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Insight on the Use and Abuse of Sodium Hypochlorite in Endodontics: A Review

Review Article

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Abstract

The present article aims to provide the dental practitioner a review about the properties of sodium hypochlorite, its mechanism of action, antibacterial efficiency, its toxicity, complications along with the sequence of events, prevention and also considers the appropriate management while facing a potentially adverse incident with the agent. The main objective of root canal treatment is to disinfect the root canal system which requires the elimination of the sources of infection and pulpal contents utilizing mechanical instrumentation, chemical irrigants with simultaneous use of intracanal medicaments. However, extrusion of these irrigants beyond and into the surrounding tissues always remains a risk factor which can pose some drastic complications. The present article discusses the use of sodium hypochlorite with its inadvertent effects. Avoiding complications of sodium hypochlorite with the use of specialized needles, avoiding excessive pressure, not wedging the needle tip in the canal. Vitality for the patient's safety remains on early recognition and management of advertent effects of sodium hypochlorite.

Keywords: Sodium Hypochlorite; Irrigants; Toxicity; Apical Extrusion; Disinfection.

Introduction

Irrigants perform both biological and physical roles during endodontic treatments. An irrigant ideally provides a mechanical flushing action and dissolve the remnants of organic tissues without damaging the periradicular tissues if extruded into the periodontium. Irrigation plays the main role in eradication of microbes from the root canal system [1]. Untoward incidents with irrigating solutions such as sulfuric acid, hydrogen peroxide, and sodium hypochlorite have been reported previously [2]. The antibacterial properties, tissue dissolution and canal lubrication of sodium hypochlorite (NaOCl) make it the most commonly used irrigating solution in endodontics. Clinically, various concentrations of NaOCl (0.5,1,2.6 and 5.25 %) have been used in root canal therapy. Careful mechanical cleansing and irrigation are usually sufficient to eliminate root canal infection. Spangberg et al reported that high concentration of NaOCl is very toxic. They recommended diluting the solution to 1% to keep its antibacterial property at the lowest toxic level [3]. Sodium hypochlorite has been used for many years and its tissue dissolution, antibacterial, and lubricating properties have been well described and investigated [4]. This article reviews potential complications and the sequence of events that occurs while using sodium hypochlorite in clinical practice, discusses measures to be taken in order to minimize risks and provides details for appropriate management in case of suspected tissue damage.

Properties

Irrigating solutions are used in root canal treatment for the removal of the infected tissue which may still be present especially in the accessory canals [5]. Hypochlorites are the most frequently used root canal irrigants since their introduction as a successful root canal irrigant in 1936 by Walker. Hypochlorites include sodium hypochlorite and natrium hypochlorite. Hypochlorite have a proteolytic effect [6]. Another important advantage which makes the use of NaOCl justifiable is the absence of clinical toxicity

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when it is used with an appropriate irrigation technique (Harrison et al 1978, Lamers et al. 1980). The Effective concentrations of sodium hypochlorite ranges from 2.6 to 5.25% (Grossman 1981, Ingle & Taintor 1985)[7].

Sodium hypochlorite works both as an oxidizing as well as a hydrolyzing agent. It is proteolytic and bactericidal. Sodium hypochlorite solutions have also been used as wound irrigants since 1915, and as a endodontic irrigant as early as 1920. Its use as an infant sanitizer is nearly universal. Sodium hypochlorite solution is relatively cheap as an endodontic irrigant. It also has low viscosity and a reasonable shelf life. Sodium hypochlorite has a very unpleasant taste. It is extremely corrosive to metals; strongly alkaline, and hypertonic. sodium hypochlorite solution leads to an unstable acid solution if there's excess chlorine in it Compared to saline Sodium hypochlorite significantly ($P < 0.01$) reduces the elastic modulus and the flexural strength of dentine. 5.25% concentration has negative effect on the properties of teeth [8]. Although NaOCl has many favorable properties, it lacks chemical stability [9].

Studies have also shown and reported that a sequential cleaning procedure including combined mechanical and chemical removal with 12% Sodium Hypochlorite solution is an effective procedure of removing debris from Ni-Ti instruments [10].

Mechanism Of Action

Sodium hypochlorite exhibits a dynamic balance as shown by the following reaction:

$NaOCl + H_2O \leftrightarrow NaOH + HOCl \leftrightarrow Na+ + OH- + H+ + OCl$

By Interpreting these chemical reactions, sodium hypochlorite acts as a solvent for organic and fat degrading fatty acids, transforming them into fatty acid salts (soap)and glycerol (alcohol) that reduces the surface tension of the remaining solution. Sodium hypochlorite neutralises amino acids forming water and salt (neutralisation reaction). With the exit of hydroxyl ions, there is a reduction in pH. Hypochlorous acid, a substance present in sodium hypochlorite solution, when in contact with organic tissue acts as a solvent and releases chlorine that, combined with the protein amino group, forms chloramines (chloramination reaction) that interfere in cell metabolism. Hypochlorous acid (HOCl-) and hypochlorite ions (OCl-) lead to amino acid degradation and hydrolysis. Chlorine (a strong oxidant) presents antimicrobial action inhibiting bacterial enzymes leading to an irreversible oxidation of SH groups (sulphydryl group) of essential bacterial enzymes. Considering physico-chemical properties of sodium hypochlorite when it is in contact with organic tissue, these reactions can be verified. Sodium hypochlorite is a very strong base (pH>11). At 1% concentration, sodium hypochlorite presents a surface tension equal to 75dynes/cm, conductivity of 65.5mS, stickiness equal to 0.986cP, density of 1.04g/cm^3 and moistening capacity equal to 1h and 27min. Its antimicrobial mechanism of action can be observed evaluating its physico-chemical characteristics and its reaction with the organic tissue. Sodium hypochlorite presents antimicrobial action on bacterial essential enzymatic sites promoting irreversible inactivation originated from hydroxyl ions and chloramination action. Dissolution of the organic tissues can be verified in saponification reaction when sodium hypochlorite degrades the fatty acids and lipids resulting in soap and glycerol [11].

Antibacterial Efficiency

A 5.25% solution of sodium hypochlorite has been recommended as irrigating solution in the treatment of infected root canals because of its well-known bactericidal action; it aids in effective mechanical flushing of debris from the root canals, and has a broad spectrum of antimicrobial activity. Newer irrigating solutions based on sodium hypochlorite have been made and tested in the recent years. A 5.25% sodium hypochlorite solution with the addition of a proteolytic enzyme (obtained from Bacillus subtilis) and a surfactant (4% ammina oxide) is one of these. Dagna et al verified its effectiveness in removing the smear layer In 2007. Taschieri et al In 2009 tested its effect on postoperative discomfort: this new irrigating solution did not produce any greater postoperative discomfort as compared to conventional NaOCl in patients undergoing endodontic therapy. Pre-warming of sodium hypochlorite resulted in even greater bactericidal effect. A strong oxidizing agent hypochlorous acid (HOCL), containing active chlorine formed when sodium hypochlorite is added to water contributes to the bactericidal activity of sodium hypochlorite [12].

For over 70 years Sodium hypochlorite has been used successfully as an endodontic irrigant. For vital and necrotic tissues NaOCl is a potent dissolving agent. The antibacterial effect of NaOCl against E. faecalis depends on the concentration and duration of exposure. Because of its unique features, such as dissolving of organic tissues, killing of microorganisms and acting as a lubricant, NaOCl becomes the most commonly used root canal irrigant. Sodium hypochlorite irrigating solution at 2.5% and 5.25% concentrations has documented elimination of all the bacteria in 10 min while sodium hypochlorite gel has not exhibited the same effect with identical time exposure on E. faecalis biofilm [13].

Toxicity

Complications causing severe tissue reactions associated with the accidental extrusion of NaOCl into periapical tissues have been described in the literature. With today's heightened awareness of infection control, patient safety, and technique sensitive dental materials, meticulous operative field isolation is mandatory. Barrier isolation (rubber dam) is the most reliable method [14]. The hypochlorite ion irreversibly oxidizes enzymes, thereby terminating the metabolic activities of tissues or organisms it contacts. The reaction of NaOCl with lipids and amino acids in pulpal tissue leads to liquefactive necrosis within minutes. There is no consensus as to the most effective concentration of NaOCl when used as endodontic irrigant, but an empirical concentration range of 0.5% to >5.25% is generally accepted. Although the use of 5% sodium hypochlorite was known to be toxic and aggressive to healthy and sound tissues [15]. An increase in NaOCl concentration leads to an increase in cytotoxicity [16]. A great deal of care should therefore be exercised when using sodium hypochlorite during endodontic irrigation [17].

Complications Of Accidental Spillage

1) Damage to the clothing: The most common accident to occur during root canal irrigation is probably the accidental spillage of sodium hypochlorite. Even minute quantities of the agent spilling

on the clothing can lead to rapid, irreparable bleaching. The practitioner should exercise care while transferring syringes filled with hypochlorite into the oral cavity. The patient should be wearing a protective plastic bib.

2) Significant injuries can take place resulting in Eye damage Seemingly mild burns with an alkali such as sodium hypochlorite as the alkali reacts with the lipid in the corneal epithelial cells, forming a soap bubble that may cause blurring of vision and patchy coloration of the cornea. Immediate ocular irrigation with large amount of sterile saline or water is required followed by an emergency referral to an ophthalmologist. The referral should be made immediately over the telephone to a nearest eye department. Use of adequate eye protection during endodontic treatment would eliminate the risk of experiencing this accident, but to irrigate the eyes injured with hypochlorite sterile saline should always be made available. It has been suggested that eyes on exposure to undiluted bleach should be irrigated with one litre of normal saline for 15 minutes.

3) Damage to the skin with an alkaline substance requires immediate water irrigation as alkalis combine with proteins or fats in tissue forming soluble protein soaps or complexes. These complexes can permit the passage of hydroxyl ions deep into the tissue and thereby limiting its contact with water dilutant on the skin surface. For irrigating skin Water is the agent of choice and it should be delivered at low pressure as high pressure can spread the hypochlorite into the rescuer's or patient's eyes.

4) As described for the eye injuries above, oral mucosa Surface injury can also be caused by the reaction of alkali with protein and fats. Close monitoring of the patient is required post immediate treatment after Swallowing of sodium hypochlorite. It is worth to be noted that skin damage can occur from secondary contamination [18].

Complications Arising From Hypochlorite Extrusion Beyond The Root Apex

Symptoms such as

1. Abrupt severe pain followed by burning sensation
2. Progressive swelling and severe oedema
3. Prolific bleeding from the root canal
4. Immediate hematoma and ecchymosis of the skin.
5. Trismus
6. Secondary infection
7. Paresthesia
8. Reversible anesthesia
9. Hyperesthesia can follow the initial severe inflammatory reaction.

Though in most of the cases, these symptoms can be reversed with proper treatment, the experience can be traumatic and terrifying for the patient. General practitioners should accordingly take extra measures to avoid such situations [19].

Prevention And Management Of NaOCL

Prevention

Severe injury to the patient can occur upon extrusion of NaOCl into periapical tissues. To minimize NaOCl accidents, these recommendations should be followed by the dentist: A correct straight line access cavity design with adequate coronal preparation. Periapical Preoperative radiographs to assess and access the root and canal anatomy. Clinician should be investigating thoroughly about the presence of any predisposing risk factors that might lead to the development of NaOCl accident such as resorptions, perforations, immature apices or any other conditions [20]. Usage of irrigation tips with side venting (Luer Lock needle) reduces the chances of forcing solutions into the periapical tissues [21]. The irrigating needle must be placed short of the working length, fit loosely within the canal and the solution should be injected with a gentle flow rate. Constantly moving the needle upwards and downwards during irrigation avoids wedging of the needle into the canal and provides better irrigation. The use of negative pressure irrigation system such as EndoVac system, The use of NaOCl irrigation to the coronal 2/3 of the root with open apex, the needle is bent slightly at an appropriate length or a rubber stopper is placed on the needle.

Management

Unfortunately for the management of sodium hypochlorite accident complications such as expert opinion or case reports low level evidences are available. Therefore, there is no standard treatment protocol that's been documented; this could be because these complications are rare and sporadic. Usually conservative and palliative management of NaOCl accident is advocated [22]. However, treatment will be determined by the severity of the case [23]. The patient should be fully informed when a NaOCl accident occurs, and found out the possible etiology. Treatment should focus on the principles of minimizing swelling, controlling pain and preventing secondary infection. Pain control is very important; local anesthesia or oral analgesics may be helpful to relief pain. Long acting local anesthetic and analgesic such as non-steroidal anti-inflammatory drugs and paracetamol. Flexible prescription by alternating ibuprofen and paracetamol at four hours interval might be effective for severe pain management [24]. (Adult doses of paracetamol 1g qds and ibuprofen or ibuprofen 400 mg qds. External compression with cold packs to the local area is recommended to alleviate discomfort and minimize edema. Cold packs should be replaced by warm compresses for several days. Antibiotics may be needed to prevent the possibility of secondary infection. Amoxicillin 250 mg tds or Metronidazole 200 mg tds in the penicillin allergic patient). Administration of dexamethasone is effective in minimizing postoperative pain and swelling after endodontic therapy or flare-up cases. In the cases of maxillary sinus involvement, it might be necessary to drain the sinus surgically. If the sinus does not get congested, irrigation of the sinus through the root canal using saline or distilled water might be feasible. Accurate details of the event should be recorded including volume and concentration of the hypochlorite solution involved [25].

Conclusion

To conclude, sodium hypochlorite is a effective antibacterial agent but, when comes in contact with the vital tissues it can become a potential irritant causing tissue destruction. So, to prevent this, injudicious use should be avoided and by the use of a sealed rubber dam isolation during treatment, use of Leur lock needle for irriga-

tion, maintain a minimum of 2 mm reduction from the working length, and avoiding wedging of the needle into the canal and most importantly avoid excessive pressure during irrigation.

Although it's a safe root canal irrigating solution, at times it may also lead to some life-threatening complications. So, to ensure safety, long lasting clinical practice, it is very essential to manage recognizing these complications.

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