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Irrigation in Pediatric Dentistry: A Literature Review

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Abstract

Disinfection of the root canal system, as part of pediatric endodontic, by preparation and irrigation is key in reducing the number of bacteria within the root canal and helping to control periradicular infection. Irrigants can augment mechanical debridement by flushing out debris, dissolving tissue, and disinfecting the root canal system. Chemical debridement is especially needed for teeth with complex internal anatomy such as fins or other irregularities that might be missed by instrumentation. This review of literature aims to highlight information about irrigating solution used in pediatric dentistry.

Keywords: Pediatric dentistry, Irrigation, Irrigating solution

Introduction

Pediatric endodontics is one of the important clinical procedures used for the treatment of pulp therapies in children. Loss of primary molars, leading to space loss, is an important issue which needs attention in the field of pediatric dentistry. Successful root canal treatment mainly depends on biomechanical preparation with an

aim to clean and shape the root canals by removing soft and hard tissue. This, in turn, makes space for irrigants to the apical third and medicaments and subsequent obturating material in the radicular structure. Usually, biomechanical preparation is done with hand files, reamers, burs, and sonic instruments and recently with rotary instruments.[1,2]

During the root canal preparation of primary teeth since there is a formation of dentinal shavings composing of organic materials and microorganisms forming the smear layer. It consists of organic and inorganic components which covers the root canal surfaces and blocks the dentinal tubules openings.[3] The inorganic material is composed of tooth structure and some nonspecific inorganic contaminants, whereas the organic components consist of heat coagulated proteins; necrotic or viable pulp tissue, and odontoblastic processes plus saliva, blood cells, and microorganisms. It harbors microorganism's that infect dentinal tubules, impedes penetration or diffusion of antibacterial irrigants and medicaments into the dentinal tubules and compromises the seal between the filling materials and the dentinal wall. Because of its potential contamination and adverse effects on the outcome of root canal treatment, smear layer removal is recommended.[4,5]

Disinfection of the root canals before filling is a pivotal step in pulp therapy. Although mechanical preparation along with antiseptic properties of obturating materials can lower bacterial load, it is inevitable to use irrigating solutions to remove the microbiota from areas inaccessible to instrumentation. The possible organisms responsible for root canal failure are gram negative anaerobic bacteria, Enterococcus faecalis, Staphylococcus aureus and Candida albicans.[6]

The complete removal of microbes from the root canals has become a challenging issue which led to the use of combination irrigants. Different solutions have been used for irrigating the primary root canals during biomechanical preparation. Physiological saline solution and sodium hypochlorite (NaOCl) are the most popularly used. NaOCl being a cytotoxic agent poses the risk of potential injury to permanent tooth germs when it reaches the periapex.[7] This review of literature aims to highlight information about irrigating solution used in pediatric dentistry.

Ideal Properties of Irrigating Solution [8,9]

1. Broad antimicrobial spectrum and high efficacy against anaerobic and facultative microorganisms
2. Ability to completely dissolve necrotic pulp tissue remnants
3. Ability to inactivate endotoxin
4. Ability to prevent the formation of a smear layer during instrumentation or to dissolve the latter once it has formed.
5. Should be non-caustic to periodontal tissues
6. Should be little or no potential to cause an anaphylactic reaction**.**
7. Has no adverse effects on the physical properties of exposed dentin
8. Has no adverse effect on the sealing ability of filling materials
9. Easy to use/apply.
10. Inexpensive

Classification of Irrigating Solutions

Chemical agents

- **Tissue dissolving agent:** Sodium hypochlorite
- **Antibacterial agent:** Chlorhexidine
- **Chelating agent:** EDTA

Natural agents: Aloe Vera, Triphala, Propolis

Chemical Irrigating Solution

Sodium hypochlorite: NaOCl is the most popular irrigating solution in use today, and is considered the

primary irrigant of choice during chemomechanical preparation.[10]

Its active chemical compound is the free available chlorine, consisting of the hypochlorite ion (OCl^-) and hypochlorous acid (HOCl). When hypochlorous acid, a substance present in NaOCl solution, comes in contact with organic tissue it acts as a solvent and releases chlorine, which combines with the protein amino group to form chloramines. Hypochlorous acid ($HOCl^-$) and hypochlorite ions (OCl^-) lead to amino acid degradation and hydrolysis. The chloramination reaction between chlorine and the amino group (NH) forms chloramines that interfere in cell metabolism. Chlorine (a strong oxidant) has an antimicrobial action, inhibiting bacterial enzymes and leading to an irreversible oxidation of SH groups (sulphydryl group) of essential bacterial enzymes.[11]

Thus, the saponification, amino acid neutralization, and chloramination reactions that occur in the presence of microorganisms and organic tissue lead to the antimicrobial effect and tissue dissolution process.

Concentration of Sodium hypochlorite: The most effective irrigation regimen is reported to be 5.25% at 40 min; irrigation with 1.3% and 2.5% NaOCl for this same time interval is ineffective in removing E faecalis from infected dentin cylinders. NaOCl was moderately effective against bacteria but less effective against endotoxins in root canal infection.[11]

Method to Increase the Efficacy of Sodium Hypochlorite

Temperature: Increasing the temperature of low-concentration NaOCl solutions. By increasing the temperature of NaOCl it facilitates the effectiveness of tissue-dissolution capacity. The capacity of 1% NaOCl at 45°C is capable of dissolving the human dental pulp was found to be equal to that of a 5.25% solution at 20°C and the short-term efficacy in the root canal system, the systemic toxicity of pre heated NaOCl irrigants should be lower than the one of the more concentrated non-heated solutions as the temperature equilibrium is reached relatively quickly.[12]

Ultrasonic: The use of ultrasonic agitation increased the effectiveness of 5% NaOCl in the apical third of the canal wall. Passive ultrasonic irrigation with a nickel-titanium tip produced superior tissue-dissolving effects as compared to sonic irrigant activation.[11]

Contact time: The time needed for NaOCl to eliminate bacteria from the root canal system, it ranged from 2 to 30 minutes. The disinfection is significantly better with a high volume and an extended exposure to NaOCl.[13]

Hypochlorite accident: Sodium hypochlorite is an effective intracanal irrigant and is used in concentrations ranging from 0.5 to 5.25%. At these concentrations, it is highly hypertonic and strongly alkaline with pH 11 to 13. Despite its safe properties, serious complications can result from inadvertent use due to its cytotoxic features. Most of the complications are the result of accidental extrusion of the solution from the apical foramen or accessory canals or perforations into the periapical area.[14]

Damage to permanent tooth follicles, peripheral tissue, and oral mucosa have been reported during negligent use of NaOCl use in pediatric endodontics.

According to Hülsmann criteria, the diagnostic features of for a NaOCl accident include:[15]

- Acute pain,
- Swelling and redness
- Bruising
- Progressive swelling involving the infraorbital area or angle of mouth
- Profuse hemorrhage often manifesting intraorally from the orifice of the tooth

- Numbness or weakness of the facial nerve
- Secondary infection, sinusitis and cellulitis

The mainstay of treatment is supportive including control of swelling, pain relief and prevention of secondary infection. Analgesics should be given in order to relieve the post incident pain. A course of antibiotics should be prescribed, as there is potential for secondary or spread of infection. Local anesthesia in the presence of diffuse swelling should be avoided to prevent spreading of existing infection.[14,16]

Extraoral cold compresses should be used for the first 6 hours in order to minimize swelling. Subsequent to this initial period, heat packs should be used after 24 hours (15 minute interval) to improve the circulation to the area. According to Kleir et al, most of the patients recovered completely within one week, which is in accordance with the present case report.[14]

The following steps can help clinicians avoid NaOCl accidents:[17]

- Adequate access preparation.
- Good working length control.
- Irrigation needle should be placed 1 to 3 mm short of working length.
- Passive needle tip placement within the canal without getting bound to the walls thus permitting free movements of the needle.
- Irrigant to be expressed into the root canal gently with a low, constant pressure, withdrawing the needle slightly from the binding point.
- Use Luer Lock needles with side-port delivery that are specifically designed for endodontic purposes.

Saline: In endodontic procedures, normal saline is one of the solutions used as an irrigant. It results in root canal debridement and lubrication. Because of its moderate activity, it may be used in conjunction with chemical irrigants. After root canal preparation, it may be used as a last rinse to flush out any leftover chemical irrigant. The most common saline solution is 0.9 percent W/V normal saline.[18]

Chlorhexidine: Chlorhexidine (CHX) is a strong antiseptic that is often used to chemically control plaque in the mouth. Mouthwash is made up of 0.1-0.2% aqueous solutions, while root canal irrigation in endodontic treatment is done with a 2% concentration. Chlorhexidine is effective against a wide spectrum of microorganisms which includes Gram-positive and Gram-negative bacteria, facultative and strict anaerobes, yeasts and fungi, particularly Candida albicans. Ruiz-Esparza et al. reported that 2% CHX showed a greater reduction of intracanal bacterial loading and suggested that this irrigating solution is an alternative for pulpectomy treatment of necrotic primary teeth.[19] Leonardo et al. concluded that CHX gluconate has been recommended as an irrigation solution because of its antibacterial effectiveness, substantivity and lower cytotoxicity compared with NaOCl.[20]

EDTA: Tissue-dissolving irrigation solutions, both organic and inorganic, are essential for a comprehensive root canal cleanup. To remove the smear layer or other debris from the root canal system, NaOCl, which dissolves only organic tissue, should not be used. A supplementary solution of EDTA and other demineralizing agents should be administered during root canal therapy. Irrigation with 17% EDTA for one minute followed by a final rinse with NaOCl is the most commonly recommended method to remove the smear layer.[21]

MTAD: MTAD (mixture of Doxycycline, citric acid and a detergent) is an endodontic irrigant with antibacterial properties and the ability to remove smear layer. It was hypothesized that MTAD may be useful for root surface conditioning. It is recommended to be used as a final

rinse after root canal preparation. It is capable of eliminating all bacteria and smear layer from the root canal system when used as a final rinse.[22]

Ozonated water: Ozone is a selective oxidant and affects only certain compounds; however, when dissolved in water, it becomes highly unstable and rapidly decomposes through a complex series of chain reactions. As a result, hydroxyl ($HO^{\cdot}$) radicals are generated, which are among the most reactive oxidizing species. Ozone reacts with various chemical compounds in aqueous systems in two different and coexisting modes; one involving direct reactions of molecular ozone and the other a free radical-mediated reaction. Both these mechanisms may be involved in the destruction of bacteria by ozone. In vivo root canal contents and caries, unlike artificial biofilms, contain many molecules such as iron, which can increase the antimicrobial effectiveness of ozone in teeth and can help produce the powerful hydroxyl radicals in vivo to further increase the antimicrobial effectiveness of ozone.[23]

Agarwal S et al. compared the antimicrobial efficacy of aqueous ozone, green tea, and normal saline as irrigants in pulpectomy procedures of the primary teeth and found that Mean colony forming unit (CFU) count after both initial and final irrigation with ozonated water was significantly lower when compared with green tea and normal saline. Author finally concluded that ozonated water can be opted for, as an irrigant of choice, owing to its neutral taste and potent antimicrobial efficacy, especially against anaerobes.[24]

Citric acid: Citric acid can also be used for irrigation of the root canal to remove the smear layer. Concentrations ranging from 1% to 50% have been used. The use of 10% citric acid as final irrigation has shown good results in smear layer removal and proven to be more biocompatible than 17% EDTA.[25]

Hariharan VS et al. conducted a study is to determine the efficacy of various irrigants in removing the smear layer in primary teeth root canals after hand instrumentation. 5.25% NaOCl, 5.25% NaOCl + 10% EDTA, 6% citric acid, 2% chlorhexidine, saline (control) were the irrigants evaluated for efficacy in removal of smear layer. Author concluded that 6% citric acid has the best smear layer removal efficacy without affecting the normal structure of dentinal tubules in primary root canals.[26]

Maleic acid (MA) - MA is a mild organic acid used to roughen enamel and dentin surfaces in adhesive dentistry. It removes the smear layer effectively at concentrations of 5% and 7%. In addition, when used at concentrations of 10% or higher, it causes demineralization and erosion of the root canal wall.[27]

Silver Diamine Fluoride: Silver diamine fluoride A 3.8% w/v silver diamine fluoride solution has been used for intracanal irrigation. $Ag(NH_3)_2F$ has potential for use as an antimicrobial root canal irrigant or inter appointment medicament to reduce bacterial loads. 60 minutes exposure to $Ag(NH_3)_2F$ completely killed E faecalis, but silver particles occluded dentinal tubular orifices after removal of the smear layer.[28]

Carisolv: Carisolv contains 0.5% sodium hypochlorite along with amino acids. The hypothesis was that this agent can also be effective in removal of smear layer from root canal system when used as an irrigant studies have shown that carisolv was ineffective in removing smear layer.[29]

Tetraclean: Tertaclean is a mixture of doxycycline hyclate (at a lower concentration than in MTAD), an acid and a detergent. It is recommended to be used as a final rinse after root canal preparation. It contains

doxycycline (50 mg per 5 ml) with polypropylene glycol (a surfactant) citric acid and cetrimide. It is capable of eliminating all bacteria and smear layer from the root canal system when used as a final rinse.[30]

Herbal Irrigating Solution

Propolis: Propolis is a resinous adhesive mixture that Apis mellifera bees prepare by collecting materials from different plants in order to preserve the honeycomb structure. More than 160 constituents have been identified in different propolis samples. It usually consists of waxes, resins, water, inorganic compounds, phenolics and essential oils. Verma MK et al. conducted a study to assess the potential of water-soluble 25% propolis extract against microorganisms present in root canals of primary teeth during endodontic procedures The results of the study have confirmed that the antibacterial effectiveness of water-soluble extract of propolis in the root canals of primary teeth in vivo. Considering the low toxicity concerns and antibacterial effectiveness, water-soluble extract of 25% propolis can be advocated as a root canal irrigant in endodontic treatment of primary teeth.[31]

Triphala: Triphala is one of the well known Indian Ayurvedic herbal formulation consisting of dried and powdered fruits of three medicinal plants namely Terminalia Bellerica, Terminalia Chebula and Emblica Officinalis. Triphala achieved 100% killing of E faecalis at 6 min. This may be attributed to its formulation, which contains three different medicinal plants in qual proportions; in such formulations, different compounds may help enhance the potency of the active compounds, producing an additive or synergistic effect.[32] An in vitro study conducted to evaluate the antimicrobial efficacy of Triphala, GTPs, MTAD, and 5% Sodium Hypochlorite against E faecalis biofilm formed on tooth substrate showed maximum antibacterial activity with NaOCl and statistically significant antibacterial activity with Triphala, GTPs and MTAD.[33]

Conclusion: The prime objective of pediatric endodontic therapy aims to maintain the primary teeth in their form and function and to facilitate the proper eruption of permanent successors. The role of clinician ascribed to maintain strict asepsis in vital pulp situation and to attain antisepsis for non-vital and necrosed pulps. The endodontic instrumentation cannot effectively eliminate the microflora from the root canals of primary teeth mechanically owing to their anatomical complexity. The dependence on irrigating solutions for endodontic success becomes more crucial, especially in primary teeth due to thin dentinal walls, complex morphology, and irregularity of root canal system. To achieve these properties various root canal irrigants are used either singly or with combination. During instrumentation canals should be irrigated using copious amounts of the NaOCl solution. Once the shaping procedure is completed, canals can be thoroughly rinsed using aqueous EDTA or citric acid. Generally each canal is rinsed for at least 1 min using 5 to 10 ml of the chelator irrigant. After the smear layer removal procedure, a final rinse with an antiseptic solution appears beneficial. Chlorhexidine appears to be the most promising agent for use as a final irrigant in this situation.

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