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SODIUM HYPOCHLORITE IN ENDODONTICS – THE BENCH MARK IRRIGANT: A REVIEW

Running title: Sodium hypochlorite in Endodontics

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ABSTRACT

The main aim of root canal treatment is to disinfect the entire root canal system. The main agenda is to eliminate the necrotic pulp. This goal can be achieved using chemical irrigation and mechanical instrumentation combined with medication of the root canal between treatment sessions. The major causes of pulpal and periapical pathosis are the microorganisms and their by-products. Various irrigation solutions have been suggested in order to eliminate or reduce bacteria and pulpal tissue remnants. The irrigants used in endodontics are Sodium hypochlorite, chlorhexidine digluconate, chitosan, EDTA and a few herbal derivatives. The most commonly used irrigant is sodium hypochlorite because of its excellent antimicrobial properties.

Key words: Antimicrobial, irrigation, sodium hypochlorite

INTRODUCTION

Irrigation is said to be the most important part of endodontic treatment when it comes to elimination of root canal microbes [1]. Elimination of microbes in the root canal is a challenging task. Various measures have been incorporated to reduce the number of microbes in the root canal system which includes instrumentation, irrigation techniques and intracanal medicaments.Mechanical instrumentation alone cannot result in a bacteria free root canal system [2].A part of root canal dentine surface planed by instruments has been assessed using a high-resolution CT which showed that 35-53% of the canal surface remained uninstrumented.[3]Hence there should be some type of irrigation or disinfection which is necessary to remove the tissue and kill the microbes from the root canal system [2]. Sodium hypochlorite is the most important and widely used irrigant in endodontic practice. It is the only solution which dissolves organic matter in the root canal. Therefore, sodium hypochlorite is considered the best irrigant in removing necrotic tissue remnants and biofilm [1]. Apart from sodium hypochlorite, various other irrigants such as Chlorhexidine digluconate, EDTA, MTAD, chitosan can be used in day to day practice. Recently, Herbal derivatives such as Mangifera Indica L. Kernel, Ocimum sanctum, Green tea and Triphala are proved to eradicate E.Faecalis[4].

AN OVERVIEW OF OTHER IRRIGANTS

Chlorhexidine digluconate (CHX):

Chlorhexidine is another commonly used irrigant after EDTA [1].Ithas an excellent bacteriostatic as well as bactericidal properties but completely lacks tissue dissolving capability.An ex-vivo study done by Basson and Tait compared the disinfecting effectiveness

of Calcium hydroxide, Iodine Potassium Iodide and chlorhexidine in root canal systems that were infected with Actinomyces Israelii and concluded that chlorhexidine was the only irrigant that was able to eradicate A.Israelii[4]. Chlorhexidine kills the microbe by attacking the cell wall or the outer membrane of the microbe. CHX shows cytotoxic effects on human cells but it does not cause pain in the periapical region due to accidental extrusion as compared to NaOCl[1]. Between NaOCl and CHX, sterile water or saline can be used to prevent chemical reactions between the two. However, they cannot be used as main irrigants since they do not exhibit antimicrobial or tissue dissolving activity [1].

EDTA:

Ethylene Diamine Tetra acetic acid was introduced by Nygaard-Ostby in 1957 as an aid in preparation of narrow and calcified canals with a recommended use of 15% EDTA at pH 7.3[4]. EDTA is a chelating agent which is used after NaOCl as the final irrigant. EDTA has a very little or no antimicrobial activity but few studies have shown that EDTA exhibits antifungal activity. Though the recommended concentration of EDTA was suggested to be 15%, some studies have suggested that the use of 5% or even 1% of the solution is strong enough to remove the smear layer [1]. The recommended time to get rid of the smear layer is about two minutes, but thicker layer might require longer times of exposure [1].

MTAD:

A new irrigant which contains a mixture of 3% doxycycline, 4.25% citric acid and detergent (Tween-80) was developed by Torabinejad et al. The use of MTAD has been effective in removing smear layer. The citric acid in the preparation removes the smear layer which in turn gives way for doxycycline to enter the dentinal tubules and exhibit an antibacterial effect [4].

Chitosan:

Chitosan is a biopolymer which is obtained from partial deacetylation of chitin which is derived from crustacean cells. Chitosan exhibits antimicrobial property due to the electrostatic interactions between NH^{3+} which binds to the components of bacterial cell surface thereby altering the cell permeability and which results in the leakage of intracellular components and cell death. Studies have shown the antimicrobial activity of EDTA-chitosan acetic acid on E.faecalis but their action on dentinal biofilms have remained unexplored[5].

HERBAL ALTERNATIVES:

Triphala:

It is a derivative of three medicinal plants Terminaliabellerica, Terminaliachebula, and Emblicaofficinalis . Triphala consists of dried and powdered fruits of these three medicinal plants. It has shown a success rate of 100% in killing E.faecalis in 6 minutes. The three different medicinal plants are formulated in equal proportions and they enhance the potency of active compounds producing a synergistic effect. The advantages of using herbal alternatives is that they are economic and have longer shelf life with low toxicity and lack of microbial resistance[4].

Mangifera indica L.kernel and Ocimum sanctum L.leaves :

Ocimum sanctum is the common tulsi leaf which is used in day to day life. The essential oil which is derived from the tulsi leaves contain eugenol which is a phenolic compound which attributes to its antimicrobial, antidiabetic and anticarcinogenic properties. Mangifera indica L. is nothing but mango. Mangiferin which is a major C-glucosylxanthone is found in the

M.indica stem bark, leaves and fruits. The tannins present in them exhibits the antibacterial activity of mango. The activity of Mangifera indica L,and Ocimum sanctum leaves was highly significant in comparison to the conventionally used 5% NaOCl according to recent studies[6].

SODIUM HYPOCHLORITE AND ITS MECHANISM OF ACTION

NaOCl is the most widely accepted and the benchmark irrigant in endodontics. The following reaction shows the dynamic balance of NaOCl

$NaOCl + H2O \rightarrow NaOH + HOCl \rightarrow Na^{+} + OH^{-} + H^{+} + OCl^{-}$

Interpreting the above chemical reaction, NaOCl acts as solvent for organic and fat degrading carboxylic acids thus transforming them into fatty acid salts(soap) and glycerol (Alcohol) that reduces the surface tension of the remaining solution. The amino acids are neutralised by NaOCl forming water and salt showing neutralisation reaction. ThepH is reduced with the exit of hydroxyl ions. Hypochlorous acid comes in contact with organic tissue acts as a solvent and releases chlorine which combines with amino group forming chloramine that interfere in cell metabolism. Amino acid degradation and hydrolysis is done by hypochlorous acid and hypochlorite ions [7].

Chlorine is a strong oxidant and shows antimicrobial action by inhibiting bacterial enzymes which leads to irreversible oxidation of sulfhydryl group of essential bacterial enzymes [7].

Antibacterial activity

The antibacterial activity of sodium hypochlorite has been proved with many in vitro studies. Walker in 1936 introduced sodium hypochlorite as an irrigant in endodontic practice. Ever since then no other irrigant is shown to be more effective than NaOCl[2]. A study conducted by siqueria et al compared the antibacterial activity of various irrigants against four black pigmented anaerobic bacteria and four facultative bacteria through agar diffusion test. Their results showed the antibacterial effectiveness of 4% NaOCl and 2.5% NaOCl was remarkably greater than other agents which were tested [10]. Various other studies concluded that 1.5%, 5.25% NaOCl is the ideal concentration to be used in controlling E.faecalis colonies[8].

Effect on biofilms

The term biofilm designates the thin layered condensations of microbes that occur on several surface structures. The pre requisite for the formation of biofilm are the planktonic bacteria which are the free-floating bacteria which exist in an aqueous environment [9].

Several reports show that microbes growing in biofilm could be 2-1000-fold more resistant than planktonic bacteria [10]

A study conducted by Giardino et al compared the efficacy of NaOCl and MTAD against E.faecalis biofilm showed that only 5.25% sodium hypochlorite can disintegrate and remove the biofilm at all times. Therefore, NaOCl is the only irrigant that can destroy and remove biofilms which are present in the root canal space [11].

Effect on tissue solubility

An ideal irrigant should be able to dissolve the organic matter inside the root canal system [2].

A study was conducted by Okino[12] et al which evaluated the tissue dissolving ability of 0.5,1,2.5% of sodium hypochlorite with 2% aqueous solution of chlorhexidine and 2% chlorhexidine in gel form and distilled water was used as control. Bovine pulp fragments were weighed and were placed in contact with 20ml of tested substance and kept in a

centrifuge at 150rpm until total dissolution. Distilled water, CHX in both solution and gel forms did not dissolve the pulp tissue within 6 hrs whereas the mean dissolution speeds for 0.5,1,2.5% of sodium hypochlorite was found to be 0.31, 0.43, 0.55mg/min respectively.

Several other studies prove that sodium hypochlorite has an excellent tissue dissolving ability when compared to other irrigants[2].

NaOCl Toxicity and complications

NaOCl is toxic at high concentrations and induces tissue irritation on contact [13]

Even small amounts of sodium hypochlorite might cause severe damage. Aerosol may also cause damage while using an ultrasonic device for root canal irrigation. Therefore, these errors should be prevented by proper protection of patient's clothing. When using hand irrigation, one should take care that the needle and syringe are securely attached so that it will not separate during irrigation in order to prevent leakage over clothing [14].

The irrigant when it comes in contact with the patient's or operators' eye, it could result in immediate pain, erythema and intense burning. There might be loss of epithelial cells in the outer layer of cornea. In such cases ocular irrigation should be carried out with large amounts of tap water or sterile saline and the patient should be referred to the ophthalmologist for further management [15].

Extrusion of sodium hypochlorite beyond the apical foramen

Unintentional extrusion of NaOCl beyond the apical foramen might occur due to the destruction of apical constriction during canal preparation or by resorption. In addition to that, extreme pressure during irrigation would lead to large volumes of the irrigant that can deposit on the apical tissue leading to tissue necrosis [14]

A case report showed that 5.25% hypochlorite was forced beyond the apex of maxillary right cuspid which resulted in severe pain with strong allergic reactions [16]. In a short span of time the patient's upper lip and cheek showed signs of ecchymosis and hematoma inferior to the right zygoma and abundant haemorrhage from the root canal. The patient was then given analgesic and antibiotics and the root canal was left open for drainage. In the next few hours, the pain had diminished but the swelling had increased in size. hot compresses were advised instead of cold compresses to stimulate local systemic circulation. The patient's face had returned to normal after a month and root canal therapy could be completed [16].

CONCLUSIONS

- Sodium hypochlorite has a vast range of activity against both Gram positive and Gram-negative bacteria. It has been proved to show the strongest antibacterial activity when compared with other irrigants.
- When it comes to destroying microbial biofilm, sodium hypochlorite is proven to be the most effective root canal irrigant.
- Heating of sodium hypochlorite increases its antimicrobial and tissue dissolving abilities.
- 'Hypochlorite accident' caused by unintentional injection of the irrigant beyond the apical foramencan cause violent tissue reactions.
- Although hypochlorite has proven to be the benchmark irrigant till date, due to its limitations such as allergic reactions, toxicity, etc.Herbal alternatives might be considered which has proven to be effective in eliminating the bacterial biofilm in the root canal system.

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