

Risks and Management of Sodium Hypochlorite in Endodontics

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Abstract

Aim: The aim of this article is to provide the dental practitioner about the potential inadvertent effects of sodium hypochlorite and its management on encountering a dental emergency.

Summary: As a major objective of root canal treatment is to disinfect the entire root canal system which requires the elimination of pulpal contents and sources of infection by using mechanical instrumentation, chemical irrigants in conduction with intra canal medicaments. However, there remains a risk of extrusion of these irrigants beyond and into the surrounding tissues which causes severe complications.

Conclusion: This article discusses the use of sodium hypochlorite with its inadvertent effects. Complications with the use of sodium hypochlorite can be avoided by the use of specialized needles, avoiding excessive pressure, not wedging the needle tip in the canal. Early recognition and management of advertent effects of sodium hypochlorite remains vital for the patient's safety.

Keywords: Sodium hypochlorite; Root canal treatment; Irrigation, Antifungal; Toxicity; Extrusion; Dissolution

Introduction

Endodontic emergencies are associated with pain and swelling which requires immediate diagnosis and treatment. The main causative factors for these emergencies are pulp and peri-radicular pathosis, traumatic injuries, procedural complications; were sodium hypochlorite accidents can occur. The impetus behind a successful root canal treatment relies on a thorough debridement of tissue remnants, bacteria and toxins from the root canal system. For a proper clean canal, mechanical preparations alone are insufficient, as reviewed by Haapasalo et al. [1]. Several studies shows that instrumentation alone were not 100 % effective to debride and clean the canals but has to be in conjunction with irrigants [2-6]. Uninstrumented areas were reported in 65% of instrumented oval canals, according to Wu and Wesselink [7]. The morphology of the canals makes it difficult for a complete debridement of root canals, as residual pulp tissue and bacteria may persists in the irregularities of the canal. Therefore, irrigants should support and complement endodontic preparations by flushing out dental debris, dissolving organic tissues, disinfecting the canal and providing lubrication during instrumentation without irritating the surrounding tissues. Hydrogen peroxide, chlorhexidine, saline are some of the irrigants used; among which sodium hypochlorite is the commonly used effective antimicrobial and tissue dissolving irrigant. Concentrations of sodium hypochlorite ranges from 0.5%-5.2%, which is applied to the canals during and after mechanical preparation. Effective concentration range of sodium hypochlorite is from 2.6%-5.25% [8, 9].

This article reviews the potential complications that occur with sodium hypochlorite in clinical practice, discusses the measures that can be taken to minimize the risks and provides details to appropriate management in rare cases of suspected tissue damage.

Rationale behind using sodium hypochlorite

- Due to the high pH, the hydroxyl ions alters the integrity of cytoplasmic membrane of microorganisms, causes irreversible enzymatic inhibition, biosynthetic alterations in cellular metabolism and phospholipid degradation by liquid peroxidation.
- Antifungal activity (Table 1)

- It disrupts or removes biofilms (Table 2).
- Strong dissolving action in the presence of organic tissue and microorganisms, by breaking down of proteins into aminoacids (Table 3).
- Haemostatic property (Table 4).

Drawbacks

The negative property or drawback of sodium hypochlorite is that it can cause soft tissue inflammation if passed outside the confines of root canals [10-27]. Acute inflammation followed by necrosis results when sodium hypochlorite comes into contact with vital tissue. It causes severe inflammation and cellular destruction in all tissues except heavily keratinized epithelium [28]. The severity of the complication depends on the concentration of solution, its pH and its duration of exposure. Sodium hypochlorite has a pH of 11-12.5 which causes injury by oxidation of proteins. Higher concentrations have some irritating effects on the periodontal ligament [29].

This article reviews the potential complications that can occur with sodium hypochlorite in clinical practice, discusses the measures that can be taken to minimize the risk and provides details to appropriate management in rare cases of suspected tissue damage.

Toxicity of sodium hypochlorite

Sodium hypochlorite when comes in contact with tissue proteins, forms nitrogen, formaldehyde and acetaldehyde in short time and peptide links are broken resulting in dissolution of proteins. During the process, hydrogen in the amino groups is replaced by chlorine thereby

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Author	Year	Findings
Sen et al. [10]	1999	Evaluated antifungal properties of 1% NaOCl, and 5% NaOCl and 0.12 % CHx against candida albicans using cylindrical dentin tubes, and found that in absence of smear layer, candida albicans display antifungal activity after 30 minutes.
Ferguson et al. [11]	2002	Determined in-vitro susceptibility of candida albicans to various irrigants and medicaments, and found out that NaOCl , hydrogen peroxide were effective against candida albicans even when diluted.
Marcia et al. [12]	2009	Evaluated the action of NaOCl associated with an intracanal medicament against candida albicans and E.faecalis and found that 1% NaOCl irrigation were effective in eliminating E.faecalis and candida albicans.
Ruff et al. [13]	2006	Found that 6 % NaOCl was equally effective and statistically superior to Biopure MTAD and 17 % EDTA in antifungal activity

Table 1: Antifungal activity.

Author	Year	Findings
Spratt et al. [14]	2001	Evaluated the effectiveness of NaOCl 2.25 %, 0.2% CHx, 10% povidine iodide agent. Monoculture biofilm of 5 rootcanal isolates including P.intermedia, peptostreptococcus miro, streptococcus intermedius and found that NaOCl was more effective.
Clegg et al. [15]	2006	Evaluated effectiveness of three concentrations of NaOCl (6,3,1.5%),2% CHX and biopure MTAD on apical dentin film in vitro and found out 6% NaOCl was only capable of both rendering bacteria nonviable and physically remove the biofilm
Ozok et al. [16]	2007	Compared growth and susceptibility of different concentrationsof NaOCl of mono and dual species biofilms of fusobacterium nucleatum in-vitro at 24 hrs and found out at 243hrs they were more resistant to NaOCl.
Giardino et al. [17]	2007	Evaluated efficiency of 5.25% NaOCl and MTAD against E.Faecalis biofilm and found that only 5.25% NaOCl can disgregate and biofilm every time.

Table 2: Biofilm.

Author	Year	Findings
Grossman et al. [18]	1941	5% NaOCl dissolves tissue in 20 minutes to 2 hrs.
Moorer et al. [19]	2003	Tissue dissolution was dependent on 3 factors-frequency of agitation,amount of organic matter in relation to amount of irrigant in system and surface area of tissue.
Okino et al. [20]	2004	Evaluate tissue dissolving ability of 0.5,1,2.5% NaOCl,25 aqueous solution of CHX, 2% CHX gel and found that 0.5,1,2.5% NaOCl had dissolution speeds at the highest
Naenni et al. [21]	2004	Assessed necrotic tissue dissolution capability of 1% NaOCl,10% CHX,30%H2o2,10% peracetic acid and found out that only NaOCl had the dissolution property.
Clarkson et al. [22]	2006	Evaluated tissue dissolution ability of two concentrations of NaOCl on porcine incisor pulp and found greater concentrations provide more dissolution of tissue.
Marcus et al. [23]	2011	Evaluated the tissue dissolving capacity of various concentrations of NaOCl either alone or in combination of 17%EDTA and found that dissolution property was more with NaOCl alone.

Table 3: Tissue dissolving effect.

forming chloramines which plays an important role in antimicrobial effectiveness. Necrotic tissues are thus dissolved and microbial agent can reach and clean the infected areas better. Pashley et al. [27] demonstrated the cytotoxicity of Sodium hypochlorite using three independent biological models. They found that a concentration as low as 1:1000 (v/v) Sodium hypochlorite in saline caused complete

Author	Year	Findings
Hafez et al. [24]	2002	Showed that 3% NaOCl was biocompatible as a haemostatic control agent
Murina et al. [25]	1986	Showed that concentrations higher than 1mm, suppresses ADP dependent aggregations of blood platelets.
Murina et al. [26]	2006	Showed that anti-aggregant effects of NaOCl are probably due to the oxidation modification of sulphur containing groups in platelet plasmatic membrane.

Table 4: Haemostatic activity.

haemolysis of red blood cells *in vitro*. As the solution used in this study was isotonic and thus excluded an osmotic pressure gradient, the observed haemolysis and loss of cellular protein was due to the oxidizing effects of Sodium hypochlorite on the cell membrane. Undiluted and 1:10 (v/v) dilutions produced moderate to severe irritation of rabbit eyes whilst intradermal injections of undiluted, 1:2, 1:4 and 1:10 (v/v) dilutions of Sodium hypochlorite caused skin ulcers. Kozol et al. [30] proved Dakin's solution to be detrimental to neutrophil chemotaxis and toxic to fibroblasts and endothelial cells.

Hegggers et al. [31] examined wound healing relative to irrigation and bactericidal properties of Sodium hypochlorite *in vitro* and *in vivo* models. They concluded that 0.025% sodium hypochlorite was the safest concentration to use because it was bactericidal but not tissue-toxic. Zhang et al. [32] evaluated the cytotoxicity of four concentrations of sodium hypochlorite (5.25%, 2.63%, 1.31%, and 0.66%), eugenol, 3% H₂O₂, Ca(OH)₂ paste and MTAD Results showed that toxicity of sodium hypochlorite was dose-dependent. Barnhart et al. [33] measured the cytotoxicity of several endodontic agents on cultured gingival fibroblast using the CyQuant assay. The results showed that IKI and Ca(OH)₂ were significantly less cytotoxic than Sodium hypochlorite. Most complications of the use of sodium hypochlorite appear to be the result of its accidental injection beyond the root apex which can cause violent tissue reactions characterized by pain, swelling, hemorrhage, and in some cases the development of secondary infection and paresthesia [34]. A great deal of care should therefore be exercised when using sodium hypochlorite during endodontic irrigation. Ehrich et al. [35] suggested that a clinician should check, both clinically and radiographically for immature apices, root resorption, apical perforations or any other conditions that may result in larger than normal volumes of irrigant being extruded from the root-canal system into the surrounding tissue. Irrigation should be performed slowly with gentle movement of the needle to ensure that it is not binding in the canal. In an *in vitro* study by Brown et al. [36], the use of a reservoir of irrigation fluid in the coronal access cavity and carried into the root canal during filing resulted in significantly less apical extrusion of irrigation solution than with deep delivery with an irrigation needle.

Complication during irrigation: (review of literature represented in Table 5)

Extrusion beyond the root apex

During root canal irrigation, accidental extrusions can occur. Even minute quantities if extruded causes vacular probabilities in blood vessels due to the damage to the vessels as well as release of chemical mediators such as histamine for the involved tissue. This causes immediate swelling and often profuse bleeding through the root canal.

In a case report, after wedging the irrigating needle into the root canal, 2.5% sodium hypochlorite was extruded beyond the apex of maxillary left central incisor. The patient experienced severe pain during irrigation of root canal system so the root canal preparation was

Complication	Author	Study
Extrusion Of Irrigant	Aranda M, Sahli C, Figueiredo R, and Escoda C [37] Motta MV, Chaves-Mendonça MA, Stirton CG, Cardozo HF [38] Gatot A, Arbelle J, Leinberman A, Yani-Inbar I [39]	Complications following an accidental sodium hypochlorite extrusion: A report of two cases Accidental injection with sodium hypochlorite: Report of a case Effects of sodium hypochlorite on soft tissues after its inadvertent injection beyond the root apex.
Damage to eye	Ingram TA [40]AG Becking [41] Khodabukus, R., Tallouzi, M.[42]	RESPONSE OF THE HUMAN EYE TO ACCIDENTAL EXPOSURE TO SODIUM HYPOCHLORITE Complications in the use of sodium hypochlorite during endodontic treatment: report of three cases CHEMICAL EYE INJURIES 1: PRESENTATION, CLINICAL FEATURES, TREATMENT AND PROGNOSIS
Damage to oral mucosa	G Markose, CJ Cotter, WS Hislop [43] RF de Sermeño, LAB da Silva, H Herrera [44] Linn JL, Messer HH [45]	Facial atrophy following accidental subcutaneous extrusion of sodium hypochlorite Tissue damage after sodium hypochlorite extrusion during root canal treatment Hypochlorite injury to the lip following injection via a labial perforation. Case report
Allergic reactions	Witton R, Brennan PA [46] A Tosti, BM Piraccini, M Pazzaglia [47] Baumgartner JC, Ibay AC.[48]	Severe tissue damage and neurological deficit following extravasation of sodium hypochlorite solution during routine endodontic treatment. Severe facial edema following root canal treatment The chemical reactions of irrigants used for root canal debridement.

Table: 5 Review of literature for Complications of Sodium hypochlorite

discontinued immediately and temporary dressing given. 3hrs later, the patient came back to clinic with an extended odema and ecchymosis over the left side of face, infraorbital region and upper lip mucosa. After removing the temporary filling, heavy bleeding from the canal was observed. The canal was biomechanically prepared by hand files with sterile saline solution irrigation. Antibiotics were prescribed against secondary infection and analgesics were also administered for pain control. Cold compress, warm mouth rinses was also advised on the first day. On the third day, pain and ecchymosis was reduced. By the 10th day, no bleeding, pain, or ecchymosis was observed. By the 20th day root canal obturation was performed.

Reeh and Messer reported on a case of injection of sodium hypochlorite (1%) through a midroot perforation of a maxillary central incisor. The patient experienced the typical symptoms of immediate severe pain and swelling, followed by fistulation and erythema extending to the infraorbital area. Paraesthesia of the floor and ala of the patient's nose persisted for more than 15 months. In a case report presented by Sabala and Powell 5.25% sodium hypochlorite was injected into the Periapical tissues of a left maxillary second premolar. The patient experienced symptoms of sudden, severe pain and a swelling rapidly developed, followed by ecchymosis of the skin. Root canal treatment was completed at the same appointment. To prevent secondary infection, antibiotics were prescribed and a surgical drainage performed. Nine days later the symptoms had resolved.

Damage to eye

Mild burns with sodium hypochlorite can react with the lipid in the corneal epithelial cells; thereby forming a soap bubble that penetrates the corneal stroma and enters into the anterior chamber leading to tissue necrosis. This results in endophthalmitis and loss of eye [37-49].

Management: Gentle irrigation of the affected eye with normal saline or tap water and then refer to the ophthalmologist.

Damage to oral mucosa

Sodium hypochlorite reacts with the proteins and fats of oral mucosa which might lead to secondary infections. The patient must be monitored with immediate treatment if swallowed.

Management: Rinse the oral mucosa with water. Analgesics and antibiotics must be prescribed to reduce secondary infection. Refer to emergency on inhalation or injection.

Allergic reactions

Sodium hypochlorite allergic reactions results in urticaria, oedema, shortness of breath, bronchospasm and hypotension.

Management: Refer immediately to intensive care unit following first aid management with administration of intravenous steroids and antihistamines [50].

Signs and Symptoms

Prevention of sodium hypochlorite extrusion

- A good proper straight line access cavity design with adequate coronal preparation.
- Preoperative Periapical radiographs to access the root and canal anatomy.
- Use of specialized needles like leur lock needles.
- Determine proper working length and carefully adjust the rubber stopper.
- Do not wedge the needle tip in the canal, has to be placed loose inside.
- Avoid using excessive digital pressure especially with the thumb.
- Constant in and out movements of the irrigating needle into the canal.
- Flow back of the solution as it is expressed into the canal, should be observed.

Management (Table 6)

- Immediate irrigation of canal with normal saline to dilute the sodium hypochlorite.
- Let the bleeding response continue to flush the irritant out.
- Advice ice pack compression for 24 hours (15 minutes interval) to minimize the swelling.
- Recommend warm, moist compress after 24 hours (15 minutes interval) .
- Prescribe Acetaminophine based narcotic analgesics for 7 days.

Author	Year	Findings
Veeresh et al. [51]	2011	A patient with continuous , severe pain, oedema on left side of face, managed by antibiotics, analgesics, cold compress and 10th day all symptoms suppressed.
Dominic et al. [52]	2014	Patient with NaOCl extrusion followed endodontic treatment in maxillary first molar with excruciating pain, with blood stained fluid from left nostril; all managed by first ENT consultant for nasoscopy and then later root canal treatment completed.
Jonathan et al. [53]	2015	A patient with NaOCl extrusion followed perforation during rootcanal treatment in maxillary first premolar with swelling, bruising; pain was managed by i.v antibiotics, analgesics, steroids and then surgical intervention and finally full recovery was observed.
Bernardo et al. [54]	2014	A patient with NaOCl apical extrusion followed rootcanal returned in 24 hours with extreme pain, burning sensation in maxillary region with oedema and was managed by amoxicillin 500mg orally for 7 days then dexamethasone 4mg I.M. for 3days. Symptoms subsided after 8 months.

Table 6: Management of NaOCl .

- Prophylactic antibiotic coverage for 10 days to prevent secondary infection. Amoxycillin 250 mg TDS or Metronidazole 200 mg TDS in penicillin allergic patients.
- Steroid therapy for 2-3 days to control inflammatory reaction.
- Reassure the patient and provide with both verbal and written homecare instructions.
- Monitor the patient periodically.

Conclusion

To conclude, sodium hypochlorite is an effective antibacterial agent but, when in contact with vital tissues it becomes 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 irrigation, maintain a minimum of 2 mm reduction from the working length, and avoiding wedging of needle into the canal and most importantly avoid excessive pressure during irrigation.

Although a safe root canal irrigating solution, its use may also lead to life-threatening complications [51-55]. So, to ensure best safe, long lasting clinical practice, it's essential to recognize and manage these complications.

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