*IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*
*e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 20, Issue 11 Ser.7 (November. 2021), PP 01-05*
*www.iosrjournals.org*

# Classification of dental materials for retrograde endodontic filling - an overview

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***Abstract:***
*The main goal of endodontic treatment is to provide a three-dimensional hermetic seal of the endodontium from the periodontium. When this is not possible due to a reason which is not conservatively solvable, it is necessary to approach retrograde via endodontic surgery. Retrograde filling materials are obtaining a good hermetic seal of the apex. The ideal retrograde obturation should meet several requirements, but on the market, where is a variability of different materials to serve on this purpose. It is often a difficult clinical decision for the dentist to choose among all of them.*
***Key Word:* endodontic materials, retrograde fillings, MTA, Biodentin, endodontic surgery**

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Date of Submission: 10-11-2021 Date of Acceptance: 26-11-2021

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The main goal of endodontic treatment is to provide a three-dimensional hermetic seal of the endodontium from the periodontium. When this is not possible due to a reason, it is necessary to approach retrograde [1].
Indications for retrograde obturation are when:
• the canals cannot be cleaned and shaped from crown to apex orthograde way;
• presence of a cemented metal / fiber post, the removal of which can cause a fracture or crack in the root;
• a separated instrument cannot be removed conventionally orthographically;
• lack or impossibility of hermetic apical sealing [2].
Retrograde fillings are used during surgical endodontic treatment to obtain a good hermetic seal of the apex. The ideal retrograde obturation material should meet a number of requirements:
- must be biocompatible to periapical tissues;
- it should adhere (ie ideally connect) to the tooth structure;
- must be bactericidal or bacteriostatic;
- it must be stable in volume and not undergo changes after curing and over time;
- must be resistant to dissolution;
- it should stimulate cementogenesis;
- it must not be corrosive and should be electrochemically inactive;
- must not stain tooth or periradicular tissue;
- it should be easily accessible and easy to operate;
- it must allow sufficient working time and then harden quickly;
- must be radiocontrast [3]

A wide variety of dental materials have been developed and offered for this type of obturation. They can be classified as:
- Metals
- Non-metals

1. **Metal retrograde filling materials:** amalgam, gold foil, silver cones, gallium alloys, lead pins, tin foil, titanium pins, gold screws, etc. [4].

1.1 **Amalgam:** Amalgam is a metal alloy that contains mercury as one of its ingredients. It is durable, less technically sensitive, easy to handle, has minimal technical time compared to other materials and its corrosion products seal the apex surface and prevent leakage of bacteria. Some of the disadvantages are local allergic reactions, mercury toxicity and lack of chemical bonding with dentin. The preferred composition of this material for retrograde filling is without zinc, but with a high content of copper [5]. Anderson *et al.* [6] report that the use of a binding agent (4-META) with amalgam significantly reduces its micropermeability. Georgiev *et al.* prove the occurrence of paraesthesia due to displacement of amalgam retrograde obturation of the upper jaw in soft tissues [7].

1.2 **Gold foil:** Years ago, gold foil was considered a first-class restorative material. Some of its advantages due to its use are durability, biocompatibility, creates a smooth surface and has good marginal adaptability. Its disadvantages include its high cost and the requirement for good manual skills of the operator. When applying the placement technology there is a risk of breaking the root at excessive pressure during condensation.

1.3 **Silver cones:** Silver cones cannot obscure the space of the root canal in three dimensions, especially in the apical third of the root, namely where the resection line will be during endodontic surgery. Another disadvantage is the inability to polish the apical part.

2. **Non-metallic retrograde fillers:** zinc-eugenol cement, glass ionomer cement, cavit, zinc-polycarboxylate cement, IRM, Super EBA, zinc-phosphate cement, composite resins, gutta-percha, MTA, Biodentin, bio aggregate, etc.

2.1 **Gutta Percha:** Gutta-percha is the most commonly used material for retrograde and orthograde obturation of root canals. The purpose is hermetic sealing both coronary and apicaly. In endodontic surgery, gutta-percha can be smoothed with both cold and hot methods. Abdal and Retief [8] observe that thermal sealing with gutta-percha provides better sealing compared to amalgam, iRM and Super EBA[9], [10], [11]. Although gutta-percha is a non-absorbable material with good manipulative properties, it also has disadvantages such as sensitivity to moisture, a tendency to depressurize the edges of the obturation during apectomy. Apical sealing depends on the structure of the gutta-percha, the degree of condensation and the quantity and quality of the sealer used.

2.2 **Glass ionomer cement:** GIC is a hybrid of silicate and polycarboxylate cements, which bind physicochemically to dentin and enamel and have anticariogenic activity. Some of its advantages are good biocompatibility, easy manipulation, ability to tightly seal, dentin bonding is done by chemical adhesion[12],[13]. Chong et al.[14] use light-curing GIC, which shows reduced micropermeability and lower sensitivity to moisture, less polymerization shrinkage and deeper penetration of the polymer into the dentinal wall. According to MacNeil K et al[15] the sealing ability of this material is influenced by the contamination of the retrograde cavity with moisture and blood during cementation. The new GICs containing glass-metal powder are considered to have less micropermeability and pathology [16]. Despite the improvements of the GIC over the years they have the following disadvantages: the retrograde preparation must be completely dry, which in most cases is impossible during endodontic surgery [17]. The problem with the cytotoxic effects of freshly mixed glass ionomer cement and the increased hardening time - 5-10 minutes is discussed. It is possible to form hollow spaces between the wall and the filling [18]

2.3 **Composites:** Composite materials in combination with dentin-binding systems have been studied and applied minimally as a means of filling root canals and retrograde cavities. This is due to their cytotoxic and irritant effects on pulp and periapical tissue. They show poorer biocompatibility than amalgams. They are very technologically sensitive and to moisture. The danger of a high monomer content must always be considered. It has an initially high cytotoxicity of 1 month [19]. Despite all the well-known shortcomings of composite materials in endodontic surgery, some authors observe good healing processes of periapical lesions after application of the material. Rud *et al.* [20] reported several prospective and retrospective studies aimed at evaluating composite materials as a retrograde filler. They apply Gluma *in vivo* and compare the results with apical seals with amalgam. Gluma shows a complete healing process in 74%, while amalgam in only 59% of cases.

2.4 **Zinc Oxygenol Cements**: The material is first described by Chisholm during a dental meeting in Tennessee in 1873. It is stable in size, has a suitable surface, is mucostatic and easily manipulable [21]. Allergy to eugenol has been reported in some patients. It hardens quickly but has low strength and high solubility.

2.4.1 **Super EBA:** Contains 60% zinc oxide, 30% aluminum trioxide, 6% natural resin, the liquid is 37.5% eugenol and 62.5% orp / 70-ethoxybenzoic acid. These cements have excellent sealing ability and are non-toxic after curing. The application of Super EBA as a retrograde material is made by Oynick and Oynick [22] in 1978. They report proliferation of collagen fibers on the obturation and support the view of the high biocompatibility of the material with periapical tissues. Baek *et al.* [23] find superiority in Super EBA to amalgam as an obturating agent for endodontic surgery. All zinc oxide-based cements have the following disadvantages: they are sensitive to moisture, cause initial tissue irritation and their resorbability is questionable.

2.4.2 **IRM** (Intermediate reducing material): IRM contains 80% zinc oxide, 20% polymethacrylate, the liquid is 99% eugenol. In a retrospective study of retrograde fillings, IRM is found to have a statistically significantly higher success rate compared to amalgam. Pitt Ford TR *et al.* [24] investigate the effect of IRM on the healing process after reimplantation of 21 molars in monkeys and concluded that the tissue response is better than the control group with amalgam fillings. The addition of 10% and 20% hydroxyapatite to IRM result in significantly better compaction[25]. X-ray contrast is the same as gutta-percha. Toxicity is greatly reduced by increasing the hardening of the cement; the long-term inflammatory potential appears to be minimal. But there are problems with condensation. Curing time varies depending on temperature, humidity and consistency. It should be stored in the refrigerator to slow down the curing time. It also has all the negative effects characteristic of the zinc-eugenol containing fillings mentioned above.

2.5 **Retroplast:** Retroplast is a system developed in 1984 specifically for use as a retrograde obturation material. The composition was changed in 1990, when silver was replaced by ytterbium trifluoride and iron oxide. There is evidence that retroplastic promotes the formation of hard tissue at the top of the root, and according to some authors it is a form of cement. In a limited number of reports of cases of retroplastic retrograde obturations have demonstrated periodontal regeneration with a cement layer on the restoration of the root end [26]. Rud et al [27] also demonstrated excellent long-term clinical success in combination with Retroplast with Gluma.

2.6 **Geristore (Resin-ionomer suspension):** This is a resin-based material and GIC, which was developed in an attempt to combine the different properties of composite resins and GIC [28].

2.7 **MTA (mineral trioxide aggregate):** It was developed at Loma Linda University in the USA by Torabinejad in 1993. It is a powder that consists of fine hydrophilic particles that harden in the presence of moisture. The main molecules that make up MTA are calcium and phosphorus ions supplied by tricalcium silicate, tricalcium aluminate, tricalcium oxide and silicate oxide. The MTA initially has a pH of 10.2, which rises to 12.5 three hours after mixing. The curing time of the cement is 2 hours 45 minutes. The compressive strength of MTA is 40 MPa immediately after curing and increases to 70 MPa up to 21 days later [29]. It is the least toxic of all retrograde obturation materials and has excellent biocompatibility. Hydrophilic in nature, it is not absorbed, but is relatively X-ray-non-contrast. Forms a good marginal seal and stimulates the formation of cement.

An important feature of the material is that it does not deteriorate dramatically in the presence of contamination with blood. According to a number of scientists, the solubility of MTA is significantly lower than other retrograde obturation materials [30], [31],[32]. The properties of MTA such as micropermeability, marginal adaptation and biocompatibility have been widely studied. The sealing ability of MTA was examined by fluorescence staining and confocal microscopy [33], methylene blue [34] and bacterial [35], marginal adaptation [36] was evaluated using CEM testing. All these parameters as physical and mechanical characteristics of the material show the superiority of MTA over other means.

MTA demonstrates excellent biocompatibility in in vitro cell cultures using established cell lines, primary cell cultures or a combination thereof [37],[38]. The tissue response by evaluating a series of osal and subcutaneous implantation experiments [39] prove the high tolerance of the body and periapical tissues to MTA. This material has the ability to initiate deposition of hard tissue, and its mechanism of action may be similar to that of calcium hydroxide [40]. A characteristic tissue reaction after the use of MTA is the presence of connective tissue 7 days postoperatively [41].

The disadvantages of MTA are difficult handling and long curing time. Its price is still high on the market, has no antimicrobial properties and dissolves at acidic pH [42], [43].

**2.8 VERRM (High Viscosity Root Repair Material**): This is a relatively new retrograde obturation material that uses Portland cement as the base material. Bismuth oxide and other compounds have been added to improve X-ray contrast and performance. Hut Kheng Chng et al showed in their study that the physical properties of VERRM are similar to MTA and is biocompatible with periradicular tissues [44].

**2.9 Biodentine:** BiodentineTM was developed by the Septodont research team as a new class of dental material that can combine high mechanical properties with excellent biocompatibility as well as bioactive behavior. BiodentineTM proved to be one of the most biocompatible of all biomaterials in dentistry, as proven by all standard ISO tests, as well as in various preclinical and clinical research collaborations. In addition, reaction dentin formation was demonstrated in rats showing high quality and quantity of protective dentin stimulation with indirect pulp coating [45].

**2.10 Active Biosilicate Technology:** To meet the technological challenge of combining calcium silicate chemistry with the requirements of a formula compatible with classical restorative and endodontic practices, Septodont has developed a new technology platform called Active Biosilicate TechnologyTM. This consists in controlling each step of the formulation of the material, starting from the purity of the raw materials. Active Biosilicate TechnologyTM is a proprietary technology developed in accordance with the state-of-the-art pharmaceutical base applied to the chemistry of ceramic minerals at high temperatures. Septodont is now able to guarantee the purity of calcium silica [46].

**2.11 Bioaggregate:** Bio Aggregate® is a fine white hydraulic powder-cement mixture that uses the advanced science of nanotechnology to produce ceramic particles that, when reacted with water, produce a biocompatible and aluminum-free ceramic biomaterial. The working time of BioAggregate® is at least 5 minutes [47],[48].

**2.12 Bone cement:** Bone cement is common in the practice of orthopedic surgery. Cement shows low cytotoxicity. High and Russell studied cell cultures and the cytotoxicity of amalgam compared to bone cement using an agarose diffusion method on a cultured cell monolayer. Fibroblasts are completely unaffected by bone cement, while amalgam causes cell lysis. Bone cements deliver locally high antibiotics but do not allow high systemic concentrations. It has also been found to be more effective than amalgam in inhibiting bacterial growth. In addition, bone cement tolerates a very humid environment. Blood contamination of bone cement leads to a slight decrease in shear strength and no difference in the mechanical penetration of the cement boundary. These characteristics potentially make it a suitable and desirable retrograde filling material.

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