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Dr. Rakhshunda Manzoor
Post Graduate Student,
Department of Pediatric Dentistry, Jaipur Dental College, Jaipur, Rajasthan, India

Marikinda Manzoor
Post Graduate Student,
Department of Conservative Dentistry, Jaipur Dental College, Jaipur, Rajasthan, India

Corresponding Author:
Dr. Rakhshunda Manzoor
Post Graduate Student,
Department of Pediatric Dentistry, Jaipur Dental College, Jaipur, Rajasthan, India

Obturating materials in pediatric dentistry: A review

Dr. Rakhshunda Manzoor and Marikinda Manzoor

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Abstract
Primary teeth should be preserved until their normal exfoliation time so as to maintain arch length and function in order to provide proper guidance for the eruption of permanent teeth, enhance esthetics and mastication, prevent aberrant tongue habits, aid in speech and prevent the psychological effects associated with tooth loss. Pulpectomy consists of removing the pulp tissue associated with micro-organisms and debris from the canal and obturating with resorbable filling material. Success rate of endodontic therapy depends on many factors like familiarity with the complexity of primary tooth canal systems, their formation and resorption pattern, obturating material as well as obturation technique used that is capable of densely filling the entire root canal system and providing a fluid tight seal from the apical segment of the canal to the cavo-surface margin in order to prevent reinfection. One of the major areas of research in pulpectomy is to discover new materials for obturation so to have the specific properties similar to teeth. This article will render the role of many important obturating materials which we use in dentistry and their advantages and disadvantages and their modifications.

Keywords: Obturating materials, pediatric dentistry, primary teeth

Introduction
Primary teeth are the best space maintainers and hence should be preserved and retained as long as possible [1]. Pulpectomy is the procedure of extirpating the diseased pulp associated with microorganism and debris from the canal and obturating with an antibacterial resorbable filling material and it is indicated when the inflammation of the pulpal tissue involves the radicular pulp or when nonvital tooth is diagnosed [1]. Ultimately, pulpectomy is needed to achieve good hermetic seal which depends on various factors such as good biomechanical preparation, types of obturating material used and achievement of minimum voids. Obturating the canal creates a fluid tight seal along the length of the root from the coronal opening to the apical system and eliminating all portals of entry between the periodontium and the root canal system [2].

In an attempt to improve the clinical success of pulpectomies, different filling materials and obturation techniques for primary teeth have been proposed. Although zinc oxide and eugenol, calcium hydroxide and iodoform based pastes are currently recommended, there is still no consensus on the gold standard material for this purpose [1, 2]. Many laboratorial studies have been designed to investigate the effectiveness of different obturation techniques and filling materials for primary teeth, but most of them used radiographs or conventional tomographic evaluations [3]. While both techniques have very low spatial resolution (ranging from 100 to 1000µm), radiographs have also de limitation of being a bidimensional evaluation [3]. Moreover, major differences in the root canal anatomy among the used specimens (lack of paired specimens) may be a source of bias in evaluating the effectiveness of a certain technique in endodontic studies and for this reason, the use of prototypes, with individualized root canal anatomy may bring advantages in this regard [2, 3]. Finally, a detailed quantitative tridimensional analysis of voids and effectiveness of root canal obturation in primary teeth have not yet been performed [3].

Optimal requirements of obturating material for deciduous teeth
Rabinowitch [1] stated, "The history of the treatment of root canals is the discussion of medication used:

- It should not irritate the periapical tissues nor coagulate any organic remnants in the canal.

- It should have a stable disinfecting power.
- Excess pressed beyond the apex should be resorbed easily.
- It should be inserted easily into the root canal and removed easily if necessary.
- It should adhere to the walls of the canal and should not shrink.
- It should not be soluble in water.
- It should not discolour the tooth.
- It should be radiopaque.
- It should induce vital periapical tissue to seal the canal with calcified or connective tissue.
- It should be harmless to the adjacent tooth germ.
- 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,
4) Ease of insertion, and
5) Ease of removal. But till now none of the currently available obturating materials possess all of these criteria
6) Should not cause any tooth discoloration.
7) The present review attempt to evaluate each of the presently available obturating materials and present a few of the emerging concepts related to obturation of primary teeth.

Fig 1: Zinc oxide eugenol (ZOE)

Zinc oxide–eugenol cement contains zinc oxide, rosin, and zinc acetate in the powder. The rosin increases fracture resistance and the zinc acetate is effective in accelerating the reaction rate. The liquid is a preparation of eugenol, which reacts with the powder to form an amorphous chelate of zinc eugenolate. The zinc oxide–eugenol cements are used to provide a sedative effect in deep preparations, but their low compressive strength presents clinical limitations. To strengthen zinc oxide–eugenol cements, acrylic resin and alumina reinforcers have been added. Although these cements are stronger, they remain weaker than the zinc phosphate and glass ionomer cements. When it was evaluated as a base, zinc oxide–eugenol demonstrated significant microleakage in comparison with glass ionomer cement [2, 3]. Because of its sedative effects and years of clinical success, zinc oxide–eugenol remains the material of choice for the pulp chamber filling material following pulpotomies or pulpectomies in the primary dentition. Zinc oxide–eugenol cements should be used with caution under resin-based composite restorations because the eugenol can inhibit the polymerization of the resin. A glass ionomer cement base may be placed over zinc oxide–eugenol before the placement of resin-based composite in order to avoid polymerization [2, 5].

Zinc oxide eugenol was discovered by Bonastre (1837) and subsequently used in dentistry by Chisholm (1876). Sweet in 1930 said that it was the first root canal filling material to be recommended. ZOE is a commonly used filling material for primary teeth. Camp [3, 5] introduced the endodontic pressure syringe to overcome the problem of underfilling, a relatively common finding when thick mixes of ZOE are employed. However, underfilling is frequently clinically acceptable. Primary teeth frequently present with interradicular radiolucent areas but without periapical lesions, and they sometimes even have some vital pulp at the apex. Conversely, overfilling may cause a mild foreign body reaction, and it has also been associated with increased failure rate when compared with underfilling or flush finishing [2, 4]. Success rate with this material varied between 65% and 100%, with an average of 83%, and no significant difference could be observed when ZOE was compared with other calcium hydroxide and/or iodoform pastes.

Hashieh [4] studied the beneficial effects of eugenol. The amount of eugenol released in the periapical region immediately after placement was 10^{-4} and drops to 10^{-6} after 24 hrs, 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.

Erasquin et al. (1967) [5] reported that the canals overfilled with (ZOE) are not recommended because it irritates the periapical tissues and causes necrosis of bone and cementum. Barker and Lockett Spedding Mortazavi and Mesbahi (1971) [6, 7, 8] stated that extruded ZOE resisted resorption and took months or even years to resorb. Coll et al. (1985) [9] reported that when ZOE extrudes from root canal, 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 the exfoliation of tooth. Areas of cementum resorption were evident, periodontal ligament exhibited intense and moderate thickening. Dentin resorption was not seen, whereas bone resorption was seen. Garcia-Godoy, Ranly and Garcia-Godoy, Praveen et al. (1987) [10, 11, 12] reported deflection of developing permanent tooth bud because of its hardness. Barr et al., [13] in 1991, stated that after primary teeth with ZOE pulpectomies were lost, they did not find retained filler particles associated with molar teeth. They reported that incisor pulpectomies may have retained ZOE initially after exfoliation, but it was not seen on subsequent radiographs at follow-up. Coll and Sadrian (1996) [14] reported that 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 permanent tooth following ZOE pulpectomy. Sadrian and Coll, [15] in 1993, stated that the data findings from their retrospective evaluation indicated that retained ZOE tended to resorb with time which may reflect osteoclastic activity to reduce or eliminate retained ZOE particles. The filling material took a mean time of 50.1 months for Zinc oxide eugenol to resorb. In the cases in which ZOE was retained, 80% showed significant reduction of the retained filler's size over time. Thus, they advised that it is

better to fill canals short of the apex rather than to the apex or beyond, to avoid retention. None of the retained filler particles caused any observed pathology. They concluded that retained Zinc oxide eugenol was not related to the pulpectomy success or failure. Contrary to these results, Holan and Fuks (1993) [16], reported that, permanent incisors that replace traumatized deciduous incisors treated with Zinc oxide eugenol pulpectomies have 2-3 times higher incidence of enamel defects when compared to normal teeth. They Compared pulpectomies of nonvital primary molars using ZOE and KRI paste, it was concluded that KRI paste presented with a higher success than ZOE in cases of first molars, maxillary molars and overfilling of the canals. Success rates for both ZOE and KRI were similar in underfilled teeth and slightly higher for KRI paste when fillings were flush to the apex. Praveen et al. (2011) [12]: Used Zinc oxide + Calcium hydroxide. 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 deciduous teeth. In a study by Mortazavi and Mesbahi, (2004) [18] it was found that in comparison with ZOE and Vitapex, the comprehensive success rates of Vitapex and ZOE were found to be 100% and 78.5%, respectively.

To improve the properties and success rate of zinc oxide eugenol combination with different components were used like formocresol, formaldehyde and paraformaldehyde and cresol but the addition of these compounds neither elevated the success rate nor made the material more resorbable as compared to zinc oxide eugenol alone [18].

Anti-inflammatory and analgesic properties, greater zone of bacterial inhibition, ease of availability, radiopacity of material, cheaper, insolubility in tissue fluids, easy to mix, and good working time are the advantages of ZOE.

A study was conducted in which iodoformized zinc oxide eugenol was tested for its antibacterial effect against the aerobic and anaerobic bacteria obtained from the root canals of primary teeth and was found to be effective for both the aerobic and anaerobic bacteria of the root canals of primary teeth with maximum sustaining period of 10 days [20].

ZOE used in combination with other materials to overcome its drawbacks.

Al-Ostwani *et al*. [21] used Zinc oxide + propolis and it was observed that ZOP paste was prepared by mixing 50% zinc oxide powder with 50% hydrolytic propolis. There was acceptable clinical and radiographic success rate with faster resorption observed in some cases.

Chawla et al. [22] used Zinc oxide eugenol (ZOE)+ Calcium hydroxide (CA(OH)2 +Sodium fluoride and it was seen that due to Ca (OH)2 - material resorbs at a faster rate than the physiologic root resorption. To overcome this limitation filling material incorporated with fluoride was utilized. The addition of fluoride was observed to render this material a resorption rate that is similar to the resorption rate of primary teeth.

Pinto et al. [23] used Zinc oxide + Calen paste and it was seen that the Clinical and radiograhic outcomes for calen/zo were equal to ZOE after 18 months, suggests that both the materials can be indicated for obturation of primary teeth.

A combination of zinc oxide powder and calcium hydroxide paste for obturation of primary teeth has shown promise in a shor term study. They observed that the obturated material remained up to the apex of root canals till the beginning of physiologic root resorption. Also, the obturated material was found to resorb at the same rate as teeth [24]. A combination of calcium hydroxide, zinc oxide, and 10% sodium fluoride solution has been tested in a clinical study. It was observed that the rate of resorption of this new combination of root canal obturating mixture was quite similar to the rate of physiologic root resorption in primary teeth [25].

Table 1: Authors and their observations for zinc oxide eugenol

Authors	Observations
Allen [17]	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 [7], Mortazavi and Mesbahi [8]	Stated that extruded ZOE resisted resorption and took months or even years to resorb
Coll and Sadrian [14]	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. [9]	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.
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. [13] Coll and Sadrian [14]	Observed deflection of permanent tooth eruption in 20% of pulpectomized tooth that were extracted
Garcia-Godoy [20], Ranly and Garcia-Godoy [11], Praveen et al. [12]	Reported deflection of developing permanent tooth bud because of its hardness
Hashieh et al. [4]	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 [16]; Moskovitz and Samara [38]	Malformation of successor is attributed to the cytotoxic and neurotoxic nature of eugenol
Jerrell and Ronk [42]	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 [43]	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. [12]; Sunitha et al. [44]	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

Table 2: Zinc Oxide combinations with other materials.

Combination	Observation
Zinc oxide + Propolis (ZOP)	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	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	$Ca(OH)^2$ - 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	It was found to be effective for both aerobic and anaerobic bacteria with a maximum sustaining period of 10 days.
Zinc oxide + Calen paste	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	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	The addition of these compounds neither increased the success rate nor made the material more resorbable as compared to zinc oxide eugenol alone

Iodoform

It is a preparation of iodine obtained by action of chlorinated lime upon an alcoholic solution of potassium iodide when heated at 1040 °F. No irritant action. Relieves pain and is a potent disinfectant. Better re-sorbability and disinfectant properties than ZOE. But they may produce a yellowish brown discoloration of the tooth.

Walkhoff Paste

It consists of Iodoform, Parachlorophenol 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.

KRI Paste

KRI paste is basically an iodoform paste, was introduced by Volkoff as a resorbable paste suitable for root canal filling. It consists of iodoform (80.5%), camphor (4.84%), para chlorophenol (2.023%), and menthol (1.213%). KRI paste 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[2], 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 KRl 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.

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.

Holan G *et al.* (1993) [16] found that the success rates of 84% with KRI paste group verus 65% with ZOE group. Overfills more successful KRI paste 79% versus ZOE 41%. The excess paste will resorb without causing any adverse side effecs.

Maisto Paste: An iodoform based paste developed by Maisto and used clinically for many years with good results reported. It consist 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) [48] 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.

Aloe vera

Aloe vera has a long history of its uses because of its beneficial properties. *Aloe vera* derives its name from the Arabic word "Alloeh" and Latin word "vera" meaning "shining bitter substance" and "true" respectively. Nearly 2000 years ago, the Greek scientists regarded *Aloe vera* as the universal panacea. The Egyptians called it "the plant of immortality". *Aloe vera* is a stem-less or short stemmed perennial, drought resisting, succulent xerophyte (store water in tissues to survive under conditions of water shortage) plant. It belongs to the lily (Liliaceae) family, and has stiff grey to bright pear green lance-shaped leaves [26]. This gel like substance contains various amino acids, minerals, enzymes and sugars which have properties like moisturizing properties, antiinflammatory, antioxidant antibacterial, antiviral and antifungal properties. *Aloe vera* has its uses in various systemic conditions like skin disorders (e.g. psoriasis), arthritis, asthma, digestive and bowel disorders, diabetes and lowering lipid levels in hyper-lipidemic patients. It can also be used as a detoxifying agent, for topical application of first and second degree burns, as an immune enhancer, in Alzheimer's disease and in various cosmetic and medical products. It has been used in dentistry as well.

Khairwa *et al*. [27] evaluated clinical and radiographic success of zinc oxide combined with *Aloe vera* and showed good success rate. They reported that this material can be used as an alternative for zinc oxide eugenol.

Fig 2: Endoflas

Endoflas is a resorbable paste manufactured in South America available in powder liquid form, inspite of various benefits, it has not found profound use with clinicians and the reason is unknown. Endoflas is usually incorporated with other obturating materials.

Among the different obturation materials available, Endoflas is a hydrophilic material consisting of Z.O.E. (56.5%), iodoform (40.6%), calcium hydroxide (1.07%), barium sulfate (1.63%), eugenol, and pentachlorophenol. It provides a good seal with the root canals. The broad-spectrum antibacterial activity helps in disinfection of the hard to reach dentinal tubules and accessory canals. Since the resorption rate of Endoflas is similar to that of the physiological root resorption rate, the resorption is limited to the obturation material that is extruded beyond the apex extra with-out the resorption of the material inside the root canal. Endoflas has a high success rate when compared to that of zinc oxide eugenol. It has a clinically proven success rate of 93.3%–95.1%. However, the success rate is lower (58%–76%) when extruded beyond apex [31, 34]. The reason behind incorporating three materials ZOE, Ca $(OH)^2$ and iodoform into endoflas was possibly to compensate the limitations of one individual material with the advantages of the other.

Praveen et al (2011) [12] 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. Rewal et al. [32] indicated that Endoflas with a success rate of 100% is a superior material compared to ZOE. Ramar and Mungra [33] compared the clinical and radiographic evaluation of Metapex, RC fill, and Endoflas for a duration of 9 months. Results showed that Endoflas gave an overall success rate of 95.1%, Metapex 90.5%, and RC Fill 84.7%. Fuks *et al*. [34] studied the success rate of Endoflas as a filling material in 55 primary teeth. Thirty-one teeth were overfilled, and of these, 29% were normal preoperatively and the remaining 71% presented with bone pathology. Twenty-four teeth were flush or underfilled, and of these, 50% had preoperative bone pathology after 52 months. Seventy percent of the cases were successful, and the remaining 30% presented with pathology and only one tooth had to be extracted. Overfilling led to a success rate of 58%, whereas in the combined flush and underfilled, the success rate was 83%. In this study, two cases showed excess filling material with Endoflas, and by the end of 6 months, only one case showed resorption of excess filling material. The time taken for the resorption of inadvertently extruded Endoflas has varied between 20-day and 11-month period in this study.

Table 3: Antibacterial properties of Metapex reported by various authors.

Authors	Observations
Hegde et al. [46]	Endoflas™ moderately inhibited the gram-negative and gram-positive organisms and showed strong inhibition of *Candida albicans*
Pelczar et al. [47]	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

Fig 3: Metapex

In 2009, AAPD guidelines cited iodoform based pastes as suitable alternatives to zinc oxide eugenol. Metapex is a combination of 30.3% calcium hydroxide, 40.4% iodoform and 22.4% silicone oil. The mixture can be dispensed into the root canals by using disposable tips. The silicone oil content of metapex neutralizes the alkalinity of the paste to a certain extent, thereby causing lesser injury to the periapical tissues. Calcium hydroxide - iodoform mixture (Metapex) is considered to be an ideal pulpal filling material for primary teeth, but it resorbs a little faster than the rate of normal physiologic root resorption. Clinical success rate of 96.8% and radiographic success rate of 72.5% was reported for metapex [35].

Metapex easily resorbs from the periapical areas, no foreign-body reaction, and it has a potent germicidal properties are the needs fulfilled by iodoform pastes that can successfully be used as root canal filling material [28]. If material is pushed beyond the apex, these materials show a resorption rate faster than the root. In a study by Mortazavi and Mesbahi [29], it was found that in comparison with ZOE and Vitapex, the comprehensive success rates of Vitapex and ZOE were found to be 100% and 78.5%, respectively.

The efficacy of calcium hydroxide and ZOE as studied by Dogra [29], by using endodontic pressure syringe system, concluded that ZOE can be used as an alternative with calcium hydroxide as a root canal filling material. In this

study, when iodoform was used as obturating material and followed up for 3 months, it was seen that one patient reported with pain. In cases of overfilled canals, during follow-up complete resorption of material in periapical region was seen by the end of 6 months. One of the detrimental properties of calcium hydroxide is that it has a tendency to resorb earlier than the physiologic resorption of root. This creates a "hollow tube" effect leading to an unfilled root that eventually becomes a site for infection [30]. In 2009, AAPD guidelines cited iodoform based pastes as suitable alternatives to zinc oxide eugenol [35]. The higher number of overfilled canals and presence of voids observed with Metapex is due to the thinner consistency of the premixed paste which may flow more easily into the narrow and tortuous canals of primary molars and reach the apex or even beyond [36]. It can also be due to the technique followed, wherein the filling material is pressed into the canal. Unlike zinc oxide eugenol, Metapex can be rapidly eliminated when extruded extraradicularly and does not set to a hard mass. However, there is a possibility of intraradicular resorption in the long term. An unfilled root canal can be permeated with tissue fluid that becomes stagnant and eventually a nidus for infection and is termed as 'hollow tube effect [37]. In comparison to other iodoform based pastes, the resorption of Endoflas usually coincides with the physiologic root resorption. This is because it contains more than 50% zinc oxide eugenol that is slowly removed by giant cells [38]. A distinctive property of Endoflas is that it does not wash out from the canals and its resorption is limited only to the excess that is extruded without depleting the intraradicular material. Although Vitapex and Metapex are similar in their composition, almost all studies have evaluated Vitapex only. [36, 39, 40] (Vitapex contains 40.4% iodoform, 30.3% calcium hydroxide and 22.4% silicone). Also, there are very few reports on the use of Endoflas as a root canal filling material [34, 38, 41]. Calcium hydroxide could be used exclusively or as an alternative to zinc oxide eugenol as a root canal filling material for the primary teeth. This could prevent the cytotoxic effects of eugenol and also could prevent the deflection of the permanent tooth bud [29].

Fig 4: Chitra HAP-Fil

Jeeva and Retnakumari et al. [45] observed the Current trend in dentistry towards the use of biomaterials such as hydroxy apatite. In an attempt to find an appropriate root canal obturating material, they designed a new product named "Chitra HAP-Fil". It is a hydroxyapatite nanoparticle gel based root filler material, which exactly corresponds to the mineral content of bone and dentine, deemed to be highly biocompatible. "Chitra HAP-Fil" apparently satisfies all requirements of an ideal pulpectomy material. This study was carried out to investigate the cellular and microbial response of Chitra HAP-Fil in comparison with Zinc oxide eugenol and Metapex by invitro methods. In Hydroxy apatite - Iodoform paste (Chitra HAP-Fil), The prime ingredient is hydroxyapatite nanoparticle gel (65%) which is the basic mineral content of human bone and pure Iodoform (32%) which imparts antibacterial property to the paste. The gelling agent (alginate) – 3% (including 0.2% surfactant) binds with the calcium ions in the hydroxyapatite. The study evaluated the cytotoxicity and antimicrobial activity of three pulpectomy materials, namely Zinc oxide eugenol, Chitra HAP-Fil and Metapex. The cellular response of three materials were evaluated and results showed that Metapex is significantly least cytotoxic than Chitra HAP Fil which is less cytotoxic than Zinc oxide eugenol.

Smartseal

It is a root canal obturating material which is based on polymer technology. It uses a hydrophilic principle which can absorb surrounding moisture and expand which results in filling of spaces and voids. Hydrophilic nature is revealed by ProPoints, which permits infinite water volume existing in the root canal system that is engrossed by these points. This water may hydrogen bond to the existing polar locations, therefore, permitting the enlargement inside the polymeric chains.

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.

CTZ Paste: CTZ is an antibiotic paste Comibation of chloramphenicol 500mg+tetracycline 500mg+zinc oxide 1000mg+ eugenol 1 drop. Chloramphenicol is an antimicrobial agent that acts against a large number of aerobic, facultative anaerobe and spirochetes as well as gram +ve and gram –ve microorganisms. Tetracycline is a broad spectrum antibiotic which can be bactericidal at high conc. offering excellent effectiveness against gram –ve bacteria and all anaerobes. ZOE provides analgesic properties and potent antibacterial action against staphylococcus, micrococci, bacillus and enterobacteria formore than 30 days.

Obturation of the Root Canal

The chosen obturation technique depends upon the material employed and accessibility of the canal to relevant instruments.

If using ZOE, it is mixed to a thick consistency and carried into the pulp chamber with a plastic instrument or on a Lentulo spiral. The material may be packed into the canals with pluggers or the Lentulo spiral. A cotton pellet held in cotton pliers and acting as a piston within the pulp chambers is quite effective in forcing the ZOE into the canals. The endodontic pressure syringe is also effective for placing the ZOE in root canals [15, 35]. However, in a study of apical seal and quality of filling evaluated on radiographs, no statistically significant differences were reported between the Lentulo spiral, pressure syringe, or plugger [39].

When the root canal is filled with a resorbable paste such as KRI, Maisto, or Endoflas, a Lentulo spiral mounted in a low-speed handpiece can be used to introduce the material into the canal. When the canal is completely filled, the material is compressed with a cotton pellet. Excessive material is rapidly resorbed.

Vitapex is packed in a convenient sterile syringe and the paste injected into the canal with disposable plastic needles. This technique is particularly easy to use for primary incisors but less practical for the narrow canals of primary molars.

Regardless of the method used to fill the canals, care should be taken to prevent extrusion of the material into the periapical tissues. It is reported that a significantly greater failure rate occurs with overfilling of ZOE than with filling just to the apex or slightly underfilling. The adequacy of the obturation is checked by radiographs [39].

In the event a small amount of the ZOE is inadvertently forced through the apical foramen, it is left alone (because the material is absorbable). It has been reported that defects on successor teeth have no relationship to length of the ZOE filling [40].

When the canals are satisfactorily obturated, a fast-setting temporary cement is placed in the pulp chamber to seal over the root canal filling. The tooth may then be restored permanently. In primary molars, it is advisable to place a preformed (stainless steel) crown as the permanent restoration to ensure good coronal seal and prevent possible fracture of the tooth.

If a primary tooth requires pulpectomy and the permanent successor tooth is absent, the primary root canals are filled with gutta-percha and sealer in an attempt to retain the primary tooth long term.

Conclusion

Zinc oxide ozonated oil and ZO added with *Aloe vera* can be used as alternative to ZOE. Endoflas can be recommended in daily practice as it has better antimicrobial property and resorption of only extruded materials. It has been found that the current obturating materials for deciduous teeth while providing satisfactory clinical results still need to be modified to suit the various clinical situation that are encountered. Due to the limitations of ZOE material several other materials have been investigated and various combinations tried with some degree of success.

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