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Management of Sodium Hypochlorite Extravasation to the Maxillary Sinus: Bridging Dentistry and Medicine

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Abstract
Sodium hypochlorite (NaOCl) is the most used irrigant in endodontic procedures due to its effective antimicrobial properties and ability to dissolve organic tissue. However, despite these advantages, sodium hypochlorite can pose significant risks when inadvertently extruded beyond the root canal system. One of the most severe complications occurs when NaOCl extravasates into the maxillary sinus, leading to several adverse outcomes. This article explores the pathophysiology, clinical implications, and management strategies associated with sodium hypochlorite extrusion into the maxillary sinus.

Highlights

- Extravasation of NaOCl into the maxillary sinus can lead to severe complications, including chemical sinusitis and tissue necrosis.
- Accurate measurement of working length and proper irrigation techniques are crucial to prevent NaOCl extrusion accidents.
- Immediate management of NaOCl accidents involves stopping the procedure, aspirating the solution, and using calcium hydroxide dressing to neutralize residual NaOCl.
- Interdisciplinary collaboration among stomatologists, dentists, maxillofacial surgeons, and otolaryngologists is essential for effective diagnosis and treatment of NaOCl-related complications.

1. Introduction

Despite advances in root canal treatment and technology, mechanical instrumentation with endodontic files alone is insufficient to effectively clean ramifications and anatomical variations, leaving one-third of root canals untreated. [1–3] Therefore, root canal irrigation is of paramount importance, both for its mechanical effects, which involve the removal of microorganisms/biofilm, dentin debris, pulp tissue, and instrumentation products, and for its chemical effects which include the breakdown of soft tissue remnants and smear layer as well as the eradication of bacteria and their byproducts. As a result, chemically active antibacterial irrigation solution should be used in conjunction with mechanical preparation. [4] Sodium hypochlorite (NaOCl) is currently the most often used irrigation solution, since it satisfies the majority of the necessary requirements. [2, 5]

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NaOCl is favored in endodontics for its effectiveness against a broad spectrum of microorganisms, including gram-positive and gram-negative bacteria, fungi, spores, and viruses. [6] The high pH of NaOCl, approximately 11-12, disrupts the integrity of bacterial cell membranes and degrades organic components of the biofilm, resulting in effective disinfection of the root canal system. Its mechanism of action involves saponification, in which NaOCl reacts with fatty acids to form soap and glycerol, thereby reducing surface tension, aiding in debris removal and enhancing its penetration into the dentinal tubules. It also neutralizes amino acids through chloramination, leading to the dissolution of vital and necrotic tissues. [7]

NaOCl concentrations typically range from 0.5% to 5.25%. A 0.5% sodium hypochlorite solution is less toxic than a 5.25% solution, while its antimicrobial effectiveness does not increase proportionately to the concentration. It appears that copious irrigation with large volumes of lower concentrations of sodium hypochlorite may achieve as much proteolytic effect as the use of a higher concentration. Therefore, an adequate concentration of sodium hypochlorite for endodontic irrigation is 0.5% to 1.0% with the pH close to neutral. [8]

2. Sodium Hypochlorite Accident

Sodium hypochlorite accident was first reported in 1974. [9] A sodium hypochlorite accident occurs when the irrigant is inadvertently extruded into periapical tissues or other anatomical spaces during endodontic treatment. These accidents, though rare, can be associated with significant morbidity. [10] When NaOCl comes into contact with vital tissues, it can cause severe chemical burns, hemolysis, ulceration, and necrosis.

The risk of sodium hypochlorite extrusion is increased in cases involving immature apices or iatrogenic apical perforation, creating a pathway for the irrigant to escape into surrounding tissues. Teeth with larger apical diameters or those with a lack of apical constriction due to resorption are also more prone to NaOCl extrusion. [11] Inadequate irrigation techniques also play a significant role in NaOCl extrusion. Using high pressure during irrigation or placing the irrigation needle too far into the canal can also increase the risk of NaOCl extrusion. [12]

Preventing sodium hypochlorite extrusion requires careful attention to detail and technique. Accurate measurement of the working length is crucial to avoid over-instrumentation and apical perforation. Both radiographs and apex locators should be used to ensure precise measurement. Proper irrigation technique is essential to minimize the risk of extrusion. [13] Using side-delivery irrigation needles can reduce the risk of direct extrusion by allowing the irrigant to exit laterally rather than through the tip. Irrigating under low and constant pressure can help prevent the solution from being forced beyond the apex. It is also important to avoid placing the needle too deep into the canal and to move it gently back and forth to prevent blockages and ensure even distribution of the irrigant. [14]

The immediate consequences of sodium hypochlorite extrusion include severe pain, swelling, and hemorrhage, resulting from its potent tissue-dissolving effects. [15] As the condition progresses, continued swelling and discoloration of the skin may extend beyond the immediate area, indicating ongoing tissue necrosis. Numerous cases have been reported in the literature where sodium hypochlorite accidents have resulted in significant complications, including nerve damage, extensive tissue necrosis, and, in extreme cases, life-threatening airway obstruction due to soft tissue swelling. [16, 17] The severity of these complications underscores the importance of endodontists to be adequately trained in the handling of sodium hypochlorite to minimize the risks associated with its use and to adopt preventive measures that can avert such potentially serious complications.

3. Sodium Hypochlorite Extravasation to the Maxillary Sinus

The maxillary sinus is located in close proximity to the roots of the maxillary molars, premolars, and, occasionally, canines. [18] The anatomical separation between the sinus floor and these tooth roots may be minimal, only a thin layer of bone or mucosa, or even absent, particularly in cases of age-related sinus pneumatization where the sinus expands into the alveolar bone, increasing the risk of sinus involvement during endodontic procedures. [19]

When sodium hypochlorite solution is used it may extrude into the maxillary sinus and into the middle meatus of the nasal cavity via the hiatus semilunaris and thus discharging anteriorly out of the nostril or posteriorly through the pharynx. These patients may experience difficulty breathing, along with irritation of the throat and respiratory mucosa. Sodium hypochlorite in the maxillary sinus will lead to a form of acute sinusitis, known as chemical sinusitis. This inflammatory response is not merely a local irritation; it can induce significant symptoms such as intense facial pain, swelling and nasal obstruction. The severity of chemical sinusitis can range from mild to severe, depending on the volume and concentration of the extravasated sodium hypochlorite, as well as the duration of exposure. [20]

Prolonged exposure to NaOCl can result in the necrosis of the sinus lining, with potential extension to surrounding tissues. In severe cases, NaOCl may erode the bony walls of the maxillary sinus, leading to further complications, such as oroantral fistula formation or communication with the nasal cavity, injury to the trigeminal nerve or infraorbital nerve, potentially resulting in paresthesia or neuralgia. Although less common, there is a risk of periorbital cellulitis and bony erosion of the orbital floor, leading to enophthalmos. [21, 22]

Tissue atrophy following extensive necrosis may lead to facial asymmetry, requiring reconstructive procedures

such as fat grafting. [23]

Assessing the relationship between the tooth roots and the maxillary sinus is particularly important in posterior maxillary teeth. If the sinus is closely associated with the roots, using chlorhexidine gluconate as an alternative irrigant may be a safer option. [8] In all cases, it is essential to communicate with patients about the potential risks and symptoms associated with NaOCl extrusion, advising them to report any sudden pain, swelling, or other unusual symptoms immediately.

4. Clinical Cases

4.1. Case 1

A 21-year-old female patient presented to the Emergency Department with a progressive swelling of the left side of her face following root canal treatment of her left second maxillary molar. 5% sodium hypochlorite solution was used as the irrigant. She complained of severe facial pain on the left side after the procedure. Her symptoms were not controlled by the analgesia prescribed by the Dentist. At presentation, our patient was afebrile. There was left-sided facial and infraorbital edema, with marked cheek swelling (Figure 1).

Figure 1. Patient presenting with edema of the middle third of the left face.

Leukocyte count and C-reactive protein were elevated. An ortopantomogram (OPG) revealed a complete opacification of the left maxillary sinus in close relations to the endodontically treated roots of the left maxillary second molar (Figure 2). The diagnosis of a chemically induced sinusitis was assumed.

The patient underwent left maxillary sinus drainage via canine fossa (anterior antrostomy) under local anesthesia (Figure 3). There was a dense purulent drainage from the sinus, a sample was collected and sent for culture. The sinus was thoroughly irrigated with normal saline. All cultures came back negative. The patient was admitted to the hospital and placed under broad spectrum antibiotic treatment with amoxicillin/clavulanate

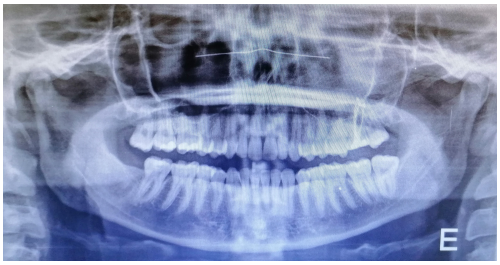

Figure 2. Left maxillary sinus opacification on OPG.

and metronidazole EV for a week. She was also treated with steroids for 3 days and nasal douche and decongestant. After acute symptom resolution the patient was discharged from the hospital.

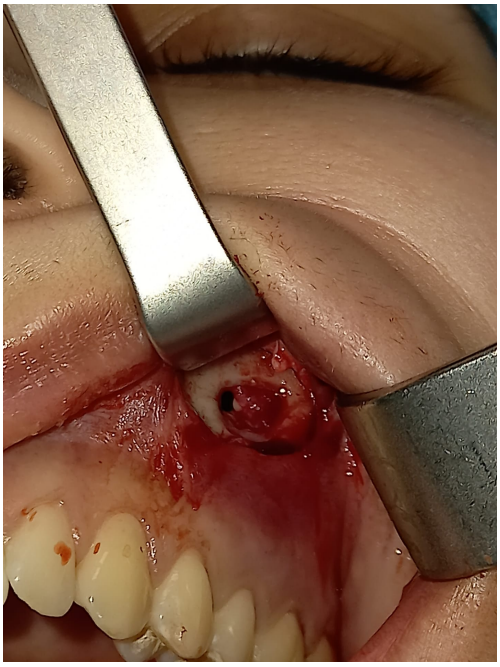

Figure 3. Canine fossa approach to the maxillary sinus.

During follow-up the patient presented full symptomatic recovery, revealing only mild sinus inflammation on CT which did not warrant any further treatment (Figures 4 and 5).

Figure 4. Post-operative OPG.

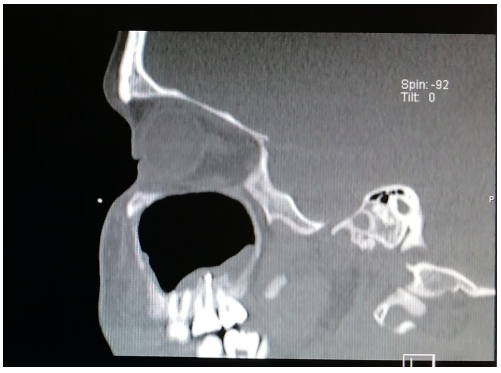

Figure 5. Post-operative Perinasal Sinus CT.

4.2. Case 2

A 56-year-old female patient presented to the Emergency Department with progressive left-side facial pain and cacosmia after a root canal treatment on her left first upper molar. She stated that, during the endodontic treatment, she experienced a sudden onset of severe facial burning pain, followed by a strong odor of bleach and posterior nasal discharge. She was prescribed analgesics and antibiotic (amoxicillin/clavulanate 875+125mg 12/12h) by her dentist. Immediately after leaving the dental office, she developed epistaxis which persisted for 24 hours. Despite the medication she had worsening symptoms. At presentation, our patient was afebrile, with no facial swelling. Ocular movements and pupillary reflexes were normal. Nasoendoscopy showed mucosal edema within the left middle meatus with a dense yellow mucus drainage towards the nasopharynx (Figure 6).

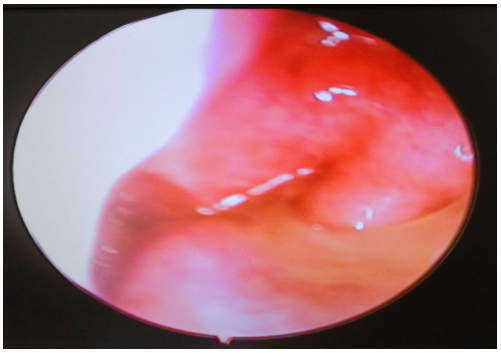

Figure 6. Mucopurulent drainage from the middle meatus.

Leukocyte count and C-reactive protein were elevated. CBCT revealed a opacification with gas pockets of the left maxillary sinus and middle meatal congestion and a close relationship of the roots of the endodontically treated left maxillary first molar with the maxillary sinus (Figures 7 and 8).

The diagnosis of a chemically induced sinusitis was assumed. The patient's medication was adjusted with antibiotics (amoxicillin/clavulanate 875+125mg 8/8h) and oral steroids (prednisolone 20mg id) for 3 days, as well as nasal douche and decongestant. Due to worsening symptoms, with intense periocular and neck pain, the patient was admitted and underwent an endoscopic middle antrostomy with maxillary sinus irrigation.

Figure 7. Opacification of the maxillary sinus on OPG.

Figure 8. Opacification with gas pockets of the left maxillary sinus on CT scan.

During follow-up the patient presented full symptomatic recovery, revealing only mild sinus inflammation on CT, in relation to the root apices of the left upper first molar, which did not warrant any further dental, medical or surgical treatment (Figures 9 and 10).

5. Discussion

Immediate and appropriate management is crucial to minimize tissue damage and prevent further complications. Upon recognizing the extrusion, the procedure should be stopped immediately. The endodontist should aspirate as much of the NaOCl as possible from the canal using an empty syringe or absorbent paper points. [14] The tooth should then be dressed with a non-sealing calcium hydroxide dressing to help neutralize residual NaOCl and reduce inflammation.

Figure 9. Post-operative OPG.

Figure 10. Post-operative CT scan.

Table 1. Treatment guidelines after accidental extrusion of NaOCl.

Negative aspiration
Inform the patient about the cause and seriousness of the complication
Pain control:
- Infiltrative anesthesia
- Abundant irrigation with saline solution
- Analgesics and NSAIDs drugs
Evaluate case severity:
- If severe: admission to hospital, IV prednisolone
- If moderate-mild: treatment in an outpatient basis, oral prednisone
Antibiotics administration only if:
- High risk of necrosis
- Secondary infection expected
During the first day: use cold packs to prevent swelling.
From the second day, use hot compresses and frequent warm mouth rinses to stimulate local blood circulation
Close monitoring of the patient
Complete root canal treatment using saline solution or chlorhexidine as irrigants

Medical management involves the administration of systemic steroids, such as intramuscular hydrocortisone or oral prednisone, to control inflammation and reduce tissue damage. Prophylactic antibiotics, such as amoxicillin or co-amoxiclav, should be prescribed to prevent secondary infection, particularly in cases of extensive tissue necrosis. [14, 24] Pain management is essential, typically involving nonsteroidal anti-inflammatory drugs (NSAIDs) and, in severe cases, narcotic analgesics. Cold packs should be applied during the first 24 hours to minimize swelling, followed by warm compresses to improve circulation and aid in healing.

Patients should be closely monitored for several hours after the incident to assess the progression of swelling and other symptoms. Regular follow-ups should be arranged initially, with a focus on monitoring the healing process and managing any complications. In severe cases, where there is significant tissue damage or infection, surgical intervention may be necessary to decompress the affected area, facilitate drainage, and prevent further damage. [25] Finally, root canal treatment can be completed, although as previously stated- irrigation with a sterile saline solution or with chlorhexidine gluconate are highly recommended (0.2%-2%). [26, 27]

5.1. Management of Chemical Sinusitis

In the event of sodium hypochlorite extravasation to the maxillary sinus, immediate referral to an oral and maxillofacial surgeon specialized in sinus-related conditions, a stomatologist or an otolaryngologist is warranted. This interdisciplinary approach ensures that the appropriate diagnostic imaging, such as a CT scan, can be performed to assess the extent of the chemical injury and guide further therapeutic interventions, including potential surgical options if conservative management proves insufficient. [28]

Management of chemical sinusitis resulting from sodium hypochlorite extravasation involves both immediate and long-term strategies. The initial treatment typically involves the use of nasal decongestants (Xylometazoline hydrochloride TDS for 7 days) and nasal steroids (Betamethasone sodium phosphate TDS for 7 days) to reduce inflammation and swelling within the nasal and sinus cavities and promote mucociliary drainage, systemic steroids (e.g. Intra-muscular 100 mg Hydrocortisone Na Succinate; Oral Prednisolone 30 mg OD 7 days) alongside antibiotics to prevent secondary infections (Amoxicillin 250 mg TDS and Metronidazole 200 mg TDS (or Co-Amoxiclav 625 mg TDS for 7 days), as the compromised mucosal integrity may predispose patients to bacterial colonization and infection. Additionally, saline irrigation can be employed to facilitate mucociliary clearance to flush out the sodium hypochlorite and reduce the chemical load and promote healing. Severe cases may necessitate endoscopic intervention to remove necrotic tissue and further alleviate any obstruction, thus ensuring that the sinus returns to its normal function without the risk of chronic or recurrent sinusitis. [29, 30]

Close monitoring of the patient is essential to detect and manage potential complications such as airway obstruction or the development of cellulitis. In cases where significant tissue damage has occurred, endoscopic sinus

surgery may be necessary to debride necrotic tissue, establish drainage, and allow for ongoing irrigation of the sinus cavity. Long-term corticosteroid therapy may be required to control inflammation and prevent the development of fibrosis within the sinus, which can lead to chronic sinusitis.

Patients should be monitored for complications such as bony erosion, which can lead to orbital involvement and other serious sequelae. [21, 22] In cases where an oroantral fistula develops due to bony erosion, surgical closure using a buccally advanced flap may be necessary to ensure proper healing and function. [30]

Follow-up imaging, such as CT scans, may be necessary to assess the extent of the injury and the effectiveness of treatment. The prognosis for patients with chemical sinusitis caused by sodium hypochlorite depends on the promptness of treatment and the extent of the initial injury.

6. Conclusion

Stomatologists, dentists, oral and maxillofacial surgery specialists, and otolaryngologists should all be aware of the whole range of maxillofacial complications that may arise from even the simplest dental procedures. Sodium hypochlorite extrusion into the maxillary sinus is a rare but serious complication of endodontic treatment. The dentists have a critical role in preventing them. The risks associated with this event underscore the importance of careful technique and thorough knowledge of tooth anatomy. When extrusion occurs, prompt and effective management is critical to minimize tissue damage and prevent long-term complications. By adopting preventive measures and remaining vigilant during endodontic procedures, endodontists can reduce the likelihood of NaOCl accidents and ensure better patient outcomes. Dentists, maxillofacial surgeons and otolaryngologists have the responsibility to rapidly and correctly diagnose the extent of such complications when they happen and treat them adequately.

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