The Sodium Hypochlorite Accident: Experience of Diplomates of the American Board of Endodontics

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

Abstract

To better understand the etiology associated with sodium hypochlorite accidents, we surveyed diplomates of the American Board of Endodontics. Of the 314 diplomates who responded, 132 reported experiencing a sodium hypochlorite accident. Questions were asked about the age and sex of the patient as well as the tooth being treated, preoperative signs, symptoms, diagnosis, and radiographic appearance. Data were analyzed by chi-square tests. Significantly more women experienced sodium hypochlorite accidents compared with men ($p < 0.0001$). More maxillary teeth than mandibular teeth ($p < 0.0001$) and more posterior than anterior teeth ($p < 0.0001$) were involved. A diagnosis of pulp necrosis with radiographic findings of periradicular radiolucency were positively associated with such accidents ($p < 0.0001$). Most respondents reported that patient signs and symptoms completely resolved within a month. The occurrence of an accident, by itself, did not adversely affect the endodontic prognosis of the involved tooth. Anatomic variations may contribute significantly to the occurrence of a sodium hypochlorite accident. *(J Endod 2008;34:1346–1350)*

Key Words

Accident, diplomates, irrigation, sodium hypochlorite, survey

From the School of Dental Medicine, University of Colorado Denver, Aurora, CO.

Address requests for reprints to Donald J. Kleier, University of Colorado School of Dental Medicine, PO Box 6508, Mail Stop F847, 13065 East 17th Avenue, Aurora, CO 80045. E-mail address: Donald.Kleier@uchsc.edu.

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Successful endodontic therapy requires shaping and cleaning of the root canal system. Irrigation with sodium hypochlorite (NaOCl) is an important adjunct used to accomplish this goal. One negative property of NaOCl is that it can cause soft-tissue inflammation if it is expressed outside the confines of the root canal (1). Clinically, this event manifests as pain and localized or widespread swelling. One name for such an event is an NaOCl accident (2).

A relatively small number of case reports have been published in the literature describing these events and their sequelae (2–20). Endodontic textbooks present techniques on how to decrease the chance of such an event occurring (21, 22). Suggestions include marking the working length on the irrigation needle, keeping the needle loose in the canal, not using excessive force on the irrigation syringe, using a perforated needle tip, and keeping the needle in constant motion while irrigating. Although these suggestions are important and helpful, we wondered if following these techniques would prevent an NaOCl accident under all clinical conditions.

Currently, there is a gap in knowledge concerning the etiology and clinical factors surrounding an NaOCl accident. The literature suggests that when an accident occurs, the operator may be at fault because of an error in the recommended irrigation technique. Based on our review of the literature and our own clinical experience, we thought there might be additional factors, beyond the operator's technique, that could contribute to the occurrence of a sodium hypochlorite accident. If these factors could be identified, clinicians might gain insight into the etiology of NaOCl accidents and be better able to avoid them.

We hypothesized that an NaOCl accident would more likely occur when NaOCl had direct access to a soft-tissue space, such as the buccal or infraorbital, rather than simply contacting periapical tissue. This might happen when the anatomic apex of a tooth naturally fenestrated through the overlying alveolar bone or when the alveolar bone had been perforated by a disease process. If this were true, then an accident might be more likely to occur in the maxilla than the mandible because of the closer proximity of roots to the labial bone surface, in females more than males because of decreased bone thickness and density, and when a periradicular lesion was present because of bone resorption leading to a fenestration of the overlying bone. To gain information about NaOCl accidents and to test our hypotheses, we surveyed diplomates of the American Board of Endodontics.

Materials and Methods

We surveyed 719 diplomates of the American Board of Endodontics who were listed in the 2006 to 2007 membership directory published by the American Association of Endodontists. The survey was administered electronically through Surveymonkey.com. Two demographic questions were asked about time spent in clinical practice. Respondents were then asked if they had experienced an NaOCl accident. Those who answered affirmatively were asked additional questions. The questions sought to obtain information about the age and sex of the patient as well as the tooth being treated, preoperative signs, symptoms, diagnosis, and radiographic appearance. Questions were also asked about the treatment procedure itself and possible explanations for the accident. The final question invited respondents to write a narrative on the accident experienced and the treatment provided. Respondents could detail up to four separate accidents.

The association between having experienced more than one NaOCl accident and years in clinical practice or hours per week devoted to direct patient care was assessed

using a chi-square test. The percent of accidents by sex, radiographic appearance, region, arch, and preoperative status were also assessed by using a chi-square test. Where indicated responses of "cannot recall" and blank responses were not included in the statistical comparisons, but the frequency is displayed in the tables and figures. Two-sided p values of less than 0.05 were considered significant.

Results

Of the 719 diplomats surveyed, 314 (44%) responded to the survey after three e-mail reminders over 30 days. Table 1 shows that a majority of respondents had been in practice over 10 years and practiced at least 32 hours per week. There was no association between having experienced more than one NaOCl accident with practice experience. One hundred eighty-two (58%) of the respondents answered that they had never experienced an NaOCl accident. One hundred thirty-two (42%) answered that they had at least one accident, and 50 of those 132 (38%) answered that they had more than one accident. Of the 132 respondents who had an NaOCl, 122 (92%) detailed at least one of those accidents by completing the survey. In all, 166 accidents were detailed as presented in Table 2.

Figure 1 shows that accidents were most commonly reported in the maxilla ($n = 122$, 73%) compared with the mandible ($n = 35$, 21%) ($p < 0.0001$). Of the respondents who could recall the region in which the NaOCl accident occurred, 107 (70%) were in the molar or premolar region as compared with 46 (30%) in the incisor or canine regions ($p < 0.0001$). Among the cases when sex was recalled, accidents were reported more frequently for females ($n = 99$, 69%) than for males ($n = 44$, 31%) ($p < 0.0001$). Figure 2 further shows the reported locations of accidents by tooth number.

Figure 3 shows the frequency of responses for the preoperative status, signs, and radiographic appearance. About 30% of respondents noted that they could not recall or gave no response to these questions. Among the 111 respondents who could recall preoperative status, the majority ($n = 73$, 66%) reported pulpal necrosis compared with irreversible pulpitis ($n = 27$, 24%) or retreatment ($n = 11$, 9%) ($p < 0.0001$). Among the 109 respondents who reported on preoperative signs, just over half ($n = 58$, 53%) reported pain but no swelling and 39 (36%) reported that the tooth was asymptomatic. Very few reported signs of localized swelling or a sinus tract before the procedure. Among the 117 respondents who could recall radiographic appearance, periradicular radiolucency was reported most commonly ($n = 71$, 61%) followed by intact normal periodontal ligament ($n = 38$, 32%), whereas external lateral or apical root resorption was least reported ($n = 8$, 7%) ($p < 0.0001$).

TABLE 1. Demographics of 314 Endodontists Who Responded to the Survey

Characteristic	*n*	%
Experience with an NaOCl accident		
Never	182	58
One time	82	26
Two times	30	10
Three times	10	3
Four times	10	3
Years in clinical practice		
0 to 10	28	9
11 to 20	58	18
21 to 30	106	34
30 or more	111	35
No response	11	4
Hours per week in direct patient care		
Less than 32	47	15
32	141	45
40	80	25
More than 40	30	10
No response	16	5

The majority of patients who experienced an NaOCl accident were in their 40s and 50s. The use of full strength or a 1:1 dilution of NaOCl was reported for 83% of accidents. When a patient did experience an NaOCl accident, 66% of patients fully recovered in less than 1 week. When asked to select from a list of choices explaining the alleged cause of the accident, 39% of respondents indicated that they thought the apex was open or had been overinstrumented.

The last question on the survey asked respondents to write about the NaOCl accident they had experienced. Of the 132 who indicated they had at least one accident, 59 (45%) provided written comments. The comments could be grouped into three categories: patient symptoms and clinical events during the accident, why the endodontist thought the accident occurred, and what treatment was rendered after the accident was discovered. Almost universally, comments were made that during the accident, the patient experienced a sudden sharp, burning pain despite anesthesia. This symptom was often followed by bleeding into the canal space and sometimes localized swelling. Only a few respondents indicated that their patients suffered significant and widespread swelling and ecchymosis. The most frequent reason cited for the accident occurring was the presence of an open apical foramen caused by periradicular disease or prior treatment by another dentist. Several cited iatrogenic perforations or external root resorption as a possible reason. The majority treated the accident with immediate additional anesthesia and canal irrigation with saline or water. This treatment was followed by analgesics, antibiotics, and locally injected or systemically prescribed steroids. There was universal agreement that the occurrence of an NaOCl accident, by itself, did not adversely affect the long-term endodontic success of the treated tooth.

Discussion

Our survey found that NaOCl accidents are very rare in endodontic practice. Of the 314 diplomates who responded to this survey, over half reported never having an accident during their entire practice career. The remaining 82 reported just one accident, and 50 reported more than one. We believe our response rate of 44% was excellent given that this was a voluntary e-mail survey about a clinical event that may have occurred many years ago.

We reviewed 19 case reports detailing 23 NaOCl accidents (2–20). Of the 23 accidents reported, 18 occurred in females and five occurred in males. In these same cases, 20 accidents occurred in the maxilla and three in the mandible. Our survey results agreed with the reviewed literature and showed that many more female patients experienced an NaOCl accident than did male patients ($p < 0.0001$). One possible explanation for this is that more females than males received endodontic therapy. However, authors investigating the overall success rate and retention of endodontically treated teeth have found the number of male versus female patients is approximately equal (23, 24). Our hypothesis that females have a greater incidence of NaOCl accidents compared with males seems confirmed, given the statistical significance of the difference.

Our survey showed that many more maxillary teeth, especially molars and premolars, were involved with NaOCl accidents compared with mandibular teeth ($p < 0.0001$). These results agreed with the reviewed literature that cited an increased incidence of accidents in maxillary compared with mandibular teeth. It is not surprising that 18 endodontists could not recall the specific tooth number involved considering the rarity of NaOCl accidents. The three questions of arch, region, and tooth number sought to identify the location of the accidents and yield results that are supportive and consistent. An explanation of

TABLE 2. NaOCl Accidents Detailed

Question	Response	*n*	%
In which arch did the accident occur?	Maxillary	122	73
	Mandibular	35	21
	Cannot recall	8	5
	No response	1	1
In which region did the accident occur?	Premolar	57	34
	Molar	50	30
	Incisor	24	14
	Canine	22	13
	Cannot recall	10	6
	No response	3	2
What was the sex of the patient?	Female	99	60
	Male	44	27
	Cannot recall	20	12
	No response	3	2
What was the approximate age of the patient?	Teenage	2	1
	20 s	13	8
	30 s	29	17
	40 s	43	26
	50 s	44	27
	60 s	11	7
	>70	5	3
	Cannot recall	7	4
	No response	12	7
What was the preoperative status/diagnosis of the treated tooth?	Pulpal necrosis	73	44
	Cannot recall	50	30
	Irreversible pulpitis	27	16
	Retreatment	11	7
	No response	5	3
What were the preoperative signs/clinical appearance?	Pain, no swelling	58	35
	Cannot recall	53	32
	Asymptomatic	39	23
	Localized swelling	9	5
	No response	4	2
	Sinus tract	3	2
What was the radiographic appearance?	Periradicular radiolucency	71	43
	Cannot recall	45	27
	Intact normal periodontal ligament	38	23
	Ext. lateral root resorption	5	3
	No response	4	2
	External apical root resorption	8	5
NaOCl dilution used when the accident occurred?	10 to 1	3	2
	5 to 1	18	11
	1 to 1	66	40
	Full strength	72	43
	Cannot recall	5	3
	No response	2	1
How long did it take for your patient to fully recover from any signs or symptoms resulting from the HA?	<1 week	110	66
	<1 week but <1 month	46	28
	<1 month but <1 year	3	2
	Cannot recall	4	2
	No response	3	2
What do you think was the main cause of the accident?	Apex was open	42	25
	Needle wedged in the canal	34	20
	Syringe pressure too great	27	16
	Apex over instrumentation	23	14
	No response	23	14
	Cannot explain it	17	10

this finding could be that more maxillary than mandibular teeth are treated in the general population. However, one study investigating a large number of patients receiving endodontic therapy found that the number of maxillary and mandibular teeth treated is approximately equal (24). Endodontists have been shown to treat more posterior and fewer anterior teeth compared with general practitioners (23). This could account for our increased numbers of maxillary premolar and molar teeth involved with NaOCl accidents and lower numbers of maxillary anterior teeth. Compared with maxillary teeth, mandibular teeth are encased in a denser cortical plate and mandibular premolar and molar teeth apices are more centrally located within the body of the mandible. The buccal roots of maxillary premolar and molar teeth have only a thin covering of cortical bone, which probably predisposes these teeth to NaOCl accidents (25). Our hypothesis that the anatomic difference in bony architecture contributes to the statistically significant difference between maxillary and mandibular teeth seems confirmed.

The results showed that the majority of respondents who could recall the preoperative status and radiographic appearance of their NaOCl accident cases chose pulp necrosis ($p < 0.0001$) and a periradicular radiolucency ($p < 0.0001$). A possible reason for this finding is

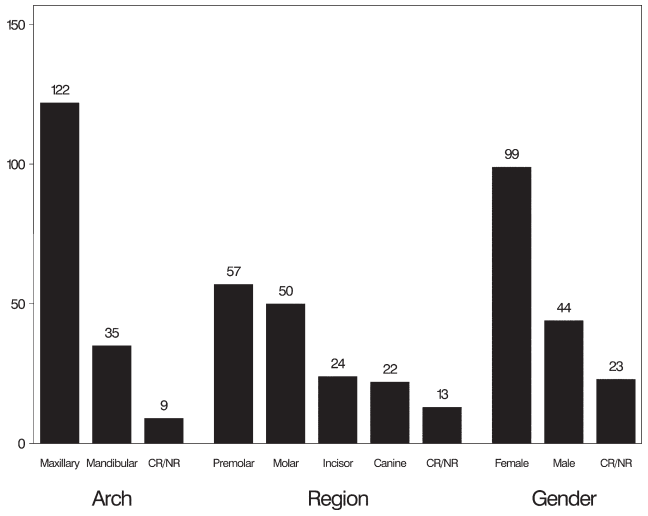

Figure 1. The frequency of arch, region, and sex for the 166 NaOCl accidents detailed. CR/NR = cannot recall or no response.

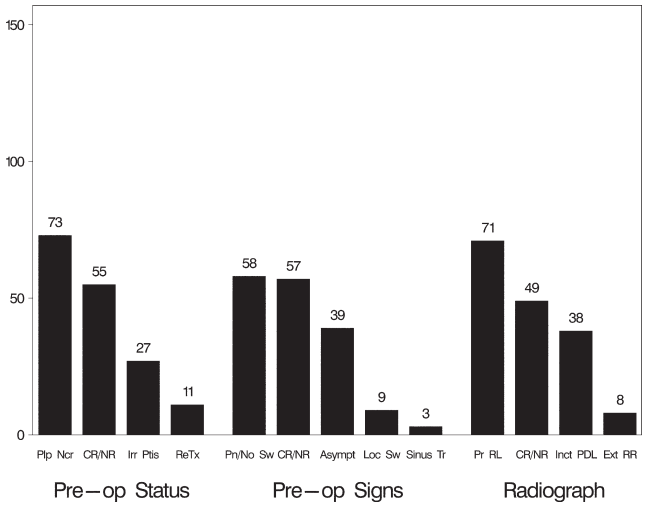

Figure 3. The frequency of preoperative (Pre-op) status, preoperative (Pre-op) signs, and radiographic appearance for the 166 NaOCl accidents detailed. Plp Ncr = pulpal necrosis; CR/NR = cannot recall or no response; Irr Ptis = irreversible pulpitis; ReTx = retreatment; Pn No SW = pain but no swelling; Asympt = asymptomatic; Loc SW = localized swelling; Sinus TR = sinus tract; Pr RL = periradicular radiolucency; Inct PDL = intact normal periodontal ligament; Ext RR = external lateral or apical root resorption.

that pulpal necrosis is often associated with a bacterial infection of the pulp and periradicular inflammation, external apical root resorption, and bone resorption. As bone resorption continues, there is an increased likelihood that a bony fenestration or dehiscence will occur causing a communication with a fascial space. This explanation seems supported by the very low incidence of accidents reported when a sinus tract was present. A sinus tract would provide a pathway into the oral cavity rather than a tissue space. The large number of endodontists (~30%) who could not recall the preoperative status, signs, or radiographic appearance is a weakness in interpreting these data. Nevertheless, when cannot-recall and no-response answers are removed, there is a strong trend that teeth with pulpal necrosis and periapical radiolucency are more likely to be involved with an NaOCl accident.

More NaOCl accidents were reported when higher concentrations of NaOCl were used. These results seem to agree with reports in the literature describing that as the concentration of NaOCl is increased, it becomes more toxic to vital tissue (1, 26). On the other hand, this association could simply be a consequence of varying concentrations of NaOCl used in clinical practice. The lowest concentration of NaOCl that is clinically effective should be used to promote patient safety. This could be a subject for further research.

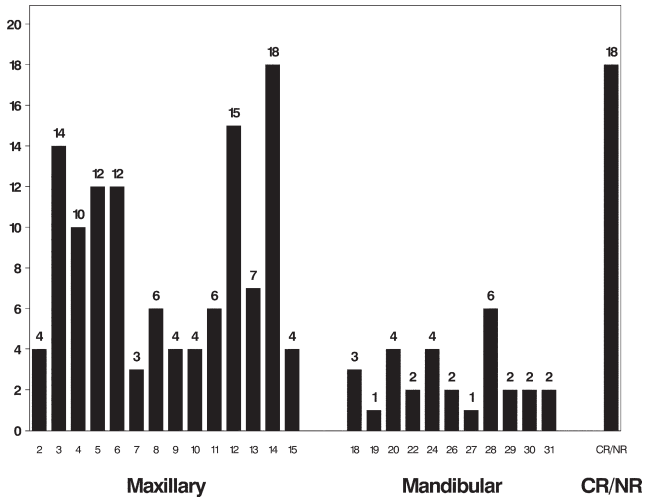

Figure 2. The frequency of the tooth reported for the 166 NaOCl accidents detailed by arch. CR/NR = cannot recall or response.

Most of the case reports we reviewed detailed the postoperative course of the patients who suffered an NaOCl accident. Almost all reported similar sequelae; the patient had immediate severe pain, gradually increasing edema, and profuse hemorrhage both interstitially and through the tooth. Most of the patients had complete resolution within a few weeks, but some had long-term paresthesia or tissue scaring. Some case reports detailed extreme swelling requiring emergency medical care and hospitalization (5, 6). Our findings agree with these reports. Most of our survey respondents (94%) reported that their patients had mild to moderate swelling that completely resolved in less than a month with most resolving in a week. We did not survey respondents about the severity of their patient's postoperative course. Their reported treatment of additional anesthesia, pain, and antibiotic medication together with oral steroids agreed with reported cases in the literature. It is not clear from our data or the literature if there is a direct relationship between the volume or concentration of solution entering a tissue space and the amount of swelling that occurs. Swelling and ecchymosis may be caused more by local factors such as the proximity and size of vascular structures at the site of hypochlorite extravasation from the root canal. This could be an area of future research using animal models.

Although our respondents did not report experiencing an NaOCl accident because of mistaken injection of the solution, there are at least three case reports in the literature detailing such an occurrence (27–29). In these reports, NaOCl for endodontic irrigation was placed in recycled anesthetic carpules, which then were accidentally used for an anesthetic injection. One patient required hospitalization after a mandibular block (29). NaOCl for endodontic irrigation should only be stored in labeled containers and irrigation syringes that are easily identified.

NaOCl is frequently used with other irrigating solutions. One such solution is chlorhexidine gluconate. When these two solutions contact each other within the root canal, a precipitate containing parachloroaniline, a potentially toxic and carcinogenic compound, is formed (30). A recent study has shown that this precipitate of parachloroaniline prob-

ably coats the root canal wall and occludes dentinal tubules (31). Because this compound could potentially come in contact with periradicular tissues through leaching or during an accidental extravasation of irrigating solution, research is needed to define the potential risk of producing this compound via canal irrigation with NaOCl followed by chlorhexidine gluconate.

We surveyed diplomates of the American Board of Endodontics. This cohort arguably represents a group with a high level of training and skill. Surveying other dental professionals who perform endodontics might result in different findings.

This was a retrospective study that asked respondents to recall historical events. The highest level of evidence exists when a research question is framed in a prospective double-blind format with suitable control groups. However, we sought to gain additional information on a relatively rare but clinically significant event. The results of our retrospective survey may provide information that leads to future research with a more rigorous study design.

Conclusion

Within the limitations of this study design, we found that NaOCl accidents were relatively rare in endodontic practice. The results of case reports and this survey showed that maxillary premolar and molar teeth in female patients with a clinical history of a necrotic pulp and periapical radiolucency were most prone to experiencing such an accident. The vast majority of patients recovered within a week to a month. Such an event did not decrease the long-term endodontic prognosis for the involved tooth. NaOCl accidents may be caused by additional factors other than faulty irrigation technique.

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