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Advancements in Obturating Materials for Pulpectomy of Primary Teeth: A Comprehensive Review

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Abstract

A healthy, intact primary tooth acts as the most effective and natural "space maintainer". Primary teeth preserve arch length and function until physiological exfoliation. So, pulpectomy is a crucial treatment for maintaining primary teeth affected by irreversible pulpitis or having a necrosed pulp. Correct choice of obturating material is of paramount importance for the success of pulpectomized teeth. The obturating material must be biocompatible, resorbable at a rate similar to root resorption, it should be non-toxic and radiopaque. This comprehensive review aims to provide an updated overview of the advancements in obturating materials specifically developed or investigated for pulpectomy in primary teeth.

Keywords: pulpectomy, children, obturating materials, root canal filling materials, root canal sealers, novel obturating materials for primary teeth.

Introduction

Primary teeth play a critical role not only in mastication, speech and aesthetics but also, act crucially, as natural space maintainers for the erupting succedaneous permanent teeth.[1] Root canal therapy was advocated as early as 1932, as a method for retaining primary teeth which would otherwise be lost.[1]

For a primary tooth pulp being irreversibly inflamed or necrotic because of deep caries, trauma, or developmental anomalies, pulpectomy has emerged as a vital treatment modality. Primary teeth having necrosed pulp consists of anaerobes residing deep in the dentin and cementum around the periapical area. Thorough debridement with antibacterial irrigating agents is necessary before placement of any obturating material[1] Achievement of a good hermetic seal is the main objective of the procedure of pulpectomy. Obturation creates a fluid tight seal along the length of the root from the coronal opening to the apical system. This eliminates all portals of entry of bacteria and microbes between the periodontium and the root canal system.[2] The success of pulpectomy directly influences the long-term oral health of a child, preventing premature tooth loss, maintaining arch integrity and reducing the likelihood of future orthodontic complications.

Historically, Zinc Oxide Eugenol has been the material of choice for obturation of primary teeth due to its antimicrobial properties. However, ZOE also presents several inherent limitations, including slow and unpredictable resorption rates that can interfere with the eruption of succedaneous permanent teeth and potential for tissue irritation. These drawbacks have driven continuous research and development efforts to identify and evaluate novel obturating materials that offer improved biocompatibility, predictable resorption synchronized with root development, enhanced antimicrobial efficacy and ease of handling.

Optimal requirements of obturating material for deciduous teeth:

According to Rabinowitch [2], the history of the treatment of root canals is the discussion of medication used:

1. It should not irritate the periapical tissues nor coagulate any organic remnants in the canal.
2. It should have a stable disinfecting power.
3. Excess pressed beyond the apex should be resorbed easily.
4. It should be inserted easily into the root canal and removed easily if necessary.
5. It should adhere to the walls of the canal and should not shrink.
6. It should not be soluble in water.
7. It should not discolour the tooth.
8. It should be radiopaque.
9. It should induce vital periapical tissue to seal the canal with calcified or connective tissue.
10. It should be harmless to the adjacent tooth germ.
11. It should not set to a hard mass, which could deflect an erupting permanent tooth.

Rifkin[2] identified criteria for an ideal obturating material used in pulpectomy that include:

1. Resorbability
2. Should have an Antiseptic property
3. Noninflammatory and nonirritating to the underlying permanent tooth germ
4. Good Radiopacity for visualization on radiographs
5. Ease of insertion
6. Ease of removal.
7. Should not cause any tooth discoloration.

Literature search of electronic databases – PubMed and Google Scholar were conducted with time restraints to recent five-year searches.

Discussion

- **Zinc Oxide Eugenol**

It is the conventional and most widely accepted obturating material in primary teeth by paediatric dentists. ZOE was discovered by Bonastre in 1837 and Chisholm introduced ZOE (1876) in dentistry. It was recommended as a root canal filling material in primary teeth for the first time by Sweet (1930). ZOE is composed of powder - Zinc oxide – 69.0%, White rosin – 29.3%, Zinc acetate - 1.0%, Zinc Stearate - 0.7% and the liquid is composed of Eugenol-85%, Olive oil-15%. Eugenol is said to have an anti-inflammatory and analgesic property. These properties are related to the amount of eugenol released in periapical area, which has a synergistic effect in pulpectomy treatment. [3]

➢ **Advantages**

In lower concentrations eugenol showed excellent anti-inflammatory and analgesic properties, radiopacity for good radiographic visibility, easy to manipulate and fill in the canals, easily available and cost effective.[4]

➢ **Disadvantages**

However, it depicted certain disadvantages as well. Zinc Oxide Eugenol when extruded beyond the canals can cause irritation of periapical tissues, leading to necrosis of bone and cementum. ZOE showed slower resorption rates which didn't coincide with that of normal

physiological root resorption. It can also alter the path of eruption of succedaneous tooth.[4]

➢ **Recent observations by authors**

In order to overcome the shortcomings related to Zinc Oxide Eugenol as an obturating material, various researches were conducted. Setty JV et al (2023)[5], assessed the clinical and radiographic efficacy of M. fragrans essential oil with Zinc Oxide Eugenol as obturating material. It showed 100% success rate throughout the follow-up period.[5] Arora P et al (2024)[6], concluded that Zinc Oxide admixed with ozonated oil showed the most promising results in primary endodontically treated teeth.[6] Patel DG et al (2023) [7], revealed 91.7% success in ZOE compared to 100% success in Zinc Oxide with Neem oil for pulpectomy of primary teeth.[7] Gowda J et al (2021)[8], showed that the combination of eugenol with Triclosan was highly effective against E.faecalis in comparison to combination of eugenol with amoxicillin. Triclosan and amoxicillin showed antagonism when used in combination against E.faecalis.[8]

- **Calcium Hydroxide**

Calcium hydroxide is a white odourless crystalline powder having low solubility in water. It has pH of about 12.5. Since, calcium hydroxide is less soluble it can stay for long period of time upon coming in contact with tissue fluids.

The widespread use of Calcium Hydroxide is lining deep restorations, as a temporary intracanal dressing and apexification procedures in permanent teeth. It is also recommended as a final obturation material for pulpectomized primary teeth. It is available as root canal filling material in paste form such as calvital, calen paste, L and C paste, seal apex.[9]

- **Advantages**

Calcium hydroxide has an advantage of easy application. It is non-toxic to permanent successor tooth. It is radiopaque and biocompatible with good antibacterial activity. Calcium hydroxide aids in mineralized tissue formation. It leads to activation of alkaline phosphatase and helps in collagen synthesis. It can also cause hydrolysis of bacterial endotoxin.

- **Disadvantages**

Calcium Hydroxide resorbs earlier than the physiological resorption of the root of primary teeth. This causes development of "hollow tube effect" resulting in inadequate seal against microorganisms. Tissue fluid seeps in the canals eventually becoming a site for infection.[9] Calcium hydroxide when used as obturating material in hyperaemic pulp, can come in contact with some vital pulp tissue remnants and can trigger the cascade of inflammatory root resorption and when used in necrotic pulp produces superficial layer of necrosis causing damage to predentin, which in turn can lead to exposure of dentine to odontoclasts and subsequent resorption.[10]

- **Recent observations by authors**

Govindaraju L, Jeevanandan G (2023)[11], developed a novel obturating material incorporating calcium hydroxide and came to a conclusion that the most effective formulation of the novel obturating material with the greatest antimicrobial property was determined to be 2% 60-40 concentration of metronidazole, calcium hydroxide and zinc oxide.[11] Orhan AI, Tatli EC (2021) [12], evaluated voids in root canal treatment of deciduous molar canals using three obturating materials $Ca(OH)_2$, iodoform-$Ca(OH)_2$ and ZOE cement. The authors found that $Ca(OH)_2$ and iodoform-$Ca(OH)_2$ with ultrasonic activation decrease void formation.[12] Qasem FA, Awad SM, Elagamy RA (2024)[13], evaluated the efficacy of

calcium hydroxide combined with gingerols (Ginge-Cal) as a novel obturation material for treating infected primary teeth and decreasing the recurrence of infection. Ginge-Cal showed 87.5% success and can be considered a promising material for treating the infected root canal when used as an obturation material for the infected root canal.[13] Qamar S, Jayanna R, Ahuja VR (2023)[14], compared and evaluated the antimicrobial efficacy against Enterococcus faecalis (E.faecalis) between a mix of calcium hydroxide powder and normal saline, a mix of calcium hydroxide powder and 2% chlorhexidine gluconate solution, a mix of triple antibiotic powder (TAP) and normal saline, and mix of TAP and 2% CHX gluconate solution. The authors concluded that Triple antibiotic powder (TAP) mixed with 2% CHX gluconate solution has superior antimicrobial efficacy against E. faecalis in primary teeth.[14]

- **Vitapex/ Metapex**

Vitapex as a root canal filling material for primary teeth was introduced by Kawakami et al. in 1979. This material contains calcium hydroxide, iodoform, along with silicone oil. Vitapex is composed of Iodoform – 40.4%, Calcium hydroxide – 30.3% and Silicone oil – 22.4%. The iodoform is a known bactericide that is released from the sealer and suppresses any residual bacteria in the canal or periapical region. Vitapex is highly resorbable and resorbs within one week to three months when extruded beyond the apex of a primary tooth, without causing foreign body reaction. Its rate of resorption from within the canals is faster than physiological root resorption. It is radiopaque and does not set to a hard mass. Bone regeneration has been clinically and histologically documented after using iodoform and calcium hydroxide mixtures.[15]

- **Recent observations by authors**

Mekkriangkrai D, Nakornchai S, Jirarattanasopha V (2023)[16], evaluated success rate and resorption rate of Vitapex pulpectomy. The authors concluded that the success rate of Vitapex pulpectomy decreased time dependently and was related to the patient's age at treatment and a preoperative lesion. The Vitapex resorption was faster than root resorption and was associated with the patient's age at treatment and the root filling extravasation.[16] Khadilkar AS et al (2024)[17], compared and evaluated Endoflas, Metapex and a mixture of Calcium hydroxide and Zinc Oxide as obturating materials in primary mandibular second molars. The authors showed similar clinical success rates among the three obturating materials.[17] Kumar KS et al (2022)[18], aimed to assess clinically and radiographically the success of Zinc Oxide eugenol, metapex and endoflas as root canal obturating materials in primary teeth at 3,6 and 9 months of time intervals. The clinical survival variable showed 100% survival proportion for zinc oxide eugenol and endoflas, while for metapex it was 69% at the end of 9 months. The radiographical survival proportion was 100% for zinc oxide eugenol, followed by endoflas at 92% and 58% for metapex group.[18] However, Ou-Yang LW et al (2021)[19], reported that the radiographic success rates for ZOE and Metapex were: 85.9% and 82.9% at the 12-month recall, and 69.2% and 64% at the 24-month recall, with no statistically significant difference between the two groups. The authors concluded that the radiographic success rates are comparable between the ZOE and Metapex groups.[19]

- **Iodoform**

Iodoform based paste has been advocated for use as a root canal obturating material as it does not cause any foreign body reaction in the periapical tissue. It resorbs easily when extruded beyond the periapex. It shows

effective germicidal properties with no side effects to the succedaneous teeth. It is easy to handle and can be easily pushed into the canals as well as into the accessory canals. Some studies have stated that this material resorbs at the same time as the roots of the primary teeth resorb. The only disadvantage of the material is that the rate of resorption of the material within the canals is faster than the rate of physiological root resorption. It also causes yellowish-brown discoloration of the teeth.[20]

➢ **Recent observations by authors:**

Junior MFS et al (2022) [21], reviewed the effectiveness of iodoform-based materials compared to non-iodoform-based filling materials in the root canal treatment of deciduous teeth and found that Iodoform-based filling materials showed better clinical and radiographic performance when compared to non-iodoform-based filling materials in the short term, and similar performance in the long term.[21] Govindaraju L et al (2024)[22], compared and evaluated the antimicrobial efficacy of the novel obturating material with the augmentation of iodoform. It was observed that there was no statistically significant difference found when iodoform was added to the novel obturating material against both S. mutans and E. faecalis. Due to the undesirable effects of iodoform on primary teeth, a novel obturating material should be developed without the addition of this component and, at the same time, provide maximum antimicrobial effect.[22] Jahan I et al (2024)[23], assessed the therapeutic efficacy of zinc oxide eugenol mixed with calcium hydroxide and iodoform, through a comparison of clinical and radiological outcomes with those of conventional zinc oxide eugenol in pulpectomy of primary teeth at 3rd and 6th month postoperative period. The authors concluded that zinc oxide eugenol mixed with calcium hydroxide and iodoform can be regarded a better effective alternative to zinc oxide eugenol alone as an obturation material for pulpectomy of primary teeth.[23]

- **Walkhoff Paste**

It consists of Iodoform, Parachrolophenol 33-37%, Camphor 63-67% and Menthol crystals 1.40-2.90%. Non-vital teeth associated with large periapical lesions can be treated with this paste.

➢ **Advantages**

Walkhoff's paste constitutes zinc oxide and paraformaldehyde. Due to its strong antimicrobial properties and excellent sealing ability it is used in paediatric endodontic practice. Its germicidal action is because of the presence of formaldehyde, which effectively sterilizes the canal and helps in preventing reinfection. The paste also exhibits good radiopacity, allowing for easy post-operative assessment. Additionally, it has slow resorption characteristics, which ensures a stable fill until the natural exfoliation of the primary tooth. (Sain et al., 2015).[24]

➢ **Disadvantages**

Walkhoff's paste has several shortcomings that limit its use in modern pediatric endodontics. The prime concern lies in its toxic potential due to the presence of paraformaldehyde, which can cause severe irritation or necrosis if extruded beyond the apex. This raises concerns about its biocompatibility, especially near developing permanent tooth buds. Additionally, its poor resorption rate relative to the physiological root resorption of primary teeth may interfere with natural exfoliation and successor eruption. (Tronstad, 1981; Reddy & Ramakrishna, 2010). [25,26]

- **KRI Paste**

KRI, basically an iodoform paste, was introduced by volkoff as a resorbable paste suitable for root canal filling. It consists of iodoform (80.8%), camphor (4.86%), para chlorophenol (2.025%), and menthol

(1.215%). It is radiopaque. Camphor and menthol are mixed with the antimicrobial agent and para chlorophenol, to minimize coagulation with adjacent tissues. Iodoform is added as a vehicle to carry the antimicrobial agent as it is a non-irritant and radiopaque.[27]

According to Rifkin, it meets all criteria required for being an ideal root canal filling material for primary teeth. It was also found to have long-lasting bactericidal potential. Overall success rate for KRI paste was 84% versus 65% for ZOE.[28]

➢ **Advantages**

KRI paste resorbs rapidly and has no undesirable effects on succedaneous teeth. Also used as a root canal medicament in abscessed primary teeth with no harmful effects. Rate of resorption of the extruded material is faster than the tooth root, sometimes the material also resorbs inside the canal, has long lasting bactericidal potential. Does not set into hard mass and can be removed if retreatment is required.

➢ **Disadvantages**

Yellowish brown discoloration of the tooth, hollow tube effect may be seen because of the quick resorption compared to tooth roots.

- **MAISTO Paste**

Maisto introduced it in 1967. It is an iodoform based paste. It consists of Zinc oxide -14g, Iodoform-42 g, thymol-2 g, Chlorophenol camphor-3 cc, lanolin – 0.5 g. It differs from KRI paste, in that it also contains Zinc oxide, thymol and lanolin. It reduces the resorption rate of the paste from within the canals of endodontically treated primary teeth.

➢ **Advantages**

Maisto paste, a formulation comprising zinc oxide, eugenol, paraformaldehyde, and camphorated phenol, has been used in pediatric endodontics for its strong antibacterial and fixative properties. Its ingredients provide effective canal disinfection and good sealing ability, which help in minimizing post-treatment infections. The paste's radiopacity also allows for easy evaluation of the obturation quality.[29]

➢ **Disadvantages**

Despite its bactericidal benefits, Maisto paste has notable disadvantages, especially concerning biocompatibility. The inclusion of paraformaldehyde can lead to toxicity and irritation of periapical tissues, especially if the material is overextended. Moreover, Maisto paste tends to resorb slower than primary root structure, which can interfere with the eruption of permanent successors and lead to foreign body reactions.[30]

- **Guedes – Pinto Paste (1981)**

Guedes-pinto in 1981 proposed a root filling material for primary teeth named as guedes- pinto paste (GPP), Composed of rifocort, camphorated para chlorophenol and iodoform. The paste is made up of one equal part of each component, mixed on a sterilized glass plate.[31]

➢ **Advantages**

Guedes-Pinto paste, composed of iodoform, camphorated paramonochlorophenol, and rifampicin, offers strong antibacterial action and is resorbable, making it suitable for use in primary teeth. It adapts well to canal walls and provides effective disinfection, with studies reporting high clinical success rates in pulpectomy cases (Fuks et al., 1996).[32]

➢ **Disadvantages**

Despite its benefits, Guedes-Pinto paste may cause discoloration of the tooth due to rifampicin and has a risk of early resorption, potentially compromising long-term canal sealing. Additionally, concerns exist about the use of antibiotic-based materials contributing to resistance (Ramar and Mungara, 2010).[33]

- **Endoflas**

Endoflas is a resorbable paste manufactured in South America available in powder liquid form.[34]

➢ **Advantages**

Endoflas is a hydrophilic material that can be used in mildly humid canals and firmly adheres to root canal surfaces, ensuring a good seal. With its broad-spectrum antibacterial activity, it effectively disinfects dentinal tubules and hard-to-reach accessory canals that cannot be mechanically cleansed. Unlike other pastes, Endoflas resorbs only when extruded extra-radicularly but remains stable intra-radicularly, preventing washout (Fuks et al., 2002).[34]

➢ **Disadvantages**

Eugenol content can cause periapical irritation. It also has a drawback of causing tooth discoloration.[34]

➢ **Recent observations by authors**

Elicheria SR et al (2022) [35], reviewed the clinical and radiographic success of Endoflas compared with other root canal obturating materials in primary teeth and found that there was a dramatic reduction of inter radicular radiolucency in Endoflas obturated teeth compared to other root canal filling materials. Even for resorption of the extruded material beyond the apex too, Endoflas depicted a faster clearance rate. Hence, it was concluded that, Endoflas can be a potential root canal obturating material for treating the primary teeth, even with furcal radiolucency.[35] Kale YJ et al (2024)[36], comparatively evaluated the microleakage of Zinc Oxide Eugenol and Endoflas as obturating materials using different root canal irrigants in primary teeth. The authors concluded that Endoflas FS exhibits less apical microleakage than ZOE as an obturating material in primary teeth. Endoflas proved to have better sealing ability.[36] Singh S et al (2025)[37], evaluated Zinc Oxide-Eugenol, Zinc Oxide-Propolis and Endoflas as obturating materials in primary molar pulpectomies and concluded that Endoflas and a combination of zinc oxide powder with propolis can be a promising material as an alternative to Zinc Oxide Eugenol alone for obturation in primary teeth.[37]

- **Herbal obturating materials**

➢ **Curcumin**

The scientific name of turmeric is Curcuma longa L. Zingiberaceae, the crude extract of which consists of 70%-76% curcumin along with 16% demethoxycurcumin and 8% bismethoxycurcumin as well as volatile oils (tumerone, atlantone and zingiberene).[38] Curcumin is a natural extract from the rhizomes of the Curcuma longa plant and is famous for its extensive therapeutic properties. It has anti-inflammatory, antioxidant and anti-carcinogenic properties. It is a known broad-spectrum antimicrobial agent and has been used as a root canal irrigant and medicament to achieve disinfection in endodontic procedures. It has also been used as a pulpotomy agent and as an obturating material for primary teeth.[39] Sahiti PS, Kamatham R (2023)[38], comparatively evaluated a modified endodontic approach using Curcum longa L. and conventional pulpectomy in primary molars and found out that 12-month clinical success rate was 92% for turmeric and 100% for metapex. No statistically significant differences were found between the groups at different follow-ups.[38] Dalal R et al (2023)[39], evaluated the success of natural compound curcumin as an obturating material in primary teeth and concluded that considering the antibacterial and anti-inflammatory properties of curcumin it cannot be suggested as a successful alternative for obturation in deciduous teeth.[39] Bommareddy CS et al (2022)[40], clinically and radiographically evaluated curcumin as an obturation material in deciduous teeth and found the success rates as follows: Metapex > calcium hydroxide >

curcumin and calcium hydroxide > Curcumin. [40] Sunil et al (2023)[41], urged that ZnO with Curcumin had shown promising clinical and radiographic results and can be used as a root canal filling material in further follow-up studies.[41]

➢ **Ocimum sanctum (Tulsi extract)**

It contains approx. 0.7% volatile oil consisting mainly of eugenol (71%). The concentration of eugenol contributes to its antimicrobial efficacy. The antimicrobial effectiveness of Ocimum sanctum extract against E. faecalis is believed to be comparable to that of ZOE. A mixture of calcium hydroxide and tulsi extract prepared to a homogeneous consistency is effective for endodontic therapy of primary teeth. As an obturating material it demonstrated excellent clinical and radiographic success, comparable to the calcium hydroxide-iodoform mix (Metapex).[42]

➢ **Zinc oxide-ozonated olive oil mix**

It has bactericidal action, debriding effect, angiogenetic effect with high oxidizing power. Ozone has considerable antimicrobial efficacy without the development of drug resistance. EL-Desouky SS et al (2023)[43], evaluated zinc-oxide ozonated olive oil mix as a new root canal filling material and concluded that it had shown good clinical and radiographic success for primary teeth pulpectomy.[43]

➢ **Zinc oxide Eugenol propolis**

It can also serve as a remarkable obturating material for pulpectomy of non-vital primary molars. Gupta S et al (2025)[44], evaluated the efficacy of propolis and its combination products as an obturating material in comparison to Vitapex. The authors concluded that zinc oxide in combination with propolis resorbed at the same pace as that of the roots. Efficacies of different obturating materials were observed as ZnOP > ZnO{$Ca(OH)_2$}P > $Ca(OH)_2$P > Vitapex. [44]

- **Other obturating materials**

➢ **Chitra Hap-Fill**

Hydroxyapatite nanoparticle gel-based material closely resembles the mineral content of bone and dentin, making it highly biocompatible and fulfilling all the requirements of an ideal pulpectomy material. Chitra hap-fill consists of hydroxyapatite nanoparticles (65%). It also contains pure iodoform (32%) to provide antibacterial properties. The paste adhere well to canal walls, does not shrink after filling and does not react chemically with dentin preventing tooth discolouration. Additionally, Chitra HAP-Fil exhibits superior antimicrobial activity against pathogens like Staphylococcus aureus, enhancing its effectiveness in disinfecting root canals.

Conclusion

The advancements in obturating materials have significantly improved the treatment outcomes of pulpectomies in primary teeth, moving beyond the traditional zinc oxide eugenol (ZOE). Newer alternatives in obturation of deciduous dentition have offered superior properties such as enhanced biocompatibility, more predictable resorption and improved handling characteristics. The ultimate success of a pulpectomy depends on the careful selection of a material that aligns with the tooth's stage of development and the clinician's expertise. Future research should focus on long-term clinical trials with larger sample sizes to establish definitive guidelines for the use of these materials, ensuring optimal outcomes and preserving the natural function of the primary dentition.

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