Comparative Evaluation of Calcium Hypochlorite and Sodium Hypochlorite on Soft-tissue Dissolution

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Abstract

Introduction: The aim of this study was to compare *in vitro* the tissue-dissolution properties of 5% and 10% calcium hypochlorite ($Ca(OCl)_2$) with two concentrations (1.36% and 4.65%) of proprietary sodium hypochlorite (NaOCl) on bovine muscle tissue. **Methods:** The available chlorine concentration of each solution was determined using iodometric titration. Tissue specimens from bovine muscle were weight adjusted (50 $\pm$ 5 mg). Ten tissue specimens in each group were immersed in 5 mL each test solution, removed after 5 minutes, blotted dry, and weighed. The process was repeated every 5 minutes with a fresh 5-mL aliquot of the test solution for 60 minutes or until complete tissue dissolution, whichever was quickest. The percentage weight loss of the specimens was calculated over the experimental period. **Results:** Available chlorine concentrations of the irrigants ranged from 1.36% to 4.65%. All solutions dissolved tissue completely after 60 minutes except 5% $Ca(OCl)_2$ (99.4% dissolution). Between the 35- and 60-minute test readings, there were no significant differences between the solutions. Chlorax (4.65% NaOCl) (Cerkamed Group, Nisko, Poland) dissolved tissue quicker during the first 35 minutes ($P < .05$). In this period, the weight loss with 10% $Ca(OCl)_2$ differed from Chlorax at all time intervals except at 5 and 35 minutes ($P < .05$); 5% $Ca(OCl)_2$ showed no significant differences with 10% $Ca(OCl)_2$ and Tesco bleach (1.36% NaOCl) (Tesco Stores Ltd, Chestnut, UK) in the first 35 minutes except at the 5-minute measurement. **Conclusions:** Within the limitations of this study, Chlorax (4.65% NaOCl) dissolved tissue faster than the $Ca(OCl)_2$ solutions and Tesco thin bleach (1.36% NaOCl) over the first 35 minutes, but there were no significant differences among the solutions thereafter. *(J Endod 2012;38:1395–1398)*

Key Words

Calcium hypochlorite, irrigation, sodium hypochlorite, tissue dissolution

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Disinfecting and cleaning the root canal system of microbial flora and pulpal tissue are prerequisites for successful root canal treatment (1). Mechanical instrumentation of the canals alone without antimicrobial intervention reduces bacterial species (2), but recent studies have shown that approximately 35% to 50% of the pulp space remained uninstrumented (3). Therefore, the use of irrigant solutions is paramount.

The ability to dissolve pulp especially from inaccessible areas such as fins and isthmuses is important because the presence of infected tissue within root canals produces persistent periradicular inflammation (4). The ability of alkaline solutions of hypochlorite to rapidly oxidize, decarboxylate, and deaminate primary and secondary α-amino acids has been shown (5, 6), and the antimicrobial efficacy of sodium hypochlorite (NaOCl) is well recognized (7, 8). The solution dissolves vital and necrotic pulp tissue (8–10), and this action is concentration dependent (11–13) relative to the available chlorine (14). Dissolution is not affected by osmolarity or buffer capacity (8), but it is improved by agitation and heat (13, 15). There are conflicting results concerning the addition of a surfactant; Stojicic et al (13) revealed higher dissolution, but a more recent study has shown no added benefit (16).

Several chemicals investigated for their tissue-dissolving ability were found to be ineffective except chlorine dioxide (17–20). Calcium hydroxide ($Ca(OH)_2$) is an intracanal medicament with antibacterial activity, and necrotic pulp tissue pretreated with this chemical enhanced the tissue-dissolving effect of NaOCl (21–26).

Calcium hypochlorite ($Ca[OCl]_2$) is used for industrial sterilization, bleaching, and water purification treatment (27). It is relatively stable and has greater available chlorine than NaOCl (up to 65% available chlorine). $Ca(OCl)_2$ is available as granules, and in a freshly prepared aqueous solution, the following reaction occurs: $Ca(OCl)_2 + 2\ H_2O \rightarrow 2\ HOCl + Ca(OH)_2$.

$Ca(OCl)_2$ has never been evaluated for its application as an endodontic irrigant. The purpose of this study was to assess the tissue-dissolving capacity of $Ca(OCl)_2$, and compare it with NaOCl at varying concentrations. The null hypothesis was that $Ca(OCl)_2$ does not dissolve tissue more effectively than NaOCl.

Materials and Methods

Bovine muscle tissue was harvested and cut to produce samples approximately 8- to 10-mm long and 1- to 2-mm thick with a standardized weight of 50 $\pm$ 5 mg (Table 1). Each sample was placed in a separate 7-mL plastic vial and stored at $-20°C$ until they were used in the study.

$Ca(OCl)_2$ solution was made up freshly from granules (R & D Laboratories Ltd, Antrim, Northern Ireland, UK) at the time of each experiment. Different concentrations were prepared with distilled water (weight/volume [w/v] ratio) to strengths of 5% and 10% and mixed using a magnetic stirrer for 10 minutes. The commercial solutions of NaOCl tested were a purported 5.25% concentration (Chlorax; Cerkamed Group, Nisko, Poland) and a proprietary bleach (Tesco Value Thin Bleach; Tesco Stores Ltd, Chestnut, UK). The available concentration of chlorine was measured for each solution by the iodine titration method. A minimum of three titration readings were made for each solution.

The frozen tissue samples were allowed to thaw to room temperature without any intervention. Each group was allocated 10 samples that were distributed equitably

TABLE 1. The Mean Concentration of Available Chlorine in Different Solutions and the Mean Initial Weight of Specimens in Each Group

Test solution	Weight (in mg) Mean	Standard deviation	Available chlorine (%)
5% $Ca(OCl)_2$	50.95	2.69	4.15
10% $Ca(OCl)_2$	50.67	2.44	4.1
Tesco Value Thin Bleach	50.41	2.12	1.36
Cholrax	50.82	1.78	4.65

across the groups to match closely the mean weight. Each sample was immersed in 5 mL allocated solution for 5 minutes. The tissue was then removed carefully, blotted dry on absorbent paper, and weighed on a precision balance (AG 245; Mettler-Toledo AG, Greifensee, Switzerland). The solution was discarded and the sample reimmersed in a fresh 5-mL aliquot of the test solution. This process was repeated at 5-minute intervals until complete dissolution of the tissue or up to 60 minutes, whichever was appropriate. The percentage differences in weights for each sample after each time interval were calculated and the mean percentage loss determined. The results were subjected to statistical analysis using one-way analysis of variance to determine if there were significant differences in weight loss among the groups at each time interval. Differences between pairs of groups were determined using the Tukey HSD test. The level of significance was set as $P < .05$.

Results

The concentrations of available chlorine are presented in Table 1. The experimental $Ca(OCl)_2$ solutions had lower levels of available chlorine than the w/v concentrations prepared. Table 2 and Figure 1 show the mean percentage weight reduction for the samples in the different tissue-dissolving solutions. The Chlorax solution dissolved tissue the quickest, with complete dissolution achieved after 45 minutes. Statistical analysis showed that there were significant differences among the groups ($P < .05$) for all times up to 35 minutes. Thereafter, there were no significant differences ($P > .05$). Analysis of the data between pairs of groups showed that after 5 minutes there was no significant difference between the Chlorax and 10% $Ca(OCl)_2$ solutions. After 10 minutes, the rates of dissolution were not significantly different between the 5% $Ca(OCl)_2$ samples and the Tesco bleach samples. Also, there was no difference between the 10% and 5% $Ca(OCl)_2$ solutions. However, there was a significant difference between Tesco bleach and 10% $Ca(OCl)_2$ at this time interval ($P = .032$). No significant differences were found between either concentration of $Ca(OCl)_2$ and Tesco bleach after 15, 20, 25, and 30 minutes although all of these dissolved significantly less tissue than Chlorax. After 35 minutes, both 5% $Ca(OCl)_2$ ($P = .019$) and Tesco bleach ($P = .034$) dissolved less tissue than Chlorax; however, all these solutions were not significantly different from the 10% $Ca(OCl)_2$ solution. Our results indicate that from 35 to 60 minutes there were no differences in the tissue-dissolution properties of the solutions.

Discussion

The dissolution of pulp tissue is an ideal requirement of an endodontic irrigant. NaOCl ionizes to liberate hypochlorous acid (HOCl) and hydroxyl ions in an aqueous environment. Saponification, amino acid neutralization, and chloramination reactions contribute to tissue dissolution with participation from hydroxyl ions in the first two reactions and HOCl in the third (28). The state of HOCl is dependent on the pH of the solution (29). At pH >8.5, hypochlorite ions (OCl^-) predominate, whereas at pH <6.5 the HOCl molecule is dominant. At pH values between 6.5 and 8.5, they are in a state of equilibrium. HOCl and OCl^- contribute to the available chlorine content of the solution although the HOCl molecule is more active. When hydroxyl ion levels decrease as a result of the saponification and amino acid neutralization reactions, the pH also decreases, thereby favoring the formation of HOCl molecules. The chloramination reaction is then initiated, which is the most important step for tissue dissolution because it results in degradation and hydrolysis of amino acids.

The synergistic effects of $Ca(OH)_2$ and NaOCl on dissolving tissue have been shown (23, 24, 26, 30). $Ca(OCl)_2$ granules partially dissolve in an aqueous solution liberating both hypochlorous acid and $Ca(OH)_2$. We undertook this pulp dissolution study to assess synergism between the ionic constituents of the $Ca(OCl)_2$ aqueous solution.

Iodometric titration was used to determine the concentration of available chlorine in the solutions, and this technique matched previous protocols (16, 24, 30, 31). We found lower levels of available chlorine in both commercial preparations tested than those advertised. Our findings for Tesco bleach (1.36%) are similar to those of Frais et al (31) (1.8%). Chlorax solution had 4.65% available chlorine concentration. The 5% and 10% (w/v) solutions of $Ca(OCl)_2$ had very similar available chlorine levels (4.15% and 4.1%, respectively). We expected that an increase in the concentration of the $Ca(OCl)_2$ solution would have resulted in higher values of titrated available chlorine. This may

TABLE 2. The Mean Percentage Reduction in Weight of Samples (with standard deviation [SD])

Time (min)	5% $Ca(OCl)_2$ Mean	5% $Ca(OCl)_2$ SD	10% $Ca(OCl)_2$ Mean	10% $Ca(OCl)_2$ SD	Tesco value thin bleach Mean	Tesco value thin bleach SD	Chlorax Mean	Chlorax SD
5	9.5[a]	3.6	17[b]	4.88	2.1	1.29	17.10[b]	6.35
10	19.4[a,b]	8.22	25.7[a]	6.62	14.2[b]	5.47	38.70	13.29
15	29.1[a]	12.05	38.7[a]	8.73	31.2[a]	9.27	60.90	17.21
20	43.5[a]	15.27	53.3[a]	10.76	45.8[a]	11.75	79.20	14.64
25	55.60[a]	16.52	68.4[a]	13.99	57.9[a]	15.24	90.90	7.84
30	71.40[a]	14.66	78.7[a]	16.57	71.1[a]	15.57	97.30	3.09
35	72.90[a]	17.45	80.3[a,b]	26.82	75[a]	21.11	99.5[b]	1.08
40	88.80[a]	11.74	92.40[a]	11.65	90[a]	14.33	99.90[a]	0.32
45	93.80[a]	7.57	96.40[a]	8.48	94.6[a]	12.29	100[a]	
50	97.20[a]	4.57	98.30[a]	5.38	95.6[a]	12.88	100[a]	
55	98.80[a]	2.53	99.5[a]	1.58	100[a]		100[a]	
60	99.40[a]	1.58	100[a]		100[a]		100[a]	

The same letters in each row indicate no significant difference, $P < .05$.