CASE REPORT/CLINICAL TECHNIQUES

Sodium Hypochlorite Accidents: A Retrospective Case-series Analysis of CBCT Imaging and Clinician Surveys

Dan Cho-Kee, DDS,[*] Bettina R. Basrani, DDS, MSc, PhD,[*] Jorge Vera, DDS, MS,[†] Ronald Ordinola-Zapata, DDS MS, PhD,[‡] and Rubén Rosas Aguilar, DDS, MS[§]

ABSTRACT

This case series study aims to investigate retrospectively the causes underlying sodium hypochlorite (NaOCl) accidents in endodontic practices through analysis of cone beam computed tomography (CBCT) imaging and comprehensive clinician surveys. Twenty-four dental practitioners who encountered a NaOCl accident during the treatment of a permanent tooth in adult patients provided deidentified patient data, facial photographs, and a limited field of view CBCT of the involved tooth. Providers also had to report patient's immediate presence of pain and swelling after root canal irrigation to include the dataset into the study. Modified surveys were administered to collect information on other demographic factors including age, sex, tooth involved, apical diagnosis, presence of ecchymosis, pain severity, among others. The CBCT volume was used to identify the presence of fenestration, root perforation, and apical pathosis. CBCT data were evaluated by 4 examiners. Among the 26 NaOCl accidents investigated, a higher incidence was observed in females (65.30%) and maxillary teeth (92.30%). All cases presented immediate swelling and edema; intracanal bleeding and hematoma were observed in 80.70 and 84.60% of the cases respectively. CBCT interpretation revealed that bone fenestrations were evident in all cases studied (100%), iatrogenic perforations were detected in 19.23% of the cases, and apical pathosis was noted in 30.70% of the cases. This case series study highlights that a direct communication between the root apex and surrounding soft tissues is highly prevalent in NaOCl accidents. Early identification of bone fenestrations or perforations identified in maxillary teeth of female patients can play a pivotal role in preventing NaOCl extrusion accidents during endodontic treatment. *(J Endod 2025;51:1485–1489.)*

SIGNIFICANCE

This study highlights bone fenestrations as a key risk factor for NaOCl accidents, present in all cases. Pretreatment CBCT evaluation to identify fenestrations or iatrogenic perforations can aid in modifying irrigation techniques, thereby minimizing the risk of sodium hypochlorite accidents.

KEY WORDS

Case series; cone beam computed tomography (CBCT); fenestration; sodium hypochlorite accident; survey

Nonsurgical root canal treatment involves the removal of inflamed and/or infected pulp tissue to prevent or manage apical periodontitis. The disinfection process implies multiple steps, including preparation of an access cavity, mechanical shaping, and cleaning with proteolytic irrigant solutions[1]. Sodium hypochlorite (NaOCl) is the most widely used irrigant in endodontics because of its excellent antimicrobial properties and organic tissue dissolving ability[1,2].

The oxidizing and proteolytic capability of NaOCl poses a notable risk if the solution is involuntarily extruded beyond the apex. Complications associated with NaOCl accidents include acute chemical damage to the periapical and surrounding connective tissues[1,3,4]. Upon contact with vital tissues, NaOCl can provoke profound tissue burns, ecchymoses, epithelial ulceration, and necrosis[2,3,5]. Other signs and complications include acute pain, periapical bleeding, extraoral swelling and paresthesia of the trigeminal nerve branches[4,6–9]. These effects happen immediately or can arise after several hours[4,6,7]. Soft tissue edema tracking into the fascial spaces of the neck requiring tracheal intubation or emergency tracheostomy to support ventilation has also been reported[8,9].

Prior investigations into NaOCl accidents risk factors have yielded valuable insights[5,10,11]. A previous study revealed the contributions of anatomical factors such as bone fenestrations and the risk of NaOCl accidents[12]. However, systematic reviews concluded that the radiographic documentation in

From the *Faculty of Dentistry, University of Toronto, Toronto, Ontario, Canada; †Department of Periodontics and Endodontics, University at Buffalo School of Dental Medicine, Buffalo, New York; ‡Division of Endodontics, Department of Restorative Sciences, University of Minnesota School of Dentistry, Minneapolis, Minnesota; and §National Autonomous University of México (ENES), León, México

Address requests for reprints to Rubén Rosas Aguilar DDS, MS, National Autonomous University of México (ENES – León), Blv. UNAM #2011, Predio El Saucillo y, Comunidad de los Tepetates, El Potrero, 37684 León de los Aldama, Guanajuato.
E-mail address: rrosasa@enes.unam.mx
0099-2399/$ - see front matter

https://doi.org/10.1016/j.joen.2025.05.024

published cases lacked a comprehensive reporting on the risk factors associated with this type of accidents[5,11]. Surprisingly, each case report published in the existing literature documents no more than 4 NaOCl accidents per study, with fewer than 70 occurrences recorded since 1975. It is imperative to understand and mitigate the risk factors contributing to these catastrophic accidents. Therefore, this case series study aims to comprehensively investigate the multifactorial causes underlying NaOCl accidents through analysis of cone beam computed tomography (CBCT) imaging and comprehensive clinician surveys.

MATERIALS AND METHODS

This study employed a modified survey developed by Guivarc'h et al[5] which has been enhanced to capture details on NaOCl accident risk factors (See Table 1). Ethics approval to collect data retrospectively was obtained through the University Research Ethics Board (Protocol #44109).

Clinical and radiographic data were systematically collected over a 2-year span, from April 2022 to April 2024, via surveys conducted at international dental conferences. Following comprehensive interviews with 35 dentists who reported NaOCl incidents during root canal treatment, only 24 practitioners satisfied the inclusion criteria, resulting in 26 thoroughly documented examples of NaOCl accidents, while most dentists reported a single case, 2 practitioners each reported two distinct incidents. Inclusion criteria required detailed clinical records for each case, comprising facial photographs taken immediately postincident and CBCT scans of the affected teeth. CBCT scans were acquired at different stages, with some scans obtained preoperatively and others postoperatively, depending on the clinical scenario. Postoperative scans were typically captured within 1 to 3 days following the incident. NaOCl accidents were characterized by immediate extraoral edema and pain after irrigation, in line with established diagnostic criteria[13]. Additional documentation included reports of either profuse bleeding from the root canal or its absence, alongside the presence of hematoma or ecchymosis that developed either immediately after irrigation or at a later time. Given the urgent nature of these incidents, patients retrospectively rated their pain intensity during follow-up visits using the visual analog scale.

Four independent evaluators reviewed the CBCT scans of the affected area on a standardized computer monitor. The resolution of CBCT scans was between 0.10 and 0.20 mm voxel size. Three variables were noted and were calibrated according to predefined criteria: (1) apical radiolucency was considered 'clearly/definitively visible on scan; (2) fenestration denoted "anatomical or pathologic perforation of cortical bone," and (3) perforation indicated "iatrogenic perforation of the tooth causing communication with surrounding tissues."[14]

Both inter- and intraexaminer reliability for each CBCT parameter was assessed using Kappa test. Descriptive statistics were subsequently employed to elucidate patterns among cases and the associated risk factors.

TABLE 1 - Clinical and Radiographic Characteristics Observed in 26 Cases of Sodium Hypochlorite Accidents

	# Of cases (frequency)
Demographics	
Female	17 (65.3%)
Fenestration	26 (100%)
Perforation	5 (19.23%)
Apical pathosis	8 (30.70%)
Maxillary tooth	24 (92.30%)
Incisor	5 (19.23%)
Canine	3 (11.53%)
Premolar	6 (23.07%)
Molar	12 (46.15%)
Clinical presentation	
Bleeding	21 (80.76%)
Edema	26 (100%)
Hematoma	22 (84.61%)
Immediate swelling	26 (100%)

RESULTS

The demographic characteristics of the assessed cases including, sex, tooth type, presence or absence of apical pathosis, fenestrations, and iatrogenic perforations are presented in Table 1. The average patient's age was 40.7 ± 16.48 years. Patients affected were mostly females (65.3%). The maxilla was involved in 24 of 26 cases. Only two mandibular teeth were affected: one mandibular incisor, and one mandibular molar. Maxillary molars were the most commonly affected tooth type (46.15%), followed by incisors (19.23%) and premolars (23.07%). All cases reported the use of a manual syringe.

Regarding the clinical manifestation, all patients reported immediate pain after the accident, with an average intensity score of 6.9 out of 10 (recorded at the follow up visit). Most patients exhibited bleeding from the canal (80.76%), immediate swelling (100%), and hematoma formation on the day of the accident (84.61%) (Fig. 1*A*). Only one case reported dysphagia or difficulty swallowing, while no cases reported dyspnea or difficulty breathing. Hospitalization was required for only one patient. Results from the survey revealed 100% of the cases involved the use of manual syringe irrigation. A non-beveled or side-vented needle was used in 80.78% of cases, and a 5 mL syringe was the most common delivery system with 4.15%. The final canal preparation ranged between sizes 25/06 and 50/06. See Table 2.

Bone fenestrations were the predominant finding observed in CBCT scans (100% of cases) (Fig. 1*B*). They were associated mostly to anatomical variations or to apical pathosis. Iatrogenic perforations were identified in 19.2% of cases (5 out of 26). The kappa analysis yielded a coefficient of 0.707, with a 95% confidence interval of (0.544–0.871), in terms of the presence of apical radiolucency and the presence of direct communication between the root canal system and adjacent tissues (iatrogenic perforations and fenestrations). The test revealed substantial agreement between the examiners. Figure 1*A* and *B* shows a clinical presentation and CBCT imaging of a sodium hypochlorite accident.

DISCUSSION

This case series study adds relevant knowledge on the NaOCl accident topic by investigating both anatomical and patient's related factors contributing to their occurrence[12]. The infrequency of these accidents in clinical practice has left a wide gap in knowledge and hence, opportunities for prevention[5].

This retrospective survey and CBCT analysis significantly contributes to the literature by analyzing 26 records and providing comprehensive documentation of each case. Earlier studies on the topic have examined risk factors through surveys, case reports, and *ex-vivo* experiments; however, such studies have significant limitations in methodology, data collection, and reporting[5,10]. Notably, only 1–4 NaOCl accidents are reported in each case report publication that are currently available in the literature[4]. The retrospective strategy was used in this study since NaOCl accidents impact only a minor proportion of patients undergoing nonsurgical root canal treatment.

The observed predominance of female patients and involvement of maxillary teeth align with findings from previous surveys conducted among endodontists[5,15]. A survey of 132 clinicians[10] found that NaOCl accidents were more likely to occur in maxillary molars, especially those with periapical radiolucencies, and in female patients in their 40–50s. The

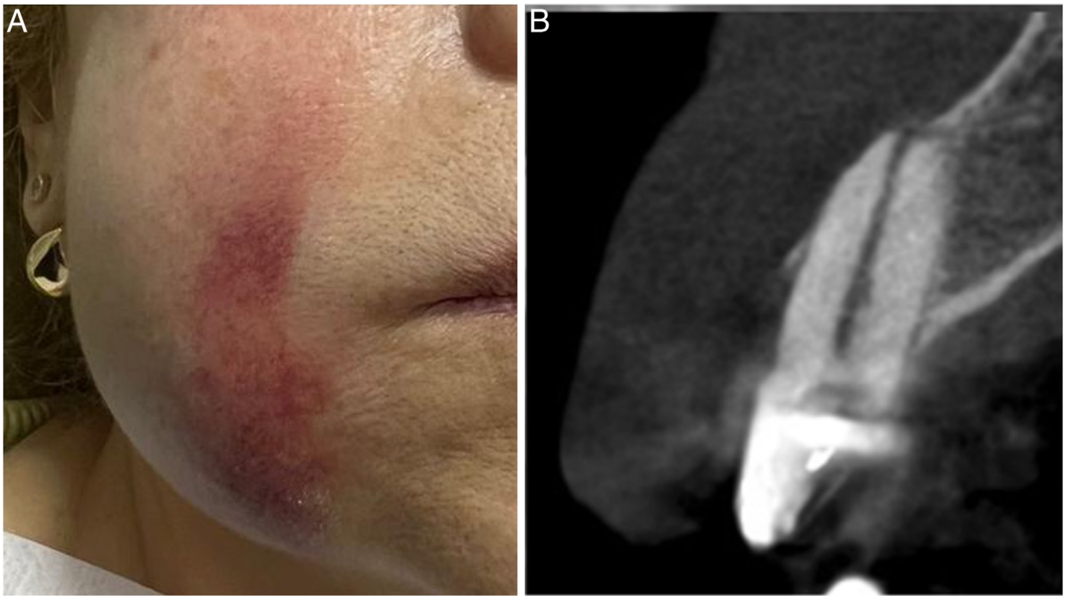

FIGURE 1 – A and B - Clinical presentation and cone-beam computed tomography (CBCT) imaging of a sodium hypochlorite accident. (*A*) Extraoral photograph showing diffuse facial swelling and periorbital ecchymosis on the affected side within hours of the incident. (*B*) Sagital CBCT slice revealing apical root fenestration.

apical foramen was often patent and subject to over-instrumentation. This trend is likely attributed to potential differences in bone density and thickness in female patients, which could contribute to reduce the apical tissue's pressure predisposing the patient to an accident[10]. Additionally, changes in the bone density and cortical thickness can also explain the differences in the incidence of these accidents in maxillary and mandibular teeth[11]. This observation is particularly relevant given the high prevalence of fenestrations in the maxilla among various adult populations including Caucasians[14], Chinese[16], and patients with history of orthodontic treatment[17].

Our findings also revealed that most accidents happened in teeth without apical pathosis (69.2%). This contrasts the theory of Psimma & Boutsioukis[18], who suggested that an increased number of accidents could be associated to the effect of apical pathosis on the surrounding bone tissue including the cortical plates[18]. The data revealed that breaches in cortical bone integrity and direct communication with surrounding soft tissues, rather than the mere presence of apical pathosis, may play a more significant role in increasing the patient's susceptibility to NaOCl accidents[12].

TABLE 2 - Clinical Variables in Reported Cases of Sodium Hypochlorite Extrusion

Category	Option	# Of cases (frequency)
Practitioner type	Specialist	20 (76.92%)
	General Dentist	3 (11.53%)
	Student	3 (11.53%)
NaOCl concentration	5.25 or 6.0%	14 (53.84%)
	2.5 or 3.0%	12 (46.15%)
Needle type	Open	5 (19.23%)
	Side vented	21 (80.78%)
Syringe capacity	20 mL	1 (3.84%)
	15 mL	1 (3.84%)
	10 mL	10 (38.46%)
	5 mL	12 (46.15%)
	3 mL	2 (7.69%)
Final apical size	25/.06	3 (11.53%)
	30/.04	2 (7.69%)
	30/.06	1 (3.84%)
	35/.02	2 (7.69%)
	35/.04	9 (34.61%)
	35/.06	2 (7.69%)
	40/.04	1 (3.84%)
	40/.06	1 (3.84%)
	45/.04	2 (7.69%)
	50/.04	1 (3.84%)
	50/.06	2 (7.69%)

One notable contrast between this study and previous findings lies in the distribution of tooth types affected. Typically, anterior teeth predominate in NaOCl accident studies due to their thinner buccal cortical plates and increased incidence of root fenestrations. However, our sample exhibited a higher prevalence of maxillary molar involvement (12 out of 26). This discrepancy may be attributed to the fact that most of our survey participants were endodontists who are more inclined to treat molar teeth compared to anterior cases[10].

All cases reported the use of a manual syringe, the most commonly used irrigation method in endodontics. While widely utilized, manual syringes pose inherent risks of extrusion compared to negative pressure irrigation methods[19]. Most cases utilized a closed-end, non-beveled, and side-vented needle, which limits irrigant flow to 1 mm beyond the needle tip. The predominant needle gauge and syringe size were 27-gauge needles with 5 mL syringes, potentially contributing to extrusion risk due to higher flow rates associated with larger needle diameters and smaller syringe sizes[19].

It is important to note that the participant pool included dental students and general practitioners, which may reflect a wide range of clinical experience and skills. This variability could certainly contribute to the incidence of both iatrogenic perforations and NaOCl accidents. The observed correlation between these events highlights the potential influence of operator-related factors, including improper irrigation technique and insufficient clinical training.

While this study contributes to the literature on sodium hypochlorite risk factors, the authors acknowledge some limitations. One disadvantage is the absence of a control group which could allow designing a case control study. Due to the rarity of reported NaOCl cases, it would be challenging to find enough control participants presenting immediate swelling during root canal treatment matched on similar confounding factors such as age, specific anatomical variation, amount of apical pressure during irrigation, and tooth number. It is important to emphasize that while anatomical variations could contribute to an increased risk of NaOCl accidents[14], additional factors such as needle wedging, poor working length control, or excessive positive pressure during manual irrigation must align simultaneously for these accidents to occur[5,10,11]. Although, it is suspected that the presence of a fenestration is necessary for a sodium hypochlorite accident to develop[12], this may not be a sufficient cause, because sodium hypochlorite accidents are rare. Because it is unlikely that all cases with fenestrations will develop an irrigation accident, therefore, bone fenestrations are a necessary but not a sufficient cause, since other unknown variables must also be present to complete the "causal circle." (Rothman's causal model)

It is important to clarify the relationship between CBCT imaging and the presence of cortical fenestrations to assess the potential contribution of NaOCl extrusion. In 8 cases, preoperative CBCT scans taken as part of routine diagnostics clearly revealed the presence of pre-existing bony fenestrations prior to any endodontic intervention. These findings suggest that fenestrations were already present before NaOCl exposure. In cases lacking preoperative imaging, the temporal sequence cannot be confirmed; however, it is unlikely that brief NaOCl exposure alone could induce cortical bone resorption in a short period of time. Cortical bone is highly resistant to rapid chemical degradation due to its dense mineralized structure[20]. Furthermore, conventional syringe irrigation generates insufficient force to create new bony defects or disrupt intact bone[12,21].

Further research is warranted to explore the interaction of additional factors and develop targeted preventive strategies to mitigate the occurrence of these accidents.

CONCLUSION

This case series study stresses the significance of direct communication between the root canal system and surrounding soft tissues in sodium hypochlorite accidents. Early identification of bone fenestrations present in maxillary teeth of female patients can play a pivotal role in preventing sodium hypochlorite extrusion accidents during endodontic treatment.

ETHICS APPROVAL STATEMENT AND DOCUMENT

This study received ethical approval to collect retrospectively data from the University of Toronto, through the University Research Ethics Board (Protocol #44109).

DATA AVAILABILITY STATEMENT

All data generated and analyzed during this study are included within the article. All patients signed informed consent forms ensuring confidentiality, and the study was approved by the ethics committee of Toronto University.

ACKNOWLEDGMENTS

The authors deny any conflicts of interest related to this study.

REFERENCES

1. Haapasalo M, Shen Y, Qian W, Gao Y. Irrigation in endodontics. Dent Clin North Am 2010;54:291–312.
2. Basrani B, Haapasalo M. Update on endodontic irrigating solutions. Endod Top 2012;27:74–102.
3. Farook S, Shah V, Lenouvel D, et al. Guidelines for management of sodium hypochlorite extrusion injuries. Br Dent J 2014;217:679–84.
4. Hülsmann M, Hahn W. Complications during root canal irrigation – literature review and case reports. Int Endod J 2000;33:186–93.
5. Guivarc'h M, Ordioni U, Ahmed HM, et al. Sodium hypochlorite accident: a systematic review. J Endod 2017;43:16–24.
6. Mehdipour O, Kleier DJ, Averbach RE. Anatomy of sodium hypochlorite accidents. Compend Contin Educ Dent 2007;28:544–6. 548, 550.
7. Gatot A, Arbelle J, Leiberman A, Yanai-Inbar I. Effects of sodium hypochlorite on soft tissues after its inadvertent injection beyond the root apex. J Endod 1991;17:573–4.
8. Kavanagh C, Taylor J. Inadvertent injection of sodium hypochlorite into the maxillary sinus. Br Dent J 1998;185:336–7.

9. Witton R, Henthorn K, Ethunandan M, et al. Neurological complications following extrusion of sodium hypochlorite solution during root canal treatment. Int Endod J 2005;38:843–8.

10. Kleier DJ, Averbach RE, Mehdipour O. The sodium hypochlorite accident: experience of diplomates of the American board of endodontics. J Endod 2008;34:1346–50.

11. Boutsioukis C, Psimma Z, van der Sluis L. Factors affecting irrigant extrusion during root canal irrigation: a systematic review. Int Endod J 2013;46:599–618.

12. Souza EM, Campos MG, Rosas Aguilar R. Mapping the periapex anatomical pattern of teeth involved in sodium hypochlorite accidents: a cross-sectional quasi-experimental study. Int Endod J 2021;54:1212–20.

13. Zhu WC, Gyamfi J, Niu LN, et al. Anatomy of sodium hypochlorite accidents involving facial ecchymosis – a review. J Dent 2013;41:935–48.

14. Nimigean VR, Nimigean V, Bencze MA, et al. Alveolar bone dehiscences and fenestrations: an anatomical study and review. Rom J Morphol Embryol 2009;50:391–7.

15. Boutsioukis C, Gogos C, Verhaagen B, et al. The effect of root canal taper on the irrigant flow: evaluation using an unsteady computational fluid dynamics model. Int Endod J 2010;43:909–16.

16. Pan H, Yang H, Zhang R, et al. Use of cone-beam computed tomography to evaluate the prevalence of root fenestration in a Chinese subpopulation. Int Endod J 2014;47:10–9.

17. Sheng Y, Guo HM, Bai YX, Li S. Dehiscence and fenestration in anterior teeth: comparison before and after orthodontic treatment. J Orofac Orthop 2020;81:1–9.

18. Psimma Z, Boutsioukis C. A critical view of sodium hypochlorite accidents. EndoEPT 2019;13:165–75.

19. Boutsioukis CK. Fluid dynamics of syringe-based irrigation to optimize anti-biofilm efficacy in root-canal disinfection. Roots 2012;4:22–31.

20. Kerbl FM, DeVilliers P, Litaker M, Eleazer PD. Physical effects of sodium hypochlorite on bone: an *ex vivo* study. J Endod 2012;38:357–9.

21. Khan S, Niu L, Eid A, et al. Periapical pressures developed by nonbinding irrigation needles at various irrigation delivery rates. J Endod 2013;39:529–33.