to the new tissue by an in growth of small blood vessels accompanied by macrophages, multinucleated giant cells and fibroblasts. Antibiotics can be incorporated in to these cements and they are not affected by moisture. However, studies by Gary Mathew Holt and Thom C Dumsha have reported no statistically significant difference in dye leakage between Composite and SuperEBA when compared with Bone cement. Thereby, indicating that it could be used as a retrofilling material.[27] Cell culture studies have shown that fibroblasts are unaffected by Bone cement whereas, Amalgam caused cell lysis.[28] Further research needs to be done to evaluate their efficacy as root end filling material.

Mineral Trioxide Aggregate (MTA)

A material mineral trioxide aggregate was developed by M. Torabinejad at Lomalinda University, U.S.A. in 1993. This material 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. It has a long setting time (2 hrs 45 min) so the material must be protected before it is fully set. Initially the pH is 10.2 which rises to 12.4 three hours after mixing and remains unchanged afterwards. The Compressive strength of MTA increases with time, from 40.0 Mpa after 24 hr to 67.3 Mpa after 21 days. MTA is apparently equal or superior to the other materials discussed in this review with respect to dye and bacterial leakage, cytotoxicity, and marginal adaptation.[29,30,31] Animal studies[29,30,32] demonstrate minimal inflammation and good healing around MTA root end fillings. Another interesting feature is the formation of cementum and periodontal ligament fibers adjacent to MTA.[31] The handling of MTA requires experience and demands care to not wash out or disturb the material after placement and compacting.

Since its introduction as a root-end filling material in 1993, the use of Mineral Trioxide Aggregate (MTA) has expanded to many applications for root repair and bone healing. The gray MTA (GMTA) is commercially available as ProRoot MTA (Dentsply Tulsa Dental, Tulsa, OK). Recently, an alternative formulation to GMTA was developed by Dentsply, known as tooth-colored formula (white) ProRoot MTA (WMTA). Both products differ mainly in the constitution.

GMTA contains tetra-calcium aluminoferrite (an iron-based chemical), whereas, the WMTA contains this element in a lower percentage.[33] This reduction is intended to decrease the potential for tooth discoloration observed when GMTA is used in anterior teeth.[34]

In 2001, the MTA-Angelus (Angelus, Londrina, PR, Brazil) was introduced. This material is composed by 80% of Portland cement and 20% of bismuth oxide. Calcium sulfate was removed from its composition to accelerate the setting time.[35] Recently, the color of this product was also changed to white, receiving the commercial name of MTA Branco (MTAB). Current studies have demonstrated that GMTA and WMTA presented similar physicochemical[36] and biological properties.[37,38]

Calcium Phosphate Cements (CPC)

Developed by ADA-Paffenbarger Dental Research Center at the United States National Institute of Standards & Technology, CPC is mixture of two calcium phosphate compounds, one acidic and the other basic.[39] Commonly known as hydroxyapatite cement, it is composed of tetracalcium phosphate and dicalcium phosphate reactants. These compounds, when mixed with water, react isothermally to form a solid implant composed of carbonated hydroxyapatite.[40] The final set cement consists of nearly all crystalline material, and porosity is in direct ratio to the amount of solvent used. It is as radio opaque as bone. When combined by dissolution in moisture, even blood, CPC sets into hydroxyapatite.[41] It demonstrates excellent biocompatibility, does not cause a sustained inflammatory response or toxic reaction. Its compressive strength is greater than 60 MPa and has shown to maintain its shape and volume over time. An in vivo monkey study found new bone formation developing immediately adjacent to CPC.[39] CPC implants are resorbed slowly and are replaced by natural bone in an approximate 1:1 ratio in an osteoconductive manner. CPC seems to be quite promising as a retrograde filling material but it is yet to get approval from the United States Food and Drug Administration.

Laser

Weilcham introduced application of lasers in endodontics in 1971. The effect of lasers is dependent on wavelength specificity and energy density. CO_2 , Nd:YAG, Er:YAG and Ho:YAG have been used of which Er:YAG has shown to be superior.[42] Clinically, lasers have shown improved healing and diminished post operative discomfort. When used for root end resection lasers cause ablation of dentinal tubules which decreases microleakage, eliminates microorganisms and increases resistance to root resorption.[43,44] But the resected surfaces were rough and cause difficulty in burnishing retrofill material smoothly to the tooth surface. A study done by John Sullivan et al[45], has shown that root ends resected with lasers without placement of retrofill material shows increased leakage than when a retrofill material is placed.

Castor Oil Polymer (COP)

Obtained from a common tropical plant Riccinus Communis, it is widely used in medicine for prostheses to replace bone because it is biocompatible, non-toxic and easy to handle. This biopolymer presents a chain of fatty acids whose molecular structures are also present in lipids of human body. Giovana Ribeiro de Martins et al[46], in their study comparing sealing ability of Mineral Trioxide Aggregate, Castor Oil Polymer and Glass Ionomer Cement as root end filling material have reported that the COP group showed decreased dye penetration than MTA and GIC when the depth of retropreparation was 1.5mm. However, further in vivo research is warranted to evaluate the physical and biological properties of COP. It is a relatively new and promising material to be used as a root end filling material.

Biodentine™

Biodentine™ with Active Biosilicate Technology™ was announced by dental materials manufacturer Septodont in September of 2010, and made available in January of 2011. According to the research and development department of said manufacturer, "a new class of dental material which could conciliate high mechanical properties with excellent biocompatibility, as well as bioactive behaviour" (Septodont Biodentine™ scientific file, 2010) had been produced. According to the manufacturer, the material can be used as a "dentine replacement material whenever original dentine is damaged."

Biodentine™ is a calcium silicate based material used for crown and root dentin repair treatment, repair of perforations or resorptions, apexification and root-end fillings. The material can also be used in class II fillings as a temporary enamel substitute and as permanent dentine substitute in large carious lesions (Septodont Biodentine™ scientific file, 2010). The manufacturer points out the biocompatibility and the bioactivity of the material, which is important since the use of the material involves indirect and direct pulp capping and pulpotomy. According to the manufacturer, Biodentine™ preserves pulp vitality and promotes its healing process. (Septodont Biodentine™ scientific file, 2010).

Laurent et al.[47] tested a new Ca_3SiO_5-based material to evaluate its genotoxicity, cytotoxicity and effects on the target cells specific functions. The study concluded that the new material is biocompatible. The material was not found to affect the specific functions of target cells and thus could safely be used in the clinic.

About et al.[48] investigated Biodentine™ bioactivity by studying its effects on pulp progenitor cells activation, differentiation and dentine regeneration in human tooth cultures. The study concluded that Biodentine™ is stimulating dentine regeneration by inducing odontoblast differentiation from pulp progenitor cells.

Laurent et al[49] did further a study to investigate the capacity of Biodentine™ to affect TGF-β1 secretion from pulp cells and to induce reparative dentine synthesis. Biodentine™ was applied directly onto the dental pulp in a human tooth culture model, resulting in a significant increase of TGF-β1 secretion from pulp cells and thus inducing an early form of dental pulp mineralization shortly after its application.

Han & Okiji[50] compared calcium and silicon uptake by adjacent root canal dentine in the presence of phosphate buffered saline using Biodentine™ and ProRoot® MTA. The results showed that both materials formed a tag-like structure composed of the material itself or calcium- or phosphate rich crystalline deposits. The thickness of the Ca- and Si-rich layers increased over time, and the thickness of the Ca- and Si-rich layer was significantly larger in Biodentine™ compared to MTA after 30 and 90 days, concluding that the dentine element uptake was greater for Biodentine™ than for MTA.

In this literature review we have concentrated on Biodentine™ as a root-end filling. For this use there is no published studies, whereas the only documentation available is from the manufacturer. The material has10 indications similar to calcium silicate containing materials e.g. MTA. Septodont claims that Biodentine™ has features as an endodontic repair material that are superior to MTA: Biodentine™ has better consistency, better handling and safety, and faster setting time which creates no need for a two step obturation.

Clinical outcomes for Biodentine™ used in root-end filling are currently lacking.

Conclusion

Based on the review of literature, it appears that no existing retrofilling material possesses all the ideal characteristics of a retrofill material. MTA, CPC and COP have shown promising results. Biological and clinical studies are required to evaluate these materials. Newer materials like biodentine require more in vivo testing and clinical follow-up.

References

References are available on request at editor@healtalkht.com

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SYNERGIA-2014

Sudha Rustagi Dental College, Faridabad (Haryana)

College festival is a prism, where college students find an array of events and activities to participate in and get valuable recognition. It is the most effective way of bringing youth under the same platform, enhance social interaction and facilitate exchange of cultural ideas and thoughts. Keeping the tradition alive. The Annual Sports & Cultural Meet was held at Sudha Rustagi Dental College, Faridabad, over a period of a week from 8th to 14th March 2014 within the college premises.

The sports events showcased intensive preparation of athletic displays along with some brain ticklers in various categories like Badminton, Football, Volleyball, Throw ball, Kho-Kho, Cricket, Athletics, Carom, Table-Tennis, Chess, Quiz, Antakashri and a lot more. Creative abilities were exhibited in Rangoli, Collage Making, Tattoo Making, Mehndi, Poster Painting, Face Painting, Non-Heat Cooking, Good Out of Waste etc.

The achievements round the year were celebrated in a grand extravaganza on the Annual day held on 14th March in the evening. The college university topper, Mankawar Khurana added to glory of meritorious list and was awarded a cash prize of Rs 5100/-. The winners of all events were felicitated with certificates and medals. The crowd witnessed a unique mix of students who made this event successful with their exceptional talent. The performances presented an amalgamation of traditional Indian as well as Western culture in form of Classical Dance, North-Eastern Bamboo Dance and performances on English Songs. All in all it was a vibrant and an ostentatious display of talent participated equally by the students as well as staff under one roof- **SYNERGIA 2014.**