

Solvent Action of Sodium Hypochlorite on Bovine Pulp and Physico-Chemical Properties of Resulting Liquid

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The solvent effect of 4 concentrations of sodium hypochlorite (0.5, 1.0, 2.5, and 5.0%) on bovine pulp tissue and the level of residual chlorine, pH and surface tension before and after dissolution were studied *in vitro*. A fragment of bovine pulp was submersed in sodium hypochlorite that circulated in an apparatus with a peristaltic pump and Luer Lok syringe. The higher the concentration of sodium hypochlorite the faster the dissolution of the pulp tissue. All concentrations of sodium hypochlorite reduced the pH and the surface tension and the higher concentrations of the solution had the least consumption of chlorine during tissue dissolution. Thus this study indicated that residual chlorine was directly proportional to concentration in the process of pulp tissue dissolution and that there was residual chlorine at all concentrations used.

Key words: sodium hypochlorite, bovine pulp, solvent action.

INTRODUCTION

Sodium hypochlorite has proven to be an excellent solution for the chemical-biomechanical preparation of root canals. One of its most important characteristics, the capability of tissue dissolution (1-5), has been studied by numerous researchers (2-12). However, there is little reported in scientific literature on the mechanism of action of sodium hypochlorite on organic material and the physico-chemical properties of this solution after dissolution of organic tissue as well as the effect of pH on tissue dissolution.

The objective of this investigation was to study, *in vitro*, the effect of four concentrations of sodium hypochlorite on the rate of bovine pulp tissue dissolution at environmental temperature and evaluate the level of residual chlorine, pH and surface tension after dissolution.

MATERIAL AND METHODS

Four concentrations of sodium hypochlorite (0.5, 1.0, 2.5, and 5.0%) were prepared from a 10% solution and stored in amber glass flasks at 9°C for three days. The solutions were removed from the refrigerator to reach room temperature before use.

Central incisors were removed from bovine mandibles and stored in cool saline for 2 h. The crowns were fractured, and the pulp was removed manually from the root canal surface with a #10 K file (Maillefer, Ballaigues, Switzerland), wrapped in plastic and frozen for 2 days. The pulp was subsequently thawed at room temperature and a 10-mm long fragment of the central portion was removed by transverse cuts with a scalpel. Each fragment was weighed on a precision scale (MLW, Bonn, Germany).

For the evaluation of dissolution, a urethane

hose was connected to the needle end of a Luer Lok glass syringe (B-D Yale, São Paulo, SP, Brazil) and to the entrance of a peristaltic pump. The exit of the pump was connected to another segment of urethane hose that was placed at the other end of the syringe. A nylon net with the pulp fragment was placed inside the syringe and 15 ml of sodium hypochlorite circulated at a constant flow of 64 ml/min. The time required for the dissolution of the pulp fragment was confirmed by 16X magnification and recorded.

Evaluation of the residual chlorine was done by titration. pH was evaluated with a Digimed meter and surface tension was analyzed with a tensiometer (Fisher Scientific, Pittsburgh, PA, USA) before and after each test of pulp tissue dissolution which was repeated 5 times for each solution at 65 ± 5% humidity and 22 ± 2°C.

The Kruskal-Wallis test and the regression/correlation test were used for statistical analysis with p<0.01 for the hypothesis of equality (H₀).

RESULTS

Table 1 shows the means of the dissolution of bovine pulp tissue, the level of residual chlorine, the pH and the surface tension before and after dissolution. The speed of pulp dissolution was obtained with the equation $v = m/t$, where v is the velocity of dissolution measured in mg/s, m is the fragment mass in mg, and t is the time of total dissolution of the pulp fragment in seconds. There was a statistically significant difference

Table 1. Results of tests of dissolution velocity, residual chlorine, pH and surface tension with 4 concentrations of sodium hypochlorite.

Physico-chemical properties	Concentration			
	0.5%	1.0%	2.5%	5.0%
Velocity of dissolution (mg.s ⁻¹)	0.02	0.03	0.06	0.11
Residual chlorine (%)	64.89	76.75	86.74	86.92
pH				
Before	12.0	12.2	12.6	13.0
After	9.6	10.5	12.4	12.9
Surface tension (dynes.cm ⁻¹)				
Before	73.4	74.6	76.0	77.3
After	63.5	60.5	48.6	39.2

at 1% among all multiple comparisons (Kruskal-Wallis) and the regression/correlation test showed a directly proportional relation between solution concentration and speed of dissolution.

For the evaluation of residual chlorine, the concentration of chlorine before dissolution was compared to that after dissolution by the equation $Cl_r = (Cl_a \times 100)/Cl_b$, where Cl_r is the residual chlorine, Cl_a is the chlorine concentration after pulp tissue dissolution and Cl_b is the chlorine concentration before dissolution. There was a statistically significant difference at 1% for all multiple comparisons. The regression/correlation test showed a directly proportional relation between sodium hypochlorite concentration and residual chlorine.

The regression/correlation test showed an inversely proportional relation between sodium hypochlorite concentration and the reduction in pH and a directly proportional relation between the concentration and the reduction of surface tension.

DISCUSSION

Sodium hypochlorite is found in aqueous solution dissociated into sodium hydroxide and hypochloric acid and is represented by the following chemical reaction: $NaOCl + H_2O \leftrightarrow NaOH + HOCl$. When sodium hypochlorite comes in contact with organic material, several chemical reactions take place, i.e. fatty acids react with sodium hydroxide creating soap and glycerol (saponification reaction), amino acids react with sodium hydroxide creating salt and water (neutralization reaction) and also react with hypochlorous acid creating chloramine and water. These reactions occur simultaneously and synergistically leading to liquefaction of organic tissue.

In agreement with other researchers, the present experiment showed that the greater the concentration of sodium hypochlorite, the more rapid was the organic tissue dissolution (4,6-10).

All solutions were strongly alkaline and after pulp dissolution, the pH decreased. This is due to the interaction of NaOH with organic material by the reactions of saponification and neutralization. It was also noted that with a greater initial concentration, there was less of a reduction of pH in the resulting solution, which is due to more hydroxyl ions in solutions of greater concentration.

With a higher initial concentration there was a greater reduction of surface tension of the final solution. This probably occurred due to the larger quantity of sodium hydroxide that reacted with fatty acids producing soap, which reduces surface tension.

The consumption of active chlorine was greater at lower concentrations of sodium hypochlorite. This indicates that there is a greater interaction of HOCl with organic material producing chloramines which is in agreement with the surface tension results that showed a greater interaction of sodium hydroxide with organic material at higher concentrations.

In an attempt to elucidate the mechanism of action of the sodium hypochlorite solutions on organic material, two experiments were carried out using the same method as used for the dissolution test. The velocity of tissue dissolution of 4 hypochlorite solutions: 0.5% sodium hypochlorite with a pH of 11.6 and with a pH of 9, and 0.36% sodium hypochlorite with a pH of 11.6 and with a pH of 7.0. The reduction of pH was accomplished with the addition of boric acid. The velocity of dissolution by 0.5% sodium hypochlorite with a pH of 9 was 0.007 mg/s, of 0.5% sodium hypochlorite with a pH of 11.6 was 0.014 mg/s, of 0.36% sodium hypochlorite with a pH of 7.0 was 0.003 mg/s, and of 0.36% sodium hypochlorite with a pH of 11.6 was 0.010 mg/s. The reduction of pH and consequently the change of the dynamic chemical equilibrium with the formation of hypochlorous acid decreased the velocity of tissue dissolution. This is due to the neutralization reaction between boric acid and sodium hydroxide that decreases the saponification and neutralization reactions.

In the second experiment, 15% aqueous NaOH was used to test pulp tissue dissolution. After 6 h, NaOH did not totally dissolve the pulp tissue although there were chromatic changes and an alteration in consistency. This indicates that pulp tissue dissolution is due to the combined synergistic effect between sodium hydroxide and hypochlorous acid, present in sodium hypochlorite. Each component reacts with certain components of the pulp.

Applying the results of this investigation to clinical use, we conclude that at all concentrations studied, there was dissolution of pulp tissue and residual chlorine. Thus, the clinician could use a concentration in function of instrumentation time of necrosed root canals. For long instrumentation times, the clinician could

use less concentrated solutions and in cases with more rapid instrumentation techniques (rotary), more concentrated solutions may be chosen provided there is no extrusion at the periapex.

RESUMO

Spanó JCE, Barbin EL, Santos TC, Guimarães LF, Pécora JD. Ação solvente da solução de hipoclorito de sódio sobre o tecido pulpar bovino e as propriedades físico-química do líquido resultante. *Braz Dent J* 2001;12(3):154-157.

Estudou-se, *in vitro*, a ação solvente de quatro concentrações da solução de hipoclorito de sódio (0,5, 1,0, 2,5 e 5,0%) sobre o tecido pulpar bovino, o teor de cloro residual, pH e a tensão superficial antes e após a dissolução. Um fragmento do tecido pulpar bovino era submerso na solução de hipoclorito de sódio que circulava em um aparato composto de uma bomba peristáltica e uma seringa Luer Lok e anotava-se o tempo até a total dissolução deste fragmento. De acordo com a metodologia empregada e com os resultados obtidos concluiu-se que: quanto maior a concentração da solução de hipoclorito de sódio maior a velocidade de dissolução do tecido pulpar, todas as soluções de hipoclorito de sódio apresentaram redução do pH e da tensão superficial após os testes de dissolução e as soluções de maior concentração apresentaram menor consumo de cloro para a realização da dissolução tecidual.

Unitermos: hipoclorito de sódio, polpa bovina, ação solvente.

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