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Pulpotomy Medicament: A Comprehensive Review

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Abstract: Pulpotomy is a common therapy in pediatric dentistry, done in a primary molar with severe caries, but without evidence of radicular pathology where the removal of caries results in exposure to carious or mechanical pulp. To facilitate healing or an agent to repair the underlying tissue, the pulpotomy technique involves coating pulp stumps with a pulp-capping agent. Pulpotomy can be performed using different techniques including non pharmacotherapeutic treatments such as electrosurgey and lasers or pharmacotherapeutic approaches by dressing pulp tissue with different medicaments or biological materials such as formocresol (FC), glutaraldehyde, ferric sulphate, freezed dried bone, bone morphogenic protein (BMP), osteogenic protein, sodium hyochloride, calcium enriched mixture (CEM) and enriched collagen solutions. Hence the aim of present review of literature is to discuss various pulpotomy medicaments in detail.

Keywords: Pulp therapy, Pulpotomy, Pulpotomy medicament

Introduction: Preservation of arch space is one of the primary objectives of pediatric dentistry;[1] hence, every effort is made to preserve the natural primary teeth as they are considered to be the best space maintainers.[2.3] Pulpotomy is indicated in primary molars when the radicular pulp tissue is healthy or is capable of healing after surgical amputation of

the affected or infected coronal pulp. According to the American Academy of Pediatric Dentistry, pulpotomy is defined as the ablation of infected or affected pulp tissues leaving the residual vital pulp tissues intact, thus preserving vitality and function (totally or partially) of the radicular pulp, while the remaining pulp stump is covered with a medicament.[4] Vital pulpotomy is the clinical treatment of choice for primary teeth with exposed pulp. Pulpotomy can be defined as the surgical removal or amputation of the coronal pulp of the vital tooth.[6] This step is generally followed by the placement of a particular medicament over the intact stump to fix, mummify or stimulate repair of the remaining radicular pulp.[7]

Formocresol remains the gold standard among all the medicines published in the literature of the pulpotomy drugs. Despite the high success rate, the use of formocresol has posed numerous questions, including its mutagenic, carcinogenic, and Allergic potential. These drawbacks of formocresol have led to the use of alternate medicaments for pulpotomy in primary teeth. Many different alternative techniques including electrosurgery and use of lasers have been proposed while medicaments such as glutaraldehyde, ferric sulfate, enriched collagen solution, MTA and Propolis.[8] Hence the aim of present review of literature is to discuss various pulpotomy medicaments in detail.

Table no. 1: Pulpotomy at a glance[9-16]

1904	Buckley: Introduced formocresol for pulpotomy
1930	Sweet suggested concept of Multivisit Pulpotomy
1962	Doyle at al. introduced 2 Visit Pulpotomy
1965	Redig et al. & Speeding et al. suggested 5 min pulpotomy
1967	Venham recommended 15 sec procedure
1975	Gluteraldehyde was suggested by Kopel et al. and introduced by S Gravenmade
1991	Fei et al. introduced farric sulphate pulpotomy
1991	Nakashima: application of bone morphogenic protein in Pulpotomy procedure
1991	Gracia Godoy suggested 1 min pulpotomy
1993	Torabinejad: Initiated the use of MTA for the repair of perforation. MTA was used for various vital pulp therapy procedures including pulpotomy
2002	Hafez AA and Cox CF used sodium hypochlorite as an pulpotomy agent

Indication of Pulpotomy[14]

1. Pulp exposure during removal of caries in primary teeth
2. Pulp exposure due to trauma
3. No history of spontaneous pain
4. Hemorrhage from exposure site is easily controllable
5. Hemorrhage from the exposure site is bright red in colour
6. No intraradicular bone loss
7. No intraradicular radioleucency
8. Absence of abscess or fistula
9. In young permanent tooth with vital exposed pulp and incompletely formed root

Stepwise Pulpotomy Procedure[14]

- Anaesthesize the tooth and tissue
- Isolate the tooth with rubber dam
- Remove caries with a high speed straight bur without entering the pulp chamber
- Remove the roof of pulp chamber with a slow speed round bur
- Remove coronal pulp with a large excavator or a large round bur
- Apply formocresol with a pledget of cotton and apply it on the amputated pulp for 4 minutes.
- Remove formocresol pledget after 4 minutes and check that hemorrhage stopped
- Filled the pulp chamber with Zinc Oxide Eugenol cement
- Restore the tooth with stainless crown.

Various Pulpotomy Medicament

Formocresol: Pulpotomy using formocresol was introduced by Buckley in 1904. In 1930, Sweet introduced the formocresol pulpotomy technique. Formocresol has subsequently become a popular pulpotomy medicament for primary teeth. Initially, the technique involved five visits. Sweet reduced the number of visits over the years, because of economic and behavior management considerations.[15] Doyle et al. (1962) used a two visit procedure in their comparison study of formocresol and calcium hydroxide. Within a few years, Spedding et al.

(1965) and Redig reported the results of a 5 min formocresol protocol, and since that time, complete mummification has been abandoned by the profession.[17,18]

The composition of Buckley's formocresol is 19% formaldehyde and 35% tricresol, 15% glycerin and 31% water base.[19] Glycerine is added to prevent the polymerization of formaldehyde to para formaldehyde. The presence of para formaldehyde causes clouding of the solution. One fifth dilution of Buckley's formocresol can be prepared by adding 30 ml of Buckley's formocresol, 90 ml of glycerol and 30 ml of water.[15]

Formocresol acts through the aldehyde group of formaldehyde, forming bonds with the side groups of the amino acids of both the bacterial proteins and those of the remaining pulp tissue. It is therefore both a bactericidal and devitalizing agent. It kills off and converts bacteria and pulp tissue into inert compounds.[19]

IARC (June 2004) classified formocresol as carcinogen that has potency to cause leukemia and nasopharyngeal carcinoma. However, Ranly calculated the formocresol concentration following pulpotomy and reported that 3000 pulpotomies will have to be performed in same individual to reach toxic levels.[20]

Glutaraldehyde: Gravenmade S 1975 introduced glutaraldehyde (GH) as a new pulp fixative agent. At ph of 7.5 to 8.5, it has a potent bactericidal effect. It is an aldehyde with higher fixative property compared to formocresol and noted that increasing the concentration and longer time improves fixation and suggested the use of 4% Glutaraldehyde for 4 minutes or 8% Glutaraldehyde for 2 minutes.[21]

The properties of glutaraldehyde which make it a potential agent for pulpotomy procedure and also an alternative to the preferred formocresol, are its superior fixative properties, self-limiting penetration, low antigenicity and low toxicity.[22] The only limitations of glutaraldehyde are instability due to short shelf life and it has to be freshly prepared.[15] Prakash et al. (1989) evalauted the clinical and radiological effects of formocresol and glutaraldehyde pulpotomies in various exposed vital human primary molars concluded that glutaraldehyde is better fixative and less toxic agent than formocresol.[23]

Ferric Sulphate: Ferric sulphate (Fe2[SO4]3) has been used as a coagulative and a haemostatic agent for crown and bridge impressions. The agglutination of blood proteins results from the reaction of blood with ferric and sulphate ions and with the acidic pH of the solution. The agglutinated proteins form plugs that occlude the capillary orifices, and thereby minimizes the chance for inflammation and internal resorption.[9]

Fei et al. (1991) reported the application of ferric sulphate in pulpotomized human primary molars with clinical and radiographic success rates of 100% and 97%, respectively. Ferric sulphate prevented problems arising from clot formation after the removal of the coronal pulp and produced a local, but reversible, inflammatory response in oral soft tissues. No concerns about toxic or harmful effects of ferric sulphate have been recorded in the dental or medical literature.[24]

Calcium Hydroxide: Calcium hydroxide was the first agent used in pulpotomies that demonstrated any capacity to induce regeneration of dentin. Calcium hydroxide was introduced in combination with other salts as a pulp-capping agent called calxyl. Additionally, in 1938, Teuscher and Zander reported the presence of a complete dentinal bridge and healthy radicular pulps that had been directly pulp capped with Ca(OH)2 dressings

Doyle et al. (1962) compared the histological, radiographic and clinical success of formocresol and Ca(OH)2 in pulpotomies of human teeth. Their results showed 76 to 100% success in the formocresol group, whereas in the Ca(OH)2 group, the success rate was from 50 to 71%.[16]

Calcium hydroxide has been used as a pulp capping agent to stimulate pulpal healing and dentin bridge formation in the permanent dentition, but it is not recommended as a pulp capping agent for pulpotomies in the primary dentition. The main disadvantage of calcium hydroxide as a medicament in primary pulp therapy is the frequent finding of internal resorption.[7]

Electrosurgery: Electrosurgery (ES) has been used in dentistry to remove soft tissue and to control the haemorrhage associated with periodontal and oral surgical procedures. ES has been defined as the intentional passage of high-frequency waveforms, or currents, through the tissues of the body to achieve a controllable surgical effect. The use of ES to promote pulpal hemostasis as a non-pharmacological pulpotomy technique has proven to be a merit as it leads to good visualization and hemostasis and is less time-consuming than the FC approach. Dean et al. (2002) who reported clinical and radiographic success of electrosurgical groups to be 96% and 84%, respectively, and for FC group, 100 and 92%, respectively.[26]

Bone Morphogenic Proteins: Bone Morphogenic Proteins (BMP) is thought to induce reparative dentin with recombinant dentinogenic proteins similar to the native proteins of the body. In 1990, Nakashima reported a histological study using bone morphogenetic protein in

50 teeth of five young adult dogs. The study was undertaken at time periods of 1, 4 and 8 weeks. The results showed that reparative dentin formed in the cavity of the amputated pulp when capped with crude allogenic bone morphogenetic protein. In addition, 8 weeks postoperatively, odontoblasts were forming tubular dentin next to the osteodentin.[27]

Freeze-dried Bone: Fadavi et al. (1988) evaluated the effects of freeze-dried bone on amputated pulp in 15 primary and one permanent monkey teeth. They compared these teeth with teeth treated with Ca(OH)2 and formocresol. Freeze-dried bone showed a complete or partial calcific barrier directly below the amputation site, and similar results were shown in the Ca(OH)2 group after 3 months; however, the results in the formocresol group were comparable to those of previously published studies.[28]

Recent Pulpotomy Medicament

Mineral Trioxide Aggregate: The mineral trioxide aggregate (MTA) was introduced by Torabinejad in mid-1990s as a novel material for the pulpotomy procedure in both primary and permanent teeth. The MTA offers properties like excellent biocompatibility, promotes tissue regeneration, and provides a good marginal integrity with no microleakage. Srinivasan D et al. (2011) compared mineral trioxide aggregate and formocresol as pulpotomy medicaments by clinical and radiographic assessments and to assess the histological features of both pulpotomy medicaments in deciduous teeth. At the end of 12 month follow up MTA was found to be superior to formocresol clinically, radiographically. Histological analysis showed better reparative ability with hard tissue barrier formation with MTA compared to formocresol.[29]

Biodentine: Biodentine (Septodont, St. Maur-Des-Fosses, France), a newer bioactive cement, has been shown to be useful in numerous clinical applications such as pulp capping, pulpotomy, and apexification. Biodentine is bioactive cement with mechanical properties similar to the dentin, hence it can be used as a dentin substitute. Placement of biodentine over a health pulpal tissue has been shown to encourage reparative dentin formation. It is biocompatible, has short setting time, long shelf life, high compressive strength, and better ehandling properties.[30] Musale PK et al. (2018) evaluated clinical and radiographic outcomes of Biodentine™ as a pulpotomy medicament compared with one-minute full-strength formocresol and white MTA. At the end of 12 month follow up biodentine was found to be superior to formocresol and white MTA.[31]

Portland cement: Portland cement (PC) differs from MTA by the absence of bismuth ions and presence of potassium ions. Both MTA and portland cement have comparable antibacterial activity and almost identical properties macroscopically, microscopically and by X-ray diffraction analysis. It has also been shown that PC and MTA have similar effects on pulp cells when used for direct pulp-capping in rat teeth. Sakai et al. (2009) compared the clinical and radiographic effectiveness of mineral trioxide aggregate and Portland cement as pulp dressing agents in carious primary teeth. He found that the PC can serve as an effective and less expensive MTA substitute in primary molar pulpotomies.[32]

Sodium hypochlorite: Sodium hypochlorite (NaOCl) most popular endodontic irrigants seems to be an acceptable alternative for FC owing to its antimicrobial property and hemostatic agent. NaOCl has been found to have promising results as a pulpotomy agent in primary teeth with results comparable to the agent of choice for maintaining vital pulp tissue, i.e., calcium hydroxide (the associated internal resorption being the major problem with calcium hydroxide). Coupled with the easy availability of NaOCl in each and every clinical scenario, it can be stated that for preservation pulpotomies, NaOCl is one of the best materials available at easy disposal to every dentist. Chauhan SP et al. (2017) compared formocresol and sodium hypochlorite as pulpotomy Medicament in primary teeth. Based on this study, result of 5% NaOCl and FC showed no significant difference in their success rate. Hence, NaOCl can be used as pulpotomy medicament; however, further clinical trials with long follow-up period are required.[33]

Lyophilized freeze dried platelet: Lyophilized freeze dried platelet regulates the multiplication of cells, migration and extracellular matrix production by acting as a signalling protein. An in-vivo study conducted by N Venugopal Reddy et al. to compare and evaluate the clinical, radiographical and histological success of FC, Propolis (PS), and Platelet derived growth factor (PDGF) as pulpotomy agents. The study showed clinical and radiographical success for PDGF group as 96.3% and 88.89% respectively, followed by PS group (96.3%, 88.4%) and FC group (76%, 72%). Histological examination showed deep and uninterrupted formation of dentin bridge with minimum inflammation in both PS and PDGF. In 2004, Kalaskar R et al. compared the efficacy of lyophilized freeze dried platelet derived preparation with calcium hydroxide in primary molars and found lyophilized freeze dried platelet to better than calcium hydroxide in 6 month follow up.[34]

3 Mix-tatin: 3 Mix-tatin has been used as a DPC and root canal filling material in primary teeth. It is composed of 3 Mix (a combination of metronidazole, minocycline, and ciprofloxacin) and statin. The successful outcome of 3 Mix-tatin could be attributed to the bio-inductive effect of simvastatin. 3 Mix-tatin in a study by Jamali et al. showed success rate of 90.5% for pulpotomy of primary molars.

Calcium-enriched mixture: Calcium-enriched mixture (CEM) cement, a novel endodontic material also known as new endodontic cement was introduced to dentistry by Asgary et al. in 2006. Nosrat in 2012 compared MTA with CEM pulpotomy, result showed 100% clinical and radiographical success rate for both the groups at 6 and 12 months' follow-up.[36]

Nanohydroxy Apatite: Nanohydroxy Apatite has been implemented in osseous defects for augmentation procedures and is gaining growing popularity in medicine and dentistry. NHA is biocompatible with pulp tissue and is non-irritating.[37]

Platelet rich fibrin: Platelet rich fibrin (PRF) is an autogenous biomaterial consisting of growth factors and cytokines entrapped in a fibrin matrix. It combines the fibrant sealant properties along with growth factors thereby providing an ideal environment for wound healing and regeneration of tissues. Patidar S et al. (2017) evaluated effectiveness of platelet-rich fibrin and mineral trioxide aggregate as pulpotomy agent in primary molars. In radiographic and clinical evaluation PRF group found to be an acceptable alternative in pulpotomy of primary teeth. PRF holds a promising future in the area of primary tooth vital pulp therapy.[38]

Natural Substances: Many natural products such as Nigella Sativa, Curcuma Longa, Turmeric, Thymus Vulgaris, Honey, Allium Sativum oil, Aloe Vera, Acemannan have claimed to play a vital role and appear to be a feasible replacement to FC. However, higher level of evidence is needed to hold up its usage in pediatric dentistry.[39]

Conclusion: Pulpotomy is a procedure which involves complete amputation of the coronal pulp, followed by employment of an appropriate medicament that will stimulate healing and preserve the vitality of the tooth. Formocresol Pulpotomy enjoys very good clinical and radiographic success rates, and is still a popular pulpotomy material despite the concerns raised due to its toxicity, mutagenicity and carcinogenicity. Other materials such as MTA and Biodentine can be used as an alternative to formocresol.

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