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Filling the Gaps: An Insight into Obturating Materials and Techniques for Primary Teeth in Children - A Narrative Review

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Abstract: ***Pulpectomy remains a cornerstone in preserving severely infected or necrotic primary teeth, with the success of the procedure heavily reliant on the choice of obturating material and technique. This narrative review explores the evolution, properties, and clinical implications of various obturating materials used in primary teeth—including Zinc Oxide Eugenol, calcium hydroxide-based pastes, iodoform-containing materials, and newer biocompatible alternatives like hydroxyapatite and SmartSeal. Additionally, it evaluates common obturation techniques such as hand condensation, syringe delivery, paper point technique, and newer innovations like the ObturaGun. The review emphasizes the ideal requirements for a successful obturating agent—biocompatibility, resorbability, antimicrobial efficacy, and compatibility with physiologic root resorption—and aims to guide clinicians in evidence-based material selection for pediatric endodontics.***

Keywords: obturation, Obturating materials, obturating techniques, primary teeth obturation

1. Introduction

The primary objective of root canal obturation is to replace the pulp tissue with an inert filling, preventing exposure to peri-radicular fluids that could support microbial growth. Naidorf emphasized that inadequate obturation can lead to bacterial localization, while Ingle and Beveridge attributed 58% of endodontic failures to incomplete obturation.

Pulpectomy in primary teeth is indicated for necrotic radicular pulp to maintain arch integrity. Despite thorough biomechanical preparation and antibacterial irrigation, residual bacteria can persist due to complex canal morphology. Thus, an ideal obturating material should be biocompatible, eliminate pathogens, neutralize toxins, and prevent reinfection, fostering a favorable healing environment.

Zinc oxide eugenol (ZOE) remains the most common obturating material, though it presents challenges like delayed resorption and potential toxicity. To address these concerns, alternative materials such as calcium hydroxide-iodoform combinations (Metapex, Vitapex), Endoflas, and herbal derivatives have demonstrated promising outcomes.

This review aims to explore the evolution of obturating materials in clinical practice, assessing their antibacterial properties, toxicity, and biocompatibility along with a description about different obturating techniques in primary teeth.

Definition

Obturate: To fill the shaped and debrided canal space with a temporary or permanent filling material. Obturation technique: The method used to fill and seal a cleaned and shaped root canal using a root canal sealer and core filling material. [68]

Ideal Requirements of Root Canal Filling Material

Grossman modified Brownlee's 5 criteria for the ideal root canal filling material and listed the following criteria for an ideal root canal filling material:

1) It should be easily introduced into the root canal.
2) It should seal the canal laterally as well as apically.
3) It should not shrink after being inserted.
4) It should be impervious to moisture.
5) It should be bacteriostatic or at least not encourage bacterial growth.
6) It should be radiopaque.
7) It should not stain tooth structure.
8) It should not irritate peri-radicular tissues.
9) It should be sterile, or easily and quickly sterilized, immediately before insertion.
10) It should be removed easily from the root canal, if necessary. [68]

Criteria for an ideal Pulpectomy obturant (Rifkin)

1) Resorbability
2) Should have an Antiseptic property
3) Non-inflammatory and nonirritating to the underlying permanent tooth germ,
4) Good Radiopacity for visualization on radiographs,
5) Ease of insertion, and Ease of removal.
6) Should not cause any tooth discoloration. [68]

Optimal requirements of obturating material for deciduous teeth by Rabinowitch

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. [68]

Points to be Noted While Obturating:

The canal should be adequately dry, without any bleeding or serous fluid discharge. Optimal cleaning and shaping are more easily achieved in teeth with vital pulp tissue, whereas extra care is required when managing necrotic and infected pulp. Treatment failure is more common in teeth with pre-existing peri-radicular radiolucency compared to those without such changes. In such cases, strict clinical protocols must be followed to determine the appropriate timing for obturation. Excessive seepage into the root canal can be managed by re-instrumentation, canal enlargement, thorough irrigation, and sealing with an intracanal medicament like calcium hydroxide paste.[67]

Obturating Materials Used In Primary Teeth:

Zinc Oxide Eugenol

Zinc oxide eugenol is one of the most widely used materials for root canal filling of primary teeth. Bonastre (1837) discovered zinc oxide eugenol and it was subsequently used in dentistry by Chisholm(1876). Zinc oxide eugenol paste was the first root canal filling material to be recommended for primary teeth, as described by Sweet in 1930. It was the only material explicitly recommended in the clinical guidelines developed by the AAPD until 2008.

Advantages

It is an excellent antibacterial and analgesic effects (in lower concentrations). Radiopaque for good radiographic visibility, easy to manipulate and fill in the canals, Insoluble in tissue fluids, Easily available, Cost effective, causes no tooth discoloration.

Disadvantages

Zinc oxide eugenol (ZOE) resorbs much slower than primary tooth roots, potentially causing issues if it remains after tooth exfoliation. This delayed resorption is due to the formation of a fibrous capsule around the extruded material. If overfilled beyond the apex, the eugenol component can irritate surrounding tissues, leading to inflammation and bone resorption. Additionally, its slow resorption may interfere with the development and eruption of the underlying permanent tooth, causing tooth bud deflection. ZOE also has limited biocompatibility and may trigger a foreign body reaction when extruded periapically, resulting in granulation tissue formation.

Outcomes of ZOE pulpectomy:

Enamel defects of succedaneous teeth following ZOE pulpectomies on extrusion of material. Coll and sadrian in 1996 stated that there is no relationship between primary teeth pulpectomy and enamel hypoplasia. Holan etal in 2011 reported that succedaneous incisors that replace traumatized primary incisors treated with ZOE pulpectomies have 2-3 times higher incidence of enamel defects compared to normal teeth.

Author's and their observations on ZOE:

Authors	Contributions
Allen [8]	Speculated that the resorption rate of zinc oxide eugenol (ZOE) and the root differed, resulting in small areas of ZOE paste possibly being retained
Barker and Lockett [6]	Material when extruded from the apex cause a mild foreign body reaction
Barker and Lockett [6] Spedding [11] Mortazavi and Mesbahi [2]	Stated that extruded ZOE resisted resorption and took months or even years to resorb
Coll and Sadrian [17]	Pulpectomized teeth rarely exfoliate later than normal and timing of exfoliation was not related to retention of ZOE paste. Anterior cross-bite, palatal eruption, and ectopic eruption of the succedaneous tooth following ZOE pulpectomy.
Coll et al. [15]	Reported that when ZOE extrudes, it develops a fibrous capsule that prevents resorption of the material. Thus, it has a slow rate of resorption and has a tendency to be retained even after tooth exfoliation. Areas of cementum resorption were evident, periodontal ligament exhibited intense and moderate thickening. Dentin resorption was not observed, whereas bone resorption was found.
Cox et al. [7]	Zinc oxide powder had no inhibitory effect and the addition of eugenol to zinc oxide retarded the growth of only the gram-positive organisms. The inclusion of zinc acetate as a setting accelerator inhibited both gram positive and gram-negative bacteria.
Erasquin et al. [5]	Reported that the canals overfilled with (ZOE) are not recommended because it irritates the periapical tissues and causes necrosis of bone and cementum.
Flaitz et al. [16] Coll and Sadrian [17]	Observed deflection of permanent tooth eruption in 20% of pulpectomized tooth that were extracted
Garcia-Godoy [12], Ranly and Garcia-Godoy [13], Praveen et al. [14]	Reported deflection of developing permanent tooth bud because of its hardnes
Hashieh et al. [20]	Studied the beneficial effects of eugenol. The amount of eugenol released in the periapical zone immediately after placement was 10-4 and falls to 10-6 after 24 hours, reaching zero after one month. Within these concentrations eugenol is said to have anti inflammatory and analgesic properties that are very useful after a pulpectomy procedure
Holan and Fuks [4]; Moskovitz and Samara [10]	Malformation of successor is attributed to the cytotoxic and neurotoxic nature of eugenol
Jerrell and Ronk [9]	Reported a case of developmental arrest of a premolar following overfilling of the root canal of the

	second primary molar using zinc oxide-eugenol/formocresol paste
Loevy [18]	Premolars erupt early after primary teeth pulpotomies. Possibly a mild chronic inflammation exists in periapical area of some pulpectomies judged successful that is not clinically evident. This could cause premature eruption of succedaneous tooth and uneven resorption of pulpectomy treated tooth.
Praveen et al. [14]; Sunitha et al. [21]	Excess material forced through the apex during filling procedures can remain in the apical tissue during the process of physiological root resorption and it takes few months or even years to resorb
Sadrian and Coll [19]	Demonstrated that none of the retained ZOE particles caused any observable pathology and were also not related to treatment failure

Iodoform Based Paste:

Iodoform

Iodoform is a preparation of iodine obtained by action of chlorinated lime upon an alcoholic solution of potassium iodide heated at 1040 degree F. It Relieves pain, and is a potent disinfectant. Better resorbability and disinfection properties than ZOE, may produce a yellowish brown discoloration of the tooth.

Walkoff 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

Walkoff's paste, composed primarily of zinc oxide and paraformaldehyde, has been historically used in pediatric endodontics due to its strong antimicrobial properties and excellent sealing ability. Its germicidal action stems from the formaldehyde component, 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. In clinical settings, Walkoff's paste has shown adequate success rates in pulpectomized primary teeth when used with caution regarding dosage and placement (Sain et al., 2015).[106]

Disadvantages

Despite its advantages, Walkoff's paste has several critical drawbacks that limit its use in modern pediatric endodontics. The main concern lies in its toxic potential, primarily due to 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. Because of these concerns, Walkoff's paste is largely considered outdated, with many clinicians opting for more biocompatible and resorbable alternatives like calcium hydroxide-based pastes (Tronstad, 1981; Reddy & Ramakrishna, 2010).[107, 108]

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 a radiopaque endodontic root filling. 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.

According to rifkin, it meets all criteria required from 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.

Kri-1: In 1989, a procedure was published for root canal preparation and filling in necrotic primary molars with a paste made of Kri-1 and pure calcium hydroxide obtaining a high percentage of success with remission of all symptoms. This was the first publication in which formaldehyde was mentioned as a component of root canal filling material, thus partly recovering Buckley's formula, which contained 40% formaldehyde and glycerine.

Concerns regarding formaldehyde constituent in these materials

Formaldehyde, like other aldehydes, quickly binds to organic substance, thus originating albumin-formaldehyde with high permeability and penetration capacity. It is metabolized in acid form, carbon dioxide and amino acid radicals, and its biodegradation primarily occurs at the hepatic level and to a lower degree, at the pulmonary and renal levels. When metabolized, part of the drug fixes on different body tissues (mainly liver and kidney), although only 1% of the dose applied on each tooth is usually absorbed. Thus, a diluted formaldehyde formulation has been recommended. [4]

KRI-3: This liquid differs from commonly used KRI-1 paste in that its parachlorophenol, camphor and menthol concentration are twelve times superior and hence possess greater antimicrobial properties.

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. Fuks AB etal in 2000 found that the KRI paste was more successful than ZOE on long term follow up.

Disadvantages

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

Holan G et al. (1993) found that the success rates of 84% with KRI paste group verus 65% with ZOE group. Overfills

more successful with KRI paste - 79% versus ZOE-41%.The excess paste will resorb without causing any adverse side effects. [4]

MAISTO PASTE

Maisto introduced it in 1967. Tagger et al. used it as root canal filling material in primary teeth. It is an iodoform based paste developed by Maisto and used clinically for many years with good results reported. 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. Pabla T et al (1997) evaluated the antimicrobial efficacy of Zinc Oxide Eugenol, Iodoform paste, KRI paste, Maisto paste and Vitapex against aerobic and anaerobic bacteria from infected nonvital primary anterior teeth. Order of antimicrobial activity: Maisto paste > Iodoform paste> Zinc Oxide Eugenol> Vitapex.

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. Studies have reported satisfactory clinical outcomes, particularly in cases of necrotic primary teeth where complete sterilization is essential (Fuks et al., 2002).[109]

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. Due to these concerns, its use is largely discouraged in contemporary practice, and more resorbable and tissue-friendly alternatives are preferred (Primosch et al., 2005).[110]

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. Study by Praetzel confirms that GP paste had a favorable antimicrobial action along with an exceptional diffusion capability against all the microorganisms. Antimicrobial action of GP occurred in decreasing order against: Bacillus subtilis, Streptococcus oralis, Streptococcus mutans, Staphylococcus epidermis, Escherichia coli, Staphylococcus aureus and Enterococcus faecalis.

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).[111]

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).[112]

Calcium Hydroxide

Calcium hydroxide is a white odourless crystalline powder. It has low solubility in water (a good clinical characteristic because a long period is necessary before it becomes soluble in tissue fluids when in direct contact with vital tissues.) It has high pH about 12.5.

Leonardo et al in 1982 recommended the addition of other substances to the paste.

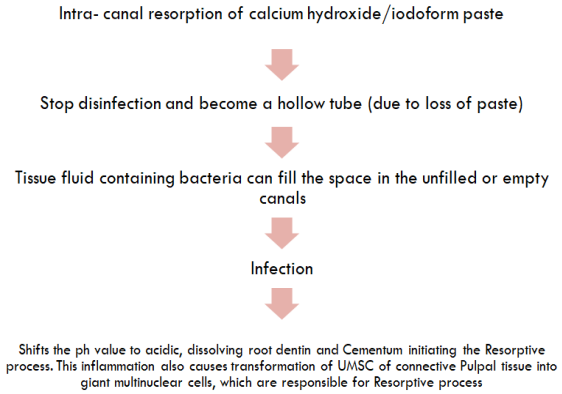
To preserve the paste consistency without hardening, enhance flow, and sustain the high pH of calcium hydroxide, to improve radiopacity and to make clinical use easier.

Advantages:

This material was found to be easy to apply. It has no toxic effects on permanent successor. Radiopaque, Biocompatible, Antibacterial activity, Induction of mineralized tissue formation, Activation of alkaline phosphatase and collagen synthesis and ability to produce hydrolysis of bacterial endotoxin.

Disadvantages

Pulp obliteration occurs due to its osteogenic potential, leading to calcific metamorphosis and root canal obliteration. In primary teeth, it can induce internal resorption by overstimulating undifferentiated mesenchymal cells, activating odontoclasts, and causing dentin resorption. It lacks adhesion to hard tissue, resulting in an inadequate seal against microleakage and bacterial infiltration. Additionally, it tends to deplete from the canal and resorbs faster than the physiological resorption of the roots. Fast resorption causes voids in the canal leading to Hollow tube effect (Goldman and Pearson 1965)



Antibacterial properties of Ca(OH)2 reported by various authors

Authors	Contributions
Abdulkader et al. [54]	Calcium hydroxide associated with distilled water, saline, glycerine was ineffective against several obligatory and facultative anaerobic bacteria
Estrela et al. [55]	Verified influence of antibacterial potential of Ca(OH)2 against Staphylococcus aureus, Enterococci faecalis, Pseudomonas aeruginosa, Bacillus subtilis, and Candida albicans and showed significant effectiveness for Ca(OH)2 paste or iodoform plus saline

Pitts 1984 studied the absorbable nature of Calcium Hydroxide. He found that significant wash out of apical plugs of Calcium Hydroxide occurred during the first month after placement. By the ninth month, plugs were virtually gone from the apical portion of the root canal. Adjacent to remaining Calcium Hydroxide particles, giant cells but no inflammatory cells were seen. Poor success rates were reported due to high occurrence of internal resorption by Via and Shroeder. Clinical Studies have reported a success rate of 80 to 90% with this material as an obturant. Heithers in 1975 reported that Ca(OH)2 can be used as a root canal dressing in teeth with large periapical lesions and in cases where it was necessary to control the passage of periapical exudates into the canal. Matsumiya and kitanuma 1960 considered that Ca(OH)2 accelerated the natural healing of periapical lesions, regardless of the bacterial statistics of root canal at the time of placement of material.

VITAPEX/METAPEX

Vitapex was introduced by Kawakami et al in 1979. Metapex and vitapex are available in preformed syringes, which is directly placed into the canals and the , material is extruded by simple pressure. A lot of researchers considered this mixture as nearly an ideal root canal filling material for primary tooth, owing to its excellent properties.

Composition of vitapex

Calcium hydroxide: 30.3% of the composition. It stimulates "blast" cells. It also neutralizes endotoxins produced by anaerobic bacteria. Iodoform: 40.4% of the composition. For radiopacity Silicone oil: 22.4% of the composition. It acts as a vehicle for the other ingredients.

Composition of metapex

Iodoform (For radiopacity) – 37%, Calcium hydroxide (alkaline) – 36 %, Polydimethylsiloxane – <27%

Advantages

The material is non-toxic to the permanent successor tooth and exhibits good antiseptic action. It adheres well to canal walls and remains in a paste-like consistency without hardening. Its resorption occurs slightly faster than the roots, with complete resorption of excess paste expected within 2–8 weeks. Additionally, it is easy to apply and radiopaque, ensuring better radiographic visibility.

Disadvantages

Iodoform-based material resorbs if pushed beyond the apex; however, its resorption rate is faster than that of the roots. It can cause tooth discoloration, and the rapid elimination of iodoform by the body may create empty spaces within the root canal, potentially compromising endodontic success. This fast resorption can lead to voids in the canal, resulting in the "hollow tube effect" as described by Goldman and Pearson (1965).[2]

Prevention:

Mortazavi and Mesbahi (2004) : 2 visits

- Formocresol pulpotomy – 1st visit
- Preparation and obturation of canals in 2nd visit
- Foreign body gaint cells chemically fixed and thus losing their ability to resorb the vitapex paste.

Antibacterial properties of metapex as reported by various authors

Authors	Contributions
Kriplani et al. [46]; Harini priya et al. [52]	Metapex has lowest antibacterial activity when compared to ZOE, Vitapex and Calcium hydroxide. However, it showed moderate activity against Streptococcus pyogenes, Staphylococcus aureus, Enterococcus feacalis, Escherichia coli and Pseudomonas aeruginosa but failed to inhibit Candida albicans. So, it was concluded from their study that ZOE>vitapex>Ca(OH)2>metapex.
Seow et al. [56]	The weak antimicrobial activity of metapex may be partially explained by the facts that calcium hydroxide, an ingredient of metapex has been demonstrated to interfere with the antiseptic capacity of dyadic combinations of endodontic medicaments
Tchaou et al. [50]	Calcium hydroxide with iodoform had exhibited no antimicrobial activity

Nurko et al. (1983) said that vitapex has success rate of 96 to 100% when extruded into furcal or apical area. Trairatvorakul C (2008) Vitapex appeared to resolve furcation pathology at a faster rate than zinc oxide-eugenol at 6 months, while at 12 months, both materials yielded similar results.

ENDOFLAS

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

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).

Disadvantages

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

Antibacterial properties of Endoflas reported by various authors

Authors	Contributions
Hegde et al. [59]	Endoflas™ moderately inhibited and the gram-negative of gram-positive organisms and showed strong inhibition Candida albicans
Pelczar et al. [58]	The high antimicrobial activity of Endoflas™ was probably due to the presence of iodoform and eugenol, both of which have antibacterial action. Eugenol acts by protein denaturation, while iodoform is an oxidizing agent. Even after the material sets, surface hydrolysis of the chelate (zinc eugenolate) results in release of eugenol, thus explaining the effective antibacterial activity of this substance even after 72 hours

Navit S et al 2016 evaluated the antimicrobial efficacy of obturating materials against E. faecalis, amongst all the groups Endoflas had significantly higher zone of inhibition. Antimicrobial efficacy of various materials according to this study can be summarized as follows: Endoflas > ZOE >Calcium hydroxide + Chlorhexidine > Calcium hydroxide + lodoform +Distilled water ~ Metapex > Saline. Rewal etal, indicated that Endoflas with a success rate of 100% is a superior material compared to ZOE. Ramar and Mungra etal compared the clinical and radiographic evaluation of Metapex, RC fill and Endflas for a duration of 9 months. Results showed that Endoflas gave an overall success rate of 95.1%, metapex 90.5% and RC fill 84.9%. Praveen et al (2011) cited that the hydrophilic property of Endoflas made obturation compatible in even mildly humid canals. Owing to its broad spectrum of antibacterial activity, it can disinfect dentinal tubules and difficult to reach accessory canals which cannot be cleansed mechanically.

Newer Obturating Materials:

ZOE / ZO and Combinations

Combination	Author	Observation
Zinc oxide + Propolis (ZOP)	Al-Ostwani et al. [26]	ZOP paste was synthesized by mixing 50% zinc oxide powder with 50% hydrolytic propolis. There was acceptable clinical and radiographic success rate with faster resorption seen in some cases.
Zinc oxide + Ozonated oil	Chandra et al. [25]	It has biological properties such as, bactericidal action, debriding effect, angiogenesis stimulation capacity and high oxidizing power (Guinesi et al., 2011). After 12 months followup there was progressive bone regeneration at the periapical region with good clinical and radiographic success rate.
Zinc oxide eugenol (ZOE)+ Calcium hydroxide (CA(OH)2 +Sodium fluoride	Chawla et al. [23]	Ca(OH)2 - demerit of resorbing at a faster rate than the physiologic root resorption. To overcome this filling material incorporated with fluoride was utilized. The addition of fluoride was seen to give this material a resorption rate that matched the resorption rate of primary teeth.
Iodoformized ZOE	Garcia-Godoy [12]	It was found to be effective for both aerobic and anaerobic bacteria with a maximum sustaining period of 10 days.
Zinc oxide + Calen paste	Pinto et al. [24]	Clinical and radiograhic outcomes for calen/zo were equal to ZOE after 18 months, suggesting that both the materials can be indicated for obturation of primary teeth
Zinc oxide + Calcium hydroxide	Praveen et al. [14]	Obturated material remained up to the apex of root canals till the beginning of physiologic root resorption and was found to resorb at the same rate as that of primary teeth
Zinc oxide eugenol + Aldehydes	Praveen et al. [14]; Chawla et al. [22]	The addition of these compounds neither increased the success rate nor made the material more resorbable as compared to zinc oxide eugenol alone
Zinc oxide + Aloe Vera	Khairwa et al. (2014)	Natural herbal materials offer better compatibility with the human body and enhance the wound healing process. They possess anti-inflammatory, antifungal, moisturizing, antibacterial, antiviral, and pain-relieving properties. It showed good clinical and radiographic success with zinc oxide combined with aloe vera.
ZOE + Curcumin	Gupta et al	They have evaluated a mixture of ZOE powder with curcumin powder as obturating material in primary teeth. It turned out be a not so successful alternative.

FRANK'S PASTE

Frank's paste, a combination of zinc oxide, eugenol, and paraformaldehyde**,** offers strong antibacterial properties and a good sealing effect**,** making it effective in managing infected root canals in primary teeth. However, its use is limited due to toxicity concerns, particularly from paraformaldehyde**,** which can lead to tissue irritation, delayed resorption, and potential damage to the underlying permanent tooth germ when overfilled. Its biocompatibility issues and lack of resorbability have led to it being replaced by more tissue-friendly materials in pediatric endodontics (Tronstad, 1981; Mortazavi & Mesbahi, 2004).[113, 114]

CHITRA HAP-FIL

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. Jeeva PP et al. (2014) reported cytotoxicity levels in the order of Metapex < Chitra HAP Fil < ZOE, indicating superior biocompatibility of hydroxyapatite-based materials.

Advantages:

Chitra HAP-Fil, composed of hydroxyapatite nanoparticles, iodoform, and alginate, offers excellent biocompatibility and bioactivity, closely resembling the mineral content of bone and dentin. Its formulation promotes favorable tissue response and supports physiological root resorption, aligning with the natural exfoliation process of primary teeth. Additionally, Chitra HAP-Fil exhibits superior antimicrobial activity against pathogens like *Staphylococcus aureus*, enhancing its effectiveness in disinfecting root canals.

Disadvantages:

Despite its benefits, Chitra HAP-Fil has certain limitations. In vitro studies indicate that its cytotoxicity is higher than that of Metapex, though still lower than zinc oxide eugenol. Furthermore, its antimicrobial efficacy against *Enterococcus faecalis* is limited compared to other materials. These factors suggest that while Chitra HAP-Fil is promising, further clinical studies are necessary to fully establish its long-term safety and effectiveness. [115]

SMART SEAL

SmartSeal is a root canal obturating material based on polymer technology that utilizes a hydrophilic principle, allowing it to absorb surrounding moisture and expand, effectively filling spaces and voids. The system comprises polyamide polymer cones (ProPoints) and a resin sealer, which includes an additional polymer powder to be mixed during manipulation, enhancing its sealing ability.

Advantages

SmartSeal is a hydrophilic, polymer-based obturation system that expands upon absorbing moisture, effectively filling voids and lateral canals within the root canal system. This expansion leads to improved sealing capabilities and reduces microleakage, which is crucial for the success of pulpectomies in primary teeth. Additionally, its biocompatibility and adaptability to various canal anatomies make it a promising alternative to traditional obturating materials.

Disadvantages

Despite its advantages, SmartSeal's use in primary teeth presents certain challenges. The material's expansion properties, while beneficial for sealing, may lead to overfilling if not carefully controlled, potentially causing irritation to periapical tissues. Moreover, the limited long-term clinical data on its resorption behavior in primary teeth raises concerns about its compatibility with the natural exfoliation process. Further research is necessary to fully understand its long-term effects and efficacy in pediatric endodontics.

PULPOTEC

With antibacterial, antiseptic, and anti-inflammatory properties, iodoform-based material is commonly used in teeth with bone lesions to reduce infection clinically. Its clinical and radiological outcomes suggest that this procedure can be a viable alternative to conventional endodontic treatment for necrotic primary teeth in pediatric dentistry.

ENDOFLAS – CHLOROPHENOL FREE

Radiolucent lesions following endodontic treatment of primary teeth may be attributed to filling materials containing phenol. To address this, Endoflas CF was developed without chlorophenol, as chlorophenol's fixation effect could negatively impact osteoblast cells.

CTZ PASTE

Component	Dose	Action
Chloramphenicol	500mg	Antimicrobial agent that acts against a large number of aerobic, facultative anaerobe and spirochetes as well as gram +ve and gram –ve microorganisms.
Tetracycline	500mg	Broad Spectrum antibiotic, bactericidal at high conc. offering excellent effectiveness against gram –ve bacteria and all anaerobes.
Zinc oxide	1000mg	Analgesic, antibacterial action against staphylococcus, micrococci, bacillus and enterobacteria for more than 30 days.
Eugenol	1 drop	Anti-inflammatory

CALEN PASTE

Leonardo et al. (1976) introduced a paste containing calcium hydroxide (2g), polyethylene glycol 400 (1.75mL), barium sulfate (1g) for radiopacity, and hydrogenized colophony (0.05g) to enhance physical properties. Later, Leonardo & Leal (1991) replaced barium sulfate with zinc oxide in the same proportion. Additionally, 0.15mL of camphorated parachlorophenol was added for infected root canals, leading to the development of Calen paste.

Advantages

Calen paste exhibits biocompatibility, high antimicrobial activity, and satisfactory clinical and radiographic outcomes, along with an intermediate setting time. Its initial pH of 6.1 progressively increases, peaking at 8.4 after five hours. It also demonstrates high radiopacity and lower solubility compared to other materials. Pinto DN et al. (2011) compared the success rates of ZOE and Calen paste thickened with zinc oxide, finding a higher success rate with Calen/ZO due to its ability to prevent pathological root resorption and promote new bone formation. Zinc oxide further enhances the paste's consistency.

RIFOCORT

It is a product formed from a corticosteroid and an antibiotic, presenting a great antimicrobial action and recommended for the treatment of primary teeth presenting with pulpal infectious processes. The paste also presented bactericidal action against most organisms except for Enterococcus faecalis and Bacillus subtilis.

OCIMUM SANCTUM AND CALCIUM HYDROXIDE MIX

A mixture of calcium hydroxide (one scoop) and tulsi extract (three drops of Shri Tulsi) was prepared to a homogeneous consistency using a stainless steel spatula and a glass slab. Endodontic therapy of primary teeth using this calcium hydroxide-tulsi mix as an obturating material demonstrated excellent clinical and radiographic success,

comparable to the calcium hydroxide-iodoform mix (Metapex).

LSTR

The Cariology Research Unit of Niigata University School of Dentistry developed the concept of Lesion Sterilization and Tissue Repair (LSTR), based on the theory that tissue repair can occur if lesions are effectively disinfected. This approach, also known as Non-Instrumentation Endodontic Treatment (NIET), utilizes a triple antibiotic paste, also referred to as a polyantibiotic paste or antibiotic mixture, consisting of metronidazole, ciprofloxacin, and minocycline.[3]

LSTR typically uses a Triple Antibiotic Paste (TAP), which can vary slightly depending on formulation:

Standard Triple Antibiotic Paste (TAP):

- Metronidazole (250 mg)
- Ciprofloxacin (250 mg)
- Minocycline (100 mg)
- Ratio: 1:1:1, mixed with a vehicle like propylene glycol or macrogol.

Modified TAP (to avoid tooth discoloration):

- Metronidazole
- Ciprofloxacin
- Clindamycin or Amoxicillin (replacing Minocycline)

Double Antibiotic Paste (DAP):

- Metronidazole + Ciprofloxacin
- (Used to reduce discoloration and antibiotic load.)

Mechanism of action

The material can produce vascular changes in pulp, involving inflammation and formation of granulation tissue with accompanying metaplasia of the connective tissue and macrophages to form osteoclast like multinucleated giant odontoclasts. The remaining vital pulp cells proliferate and develop new pulp tissue into the coronal pulp chamber, so called pulp revascularization.

Advantages

The Lesion Sterilization and Tissue Repair (LSTR) technique provides excellent antibacterial activity, particularly against polymicrobial infections in necrotic primary teeth. It is a non-instrumentation, minimally invasive approach that requires little mechanical preparation, thereby preserving more of the natural tooth structure. LSTR is effective even in non-vital teeth with periapical lesions and is especially advantageous for uncooperative pediatric patients due to its reduced chair time, making it a practical and efficient option in clinical pediatric dentistry.

Disadvantages

Tooth discoloration, especially with minocycline, Potential for antibiotic resistance with improper use, Cytotoxicity concerns with prolonged exposure to surrounding tissues, Not a true obturating material—does not fill or seal the canal completely like conventional materials and Limited long-term evidence supporting complete healing and root resorption compatibility.[103,104,105]

GINGECAL

Gingecal is primarily a calcium hydroxide-based paste used for root canal obturation in primary teeth. Its typical composition includes:

1) Calcium hydroxide ($Ca(OH)_2$) – the main active ingredient, responsible for its high pH, antimicrobial activity, and stimulation of hard tissue formation.
2) Iodoform – contributes to its antibacterial properties and radiopacity.
3) Silicone oil or other vehicles – used to provide the paste-like consistency and aid in its flow and placement into the canals.
4) Radiopacifiers – such as barium sulfate or similar compounds, to allow radiographic visualization.

Advantages

Biocompatibility with periapical tissues (Reddy et al., 2021), Antibacterial properties due to its alkaline pH, Ease of application and radiopacity for easy post-operative evaluation and Resorbability, making it suitable for primary teeth that will eventually exfoliate.

Disadvantages

Faster resorption than the root in some cases, potentially leading to voids (Sharma et al., 2019), Incomplete obturation due to its flow characteristics and Potential irritation if overextended beyond the apex.[87, 88, 89]

Comparison of different properties of Gingecal with ZOE and Metapex

Property	Gingecal	ZOE (Zinc Oxide Eugenol)	Metapex
Composition	Calcium hydroxide, iodoform, radiopacifiers, silicone oil	Zinc oxide, eugenol	Calcium hydroxide, iodoform, silicone oil
Antibacterial Effect	High (alkaline pH + iodoform)	Moderate	High (due to iodoform and high pH)
Resorbability	Resorbable, usually in sync with roots	Poor resorption, may remain after tooth exfoliates	Resorbable, sometimes faster than natural root
Biocompatibility	Good	Moderate (eugenol can irritate tissues)	Good
Radiopacity	Good	Good	Excellent
Handling/Application	Paste, easy to apply	Requires mixing, thicker consistency	Syringe delivery, very easy to use
Risk of Overextension	Mild irritation if overfilled	Can cause persistent irritation	Generally well-tolerated but may cause faster resorption
Clinical Success Rate	Comparable to ZOE and Metapex (limited studies)	Long-term success data available	Good short- to medium-term outcomes

OBTURATION TECHNIQUES IN PRIMARY TEETH PULPECTOMY

AMALGAM PLUGGER BY NOSONWITZ (1960) AND KING (1984)

The amalgam plugger technique is a manual method of obturation used in pediatric endodontics, where a paste-like root canal filling material (such as ZOE, calcium hydroxide-iodoform paste, or Metapex) is inserted into the canal using an amalgam plugger. The material is carried incrementally and compacted into the canal, ensuring adequate fill and minimal voids.

Advantages

Cost-effective and easily available instruments, Good tactile control for manual condensation, Minimizes extrusion of material beyond apex with careful technique and Adaptability for different canal sizes.

Disadvantages

Technique sensitive; risk of voids if not performed properly, Limited penetration in narrow or curved canals, Time-consuming compared to syringe techniques and May not be as efficient for paste-based materials like Metapex.[90, 91, 92]

PAPER POINTS BY SPEDDING (1973)

The paper point technique is a simple and manual method used for obturating root canals in primary teeth. In this technique, pre-sterilized paper points are dipped in a root canal paste (e.g., zinc oxide eugenol, Metapex, or iodoform-calcium hydroxide paste) and then inserted into the canal. The paste is transferred and compacted incrementally with each point.

Advantages

Simple and cost-effective method, Does not require specialized instruments, Reduces the risk of material extrusion beyond the apex and Suitable for narrow or curved canals.

Disadvantages

Risk of voids due to inadequate compaction, Not ideal for larger or irregularly shaped canals, Time-consuming and operator-sensitive and Limited control over uniform filling.[93, 94, 95]

PLUGGING ACTION WITH WET COTTON PELLET BY DON- NENBERG (1974)

The Don Nenberg technique involves using a wet cotton pellet to aid in the compaction of obturating material (typically zinc oxide eugenol or other pastes) within the root canal of primary teeth. After placing the paste into the canal, a small, moistened cotton pellet is pressed gently into the canal opening. The moisture softens the material slightly, and the pressure compacts it deeper into the canal, aiding better adaptation and fill.

Advantages

Improves compaction of the paste into the canal, Reduces voids and improves seal, Moisture from the cotton helps in softening and adapting the paste, Simple and requires no special equipment.

Disadvantages

Technique-sensitive; excessive pressure may lead to overfilling, Residual cotton fibers may contaminate the material if not removed carefully and Less effective in narrow or curved canals.[96, 97, 98]

ENDODONTIC PRESSURE SYRINGE

Described by Greenberg (1963), the apparatus consists of a syringe barrel, threaded plugger, wrench, and threaded needle. The needle is inserted into the canal until wall resistance is encountered. Using a slow withdrawing motion, it is retracted in 3mm intervals with each quarter turn of the screw until the canal is visibly filled at the orifice with zinc oxide eugenol paste. The 13 to 30-gauge needle corresponds to the largest endodontic file used to instrument the root canal.

Advantages

Needles are very flexible and can easily manuvered in the tortuous canals of primary molars.

Disadvantages

Overfilling can occur in cases of apical and lateral resorption, and correctly placing the rubber stop can be challenging. The need to refill the syringe hub multiple times during the procedure often requires repeated removal and reinsertion of the needle, which may displace the paste, create voids, and compromise filling quality. Additionally, the requirement to clean the syringe immediately after use makes this method more complex and time-consuming.

LENTULO SPIRAL

Advocated by Kopel in 1970, root canal obturation methods in primary teeth were evaluated in vitro by Aylard, Johnson, and Dandashi et al. They concluded that the lentulospiral mounted in a slow-speed handpiece was superior for filling both straight and curved root canals in primary teeth. However, their study demonstrated no significant differences between the lentulo technique and the pressure syringe technique when filling straight canals.

Advantages

Most effective and straight forward techniques for applying selaers and calcium hydroxide into permanent tooth root canals or pastes into primary tooth canals, because of its design and flexibility that allow files to carry the paste uniformly throughout the narrow, curved canals in primary molars.

Disadvantages

Difficulties with fitting the rubber stop, instrument fracture and tendency for extrusion beyond the apex.

MECHANICAL SYRINGE

This was proposed by Greenberg in 1971. The canal shape governed the selection of the filling technique.

Disadvantages:

Poor performer in both canal types i.e curved and straight canals based on studies conducted by Aylard and johnson. The screw mechanism of the endodontic pressure syringe would be able to generate far greater pressures than plunger system in the mechanical syringe.

INCREMENTAL FILLING TECHNIQUE

First used by Gould in 1972, this method of root canal obturation involves placing the filling material, typically zinc oxide-eugenol paste, into the canal in small, successive increments using a plugger that matches the canal size. This technique ensures thorough and even distribution of the material throughout the canal length rather than filling it all at once, gradually building up the filling in layers until the canal is completely filled. The endodontic plugger's length is set to the predetermined root canal length minus 2mm.

Advantages

The material is placed in bulk and pushed into canals with endodontic pluggers.

Disadvantages

Placing the paste in a narrow, apically curved canal is more challenging than in a wider apical preparation. Due to the limited flexibility of endodontic pluggers, the paste may not reach the full working length in narrow, curved canals. Additionally, movements of the plugger during paste application can increase the risk of creating large voids, compromising the quality of the obturation.

JIFFY TUBE

Popularized by Riffkin in 1980, this technique involves back-loading a standardized mixture of ZOE into a tube. The tube tip is then placed at the canal orifice, and the material is expressed into the canal using a downward squeezing motion until the orifice appears visibly filled.

TUBERCULIN SYRINGE

Aylard and Johnson (1987) introduced a technique in which a standardized mixture of ZOE was backloaded into a syringe equipped with a standard 26-gauge, 3/8-inch needle. The material was expressed into the canal using slow finger pressure on the plunger until the orifice was visibly filled. Their study found no significant difference in the straight canal filling capabilities between tuberculin and mechanical syringes.

Disadvantages

The main drawback of the tuberculin syringe technique is the difficulty in separating the tip during injection, necessitating frequent needle replacement. This compromises optimal filling and increases the likelihood of voids in the paste. To address this, Hartman and Pruhs recommended using a wet cotton pellet to push the filling material into the canals of primary teeth.

REAMER TECHNIQUE

A reamer coated with ZOE paste is inserted into the canal with a clockwise rotation and vibratory motion to facilitate the material's flow to the apex. It is then withdrawn while maintaining the clockwise rotary motion. A rubber stopper is used to ensure the reamer remains at the predetermined working length, and the process is repeated 5–7 times until the canal orifice appears completely filled with the paste.

Advantages

The study by Priya Nagar et al. demonstrated that the obturation quality of both the reamer technique and the insulin syringe technique was similar. Both techniques showed a lower likelihood of void formation and achieved good radiopacity.

INSULIN SYRINGE TECHNIQUE

As described by Priya Nagar et al., a homogeneous mixture of ZOE, prepared according to the manufacturer's instructions, is loaded into an insulin syringe, with a stopper placed after assessing the working length of the canal. The material is then gradually pressed into the canal while simultaneously withdrawing the needle outward, ensuring proper filling and minimizing void formation. Additional material is applied over the orifice and compressed using wet cotton to achieve a well-sealed obturation.

Advantages

With optimum operator skills and proper material mix optimal filling with less no of voids and good radiopacity can be achieved.

Disadvantages

Length of the needle is short it can penetrate only two third length of canal.

Disposable Injection Technique

ZOE can be loaded into a 2ml syringe with a 24-gauge needle, with a stopper adjusted to the measured length using an RCT instrument as a guide. The material is gently pushed into the canal until it is seen flowing out of the canal orifice. The needle is then gradually withdrawn while continuing to push the material until it reaches the pulp chamber, ensuring proper canal filling.

Advantages

Simple, economical can be used with almost all filing materials, easy to master with minimal chances of failure as reported by Bhandari et al.

NAVITIP

The Navitip system, featuring a thin and flexible metal tip, was introduced for delivering root canal sealer. It is available in different lengths and includes a rubber stop for precise placement. Endoseal, a syringe-delivered zinc oxide eugenol-based canal sealer, can be effectively expressed using the Navitip system.

Advantages

The NaviTip system offers adequate tip thickness, good flexibility, and ease of stopper adaptation, preventing paste extrusion from the apex and reducing the likelihood of voids. Studies by Gibson et al. demonstrated that calcium hydroxide ($Ca(OH)_2$) injected into the canal using NaviTip consistently produced better results than spirally placed dressings.

Disadvantages

In case of thick mix material cannot be expressed out of the lumen.

BIDIRECTIONAL SPIRAL

Dr. Barry Musikant (1998) developed the bi-directional spiral technique, which ensures minimal extrusion of obturating material beyond the apex. This controlled coverage is achieved by the opposing spirals—those at the

coronal end spin the material downward toward the apex, while the spirals at the apical end spin it upward toward the coronal end. Where these opposing spirals meet, approximately 3-4mm from the apical end of the shaft, the material is directed laterally for effective canal filling.

Advantages
Bi-directional spiral prevented extrusion of the sealer from the root canals of permanent teeth.

Disadvantages
The highest number of voids was seen in canals filled with the lentulospirals and bidirectional spiral as observed by Grover et al.

PASTINJECT
Pastinject is a specially designed paste carrier with flattened blades, which improves material placement into root canal.

Advantages
The bi-directional spiral offers great flexibility, allowing it to adapt perfectly to the canal shape. Its translational movement facilitates the transport of the filling material and ensures uniform application onto the canal walls. In a study conducted by Grover et al., Pastinject was found to be the most effective obturation technique among lentulospirals, bi-directional spirals, Pastinject, and pressure syringes. It resulted in a higher number of optimally filled canals with minimal voids while also enabling easier material placement into the canals.

Disadvantages
Bi-directional spiral and Pastinject are used for the placement of calcium hydroxide and root canal sealers in the permanent teeth, but there are not enough studies to evaluate their use as obturation techniques in primary teeth.

Other Techniques

Obturagun Technique
The **Obturagun technique** is a **mechanized method** of delivering root canal filling materials in primary teeth using a specialized device called an **Obturagun**. This device functions similarly to a syringe but is ergonomically designed to ensure **controlled and precise delivery** of obturating materials such as calcium hydroxide-iodoform paste or ZOE into the root canals.

Advantages
Precise and controlled delivery of material, minimizes risk of overfilling and voids, time-efficient and operator-friendly and reduces patient chair time, beneficial for pediatric patients.

Disadvantages
Cost of the device may be high compared to manual methods, Requires training and technique sensitivity for optimal results, May not be suitable for very narrow or tortuous canals, Device maintenance and sterilization must be managed carefully. [99, 100, 101]

2. Conclusion

Good obturation along with hermetic seal is the gold standard for both primary and permanent teeth root canal procedure. Each technique has its pros and cons but it is totally dependent on performer for perfect outcome. But further controlled studies and research are still necessary to find an ideal obturating material and technique for deciduous teeth which is quick, convenient yet efficient.

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