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 inadvertent 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 compliment endodontic preparations by flushing out dentinal 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 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.

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
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. Pasley 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 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.

Heggars 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 cytoxicity of four concentrations of sodium hypochlorite (5.25%, 2.63%, 1.31%, and 0.66%), eugenol, 3% H2O2, Ca(OH)2, and MTAD Results showed that toxicity of sodium hypochlorite was dose-dependent. Barnhart et al. [33] measured the cytoxicity 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 any 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

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### Table 1: Antifungal activity

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sen et al. [10]</td>
<td>1999</td>
<td>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.</td>
</tr>
<tr>
<td>Ferguson et al. [11]</td>
<td>2002</td>
<td>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.</td>
</tr>
<tr>
<td>Marcia et al. [12]</td>
<td>2009</td>
<td>Evaluated the action of NaOCl associated with an intracanal medication against candida albicans and E.faecalis and found that 1% NaOCl irrigation were effective in eliminating E.faecalis and candida albicans.</td>
</tr>
<tr>
<td>Ruff et al. [13]</td>
<td>2006</td>
<td>Found that 6 % NaOCl was equally effective and statistically superior to Biopure MTAD and 17 % EDTA in antifungal activity.</td>
</tr>
</tbody>
</table>

### Table 2: Biofilm

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spratt et al. [14]</td>
<td>2001</td>
<td>Evaluated the effectiveness of NaOCl 2.25 %, 0.2% CHX, 10% povidone iodide agent. Monoculture biofilm of 5 root-canal isolates including P.intermedia, peptostreptococci, streptococcus intermedius and found that NaOCl was more effective.</td>
</tr>
<tr>
<td>Clegg et al. [15]</td>
<td>2006</td>
<td>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.</td>
</tr>
<tr>
<td>Ozok et al. [16]</td>
<td>2007</td>
<td>Compared growth and susceptibility of different concentrations of 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.</td>
</tr>
<tr>
<td>Giardino et al. [17]</td>
<td>2007</td>
<td>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.</td>
</tr>
</tbody>
</table>

### Table 3: Tissue dissolving effect

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grossman et al. [18]</td>
<td>1941</td>
<td>5% NaOCl dissolves tissue in 20 minutes to 2 hrs.</td>
</tr>
<tr>
<td>Moorer et al. [19]</td>
<td>2003</td>
<td>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.</td>
</tr>
<tr>
<td>Okino et al. [20]</td>
<td>2004</td>
<td>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</td>
</tr>
<tr>
<td>Naenni et al. [21]</td>
<td>2004</td>
<td>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.</td>
</tr>
<tr>
<td>Clarkson et al. [22]</td>
<td>2006</td>
<td>Evaluated tissue dissolution ability of two concentrations of NaOCl on porcine incisor pulp and found greater concentrations provide more dissolution of tissue.</td>
</tr>
<tr>
<td>Marcus et al. [23]</td>
<td>2011</td>
<td>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.</td>
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</tbody>
</table>

### Table 4: Haemostatic activity

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hafez et al. [24]</td>
<td>2002</td>
<td>Showed that 3% NaOCl was biocompatible as a haemostatic control agent.</td>
</tr>
<tr>
<td>Murina et al. [25]</td>
<td>1986</td>
<td>Showed that concentrations higher than 1mm, suppresses ADP dependent aggregations of blood platelets.</td>
</tr>
<tr>
<td>Murina et al. [26]</td>
<td>2006</td>
<td>Showed that anti-aggregant effects of NaOCl are probably due to the oxidation modification of sulphur containing groups in platelet plasmatic membrane.</td>
</tr>
</tbody>
</table>
discontinued immediately and temporary dressing given. 3hrs later, the
card 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. Parasthesia 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
conceal 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 ingestion.

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.

Table: 5 Review of literature for Complications of Sodium hypochlorite

<table>
<thead>
<tr>
<th>Complication</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extrusion Of Irritant</td>
<td>Aranda M, Sahil C, Figueiredo R, and Escoda C [37]</td>
</tr>
<tr>
<td>Damage to eye</td>
<td>Ingram TA [40] AG Becking [41] Khodabukus, R., Tallouzi, M. [42]</td>
</tr>
</tbody>
</table>

Further reading:
Baumgartner JC, Ibay AC. [48]
Herrera [44] Linn JL, Messer HH [45]
Aranda M, Sahil C, Figueiredo R, and Escoda C [37]
G Markose, CJ Cotter, WS Hislop [43]
RF de Sermeño, LAB da Silva, H Herrera [44] Linn JL, Messer HH [45]
A patient with a continuous, severe pain, oedema on left side of face, managed by antibiotics, analgesics, cold compress and 10th day all symptoms suppressed.

Patient with NaOCl extrusion followed endodontic treatment in maxillary first molar with exfoliating pain, with blood stained fluid from left nostril; all managed by first ENT consultant for nasoscopy and then later root canal treatment completed.

A patient with NaOCl apical extrusion followed root canal 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 3 days. 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, judicious 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 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.

References


