Anatomy of Sodium Hypochlorite Accidents

by Omid Mehdipour, DDS Donald J. Kleier, DMD Robert E. Averbach, DDS

Omid Mehdipour, DDS
International Student Program

Donald J. Kleier, DMD
Professor and Chairman

Robert E. Averbach, DDS
Professor of Endodontics
Division of Endodontics
University of Colorado
School of Dental Medicine
Aurora, Colorado

Abstract
Sodium hypochlorite (NaOCl) in various concentrations is the most widely used endodontic irrigant, but it can be an irritant to vital tissues. There are several reports about the complications of irrigation with NaOCl during root canal therapy. 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. This article is a review and comparison of all reported NaOCl accidents in the literature.

The impetus behind root canal cleaning and shaping is the elimination of tissue remnants, bacteria, and toxins from the root canal system. This is generally accepted to be a major factor in the success of root canal treatment. Mechanical procedures alone are insufficient for total canal cleaning. Residual pulpal tissue, bacteria, and dentin debris may persist in the irregularities of canal systems. Therefore, irrigating solutions should support and complement endodontic preparation. These irrigants should flush out dentin debris, dissolve organic tissue, disinfect the canal system, and provide lubrication during instrumentation, without irritating the surrounding tissues. Some of the irrigants currently used include hydrogen peroxide, physiologic saline, water, sodium hypochlorite (NaOCl), chlorhexidine, and electrochemically activated water.

Because of its physicochemical and antibacterial properties, NaOCl is one of the most popular irrigants. A 0.5% solution of NaOCl was used effectively during World War I to clean contaminated wounds.[1] In 1920, Crane described the use of Dakin's solution (NaOCl buffered with sodium bicarbonate) for root canal debridement and sterilization. Since then NaOCl has become a popular and effective intracanal irrigant.[2] It is an

inexpensive, readily available, and easily used chemical that usually rates well in research.[3,4]

A variety of NaOCl concentrations ranging from 0.5% to 5.25% have been advocated, as well as a variety of temperatures. The longer the solution can remain in contact with tissue, the higher the temperature of the solution, and the higher the concentration, the greater the ability of NaOCl to dissolve the tissue.[5-7] The optimum concentration for use clinically is still a matter of controversy. Consequently, the clinician must decide on the concentration and temperature of the NaOCl and the potential consequences of this choice.[5,8,9]

Advantages of NaOCl

The ability of NaOCl to dissolve organic soft tissue of the pulp and predentin is a result of oxidation. The powerful oxidative activity of hypochlorite not only dissolves the pulpal and dentinal tissue but also acts as a potent antimicrobial agent.[3] It is well recognized to be effective against a broad range of pathogens: gram-positive and gram-negative bacteria, fungi, spores, and viruses including the human immunodeficiency virus.[10]

NaOCl, especially when used in high concentrations, is known to be effective in dissolving organic tissue remnants and disinfecting the canal system.[4] Effective concentrations of NaOCl range from 2.6% o 5.25%. The dilution of NaOCl was suggested because it has been proved that concentrations over 0.5% are cytotoxic.[11]

Compared with a chlorhexidine gel, NaOCl not only has a higher capacity to kill microorganisms but is also more able to remove cells from the root canal.[12] Water is not effective in removing dentine debris from grooves in the apical portion of root canals.[13]

Disadvantages of NaOCl

Acute inflammation followed by necrosis results when NaOCl comes into contact with vital tissue. It causes severe inflammation and cellular destruction in all tissues except heavily keratinized epithelium.[5] The cytotoxic effect of 5.25% NaOCl on vital tissues, resulting in hemolysis, is well documented, and its use warrants proper care. The clinical efficacy of NaOCl relates to its nonspecific ability to oxidize, hydrolyze, and osmotically draw fluids out of tissues.[5]

The severity of the reaction depends on the concentration of the solution, its pH, and the duration of exposure. NaOCl has a pH of 11 to 12.5, which causes injury primarily by oxidation of proteins. In high concentrations, severe necrotic changes could be observed.[14] The higher concentrations also have some irritating effects on the periodontal ligament.[15] One report cites periodontal side effects of NaOCl with lower concentrations.[16] However, when confined to the canal space as an intracanal endodontic irrigant, clinical toxicity of NaOCl is no greater than the clinical toxicity of normal saline solution.[6]

NaOCl causes vascular permeability in blood vessels, probably as a result of damage to the vessels as well as the release of chemical mediators, such as histamine, from involved tissue. This characteristic causes immediate swelling and often profuse bleeding through the root canal when NaOCl is not used properly as an endodontic irrigant.[17]

There is only 1 report of hypersensitivity to NaOCl, which can easily be detected by skin patch testing.[18] There are reports about the effects of improper use of NaOCl, including inadvertent injection into the maxillary sinus[19] or splashing solution into the eyes.[20] The extrusion of NaOCl can cause facial nerve weakness in addition to other soft-tissue damage.[21] In addition to its toxicity to vital tissues, NaOCl has an unpleasant odor and causes damage if it comes into contact with clothing.[22]

There are 2 reports of inadvertently injecting NaOCl instead of anesthetic solution. One resulted in severe palatal tissue necrosis,[23] and the second involved edema in the pterygomandibular space and peritonsillar and pharyngeal areas because of mandibular block injection with NaOCl instead of anesthetic solution. In the second case, the patient was admitted to an intensive care unit for probable airway obstruction and given opioid analgesic intravenously for pain reduction.[24] Damage to permanent tooth follicles, peripheral tissue, and oral mucosa have been reported during careless NaOCl use in pediatric endodontics.[25] There are only a small number of cases in the literature that have reported postoperative skin complications, long-term paresthesia, and altered nerve sensations arising from the use of NaOCl as an endodontic irrigant.[26]

There are 23 reported cases of NaOCl accidents in the literature.[14,19,21,26-41] Almost all of the cases have similar sequelae including severe pain, edema, and profuse hemorrhage both interstitially and through the tooth. The reports mentioned several days of increasing edema and ecchymosis accompanied by tissue necrosis and paresthesia; in some cases, secondary infections have been observed. Most of the cases had complete resolution within a few weeks but a few were marked by long-term paresthesia or scarring. Remaining residual paresthesia indicates some permanent damage to the nerve endings in the affected area.[36]

NaOCl Accident Management

Proper management of a NaOCl accident is important for achieving the best outcomes. The following lists some important factors for managing a NaOCl accident:

- Early recognition of the problem; the patient should be informed of the cause and nature of the accident (Table 2, see end of the article)
- Immediate irrigation of the canal with normal saline to dilute the NaOCl
- Allow bleeding response to flush the irritant out of the tissues
- Reassure patient
- Provide patient with both verbal and written home care instructions
- Monitor the patient

After the NaOCl accident has been recognized and the patient has been informed, the authors recommend a treatment that focuses on palliative care, including cold and warm compresses, saline rinses, pain control, prophylactic antibiotics, steroid therapy, and monitoring (Table 3). It is important to reassure the patient throughout treatment because of the amount of time it will take for the inflammation to resolve.

Avoiding NaOCl Accidents

The following steps can help clinicians avoid NaOCl accidents:

- Adequate access preparation
- Good working length control
- Irrigation needle placed 1 mm to 3 mm short of working length
- Needle placed passively and not locked in the canal
- Irrigant expressed into the root canal slowly
- Constant in and out movements of the irrigating needle into the canal space
- "Flowback" of solution as it is expressed into the canal should be observed
- Use side delivery needles that are specifically designed for endodontic purposes

Discussion

NaOCl is tissue cytotoxic. When it comes into contact with tissue, it causes hemolysis and ulceration, inhibits neutrophil migration, and damages endothelial and fibroblast cells.[14,42] Incorrect determination of working length, lateral perforation, and wedging of the irrigating needle are the most common procedural accidents associated with adverse NaOCl reactions.[29]

The optimal clinical concentration of NaOCl is still controversial. A 1% concentration of NaOCl provides tissue dissolution and an antimicrobial effect, but the concentration reported in the literature has been as high as 5.25%.[43,44] Evidence demonstrates that high concentrations of NaOCl have enhanced antimicrobial activity.[45] Irrigation time may increase the antimicrobial effect of endodontic irrigants without affecting the surrounding tissues. It has been found that 0.5% NaOCl had nearly the same bactericidal effect as 5.25% NaOCl when used for 30 minutes.[46]

After a NaOCl accident, early and aggressive treatment is advocated to reduce potentially serious complications. The use of antibiotics is recommended because there is a possibility of tissue necrosis and infection.[47] Steroids also may be useful.

Depending on the degree of injury, some cases might require surgical intervention. The aim of any surgical procedure should be to provide decompression and facilitate drainage, and to create an environment conducive to healing. The other advantage of surgery is meticulous debridement of grossly necrotic tissue and direct irrigation of affected sites.[25]

Conclusion

NaOCl is an effective antibacterial agent but can be highly irritating when it comes in contact with vital tissue. Most of the reported complications occurred because of incorrect determination of endodontic working length, iatrogenic widening of the apical foramen, lateral perforation, or wedging of the irrigating needle. If a perforation or open apex exists, then great care should be exercised to prevent a NaOCl accident or an alternative irrigation solution should be considered.

Table 2—How to recognize a NaOCl accident

• Immediate severe pain (for 2-6 minutes)

• Ballooning or immediate edema in adjacent soft tissue because of perfusion to the loose connective tissue

• Extension of edema to a large site of the face such as cheeks, peri- orbital region, or lips

• Ecchymosis on skin or mucosa as a result of profuse interstitial bleeding

• Profuse intraoral bleeding directly from root canal

• Chlorine taste or smell because of injected NaOCl to maxillary sinus

• Severe initial pain replaced with a constant discomfort or numbness, related to tissue destruction and distension

• Reversible or persistent anesthesia

• Possibility of secondary infection or spreading of former infection

Table 3—How to treat a NaOCl accident

• Remain calm and inform the patient about the cause and nature of the complication.

• Immediately irrigate with normal saline to decrease the soft-tissue irritation by diluting the NaOCl.

• Let the bleeding response continue as it helps to flush the irritant out of the tissues.

• Recommend ice bag compresses for 24 hours (15-minute intervals)to minimize swelling.

• Recommend warm, moist compresses after 24 hours (15-minute intervals).

• Recommend rinsing with normal saline for 1 week to improve circulation to the affected area.

• For pain control

• Initial control of acute pain could be achieved with anesthetic nerve block.

• Acetaminophen-based narcotic analgesics for 3 to 7 days (NSAID analgesic should be avoided to decrease the amount of bleeding into the soft tissues).

• Prophylactic antibiotic coverage for 7 to 10 days to prevent secondary infection or spreading of the present infection.

• Steroid therapy with methylprednisolone for 2 to 3 days to control inflammatory reaction.

• Daily contact to monitor recovery.

• In severe cases such as respiratory distress, accessing the local emergency service via 911 is appropriate.

• Reassure the patient about the lengthy resolution of the inflammatory reaction.

• Provide the patient with both verbal and written home care instructions.

• Monitor the patient for pain control, secondary infection, and reassurance.

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