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ORIGINAL ARTICLE

An Evaluation of the Effect of Different Vehicles on Changes in the pH of Calcium Hydroxide

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ABSTRACT

Background Knowledge: Calcium hydroxide with a pH of almost 12.5 is a strong alkaline substance. In an aqueous solution, dissolution of calcium hydroxide occurs into calcium and hydroxyl ions. Its biological properties include antimicrobial activity, inhibiting resorption of tooth and inducing of repair by formation of hard tissue. Hence it is widely used in several clinical situations.

The capacity of calcium hydroxide to produce an alkaline shift in pH is responsible for its antimicrobial effect. This property will be affected when it is combined with other substances/vehicles like 2% chlorhexidine, sodium hypochlorite etc, which makes the action last longer.

Therefore this study was conducted to determine the changes in pH of five different types of calcium hydroxide based intracanal medicaments.

Materials and methods: This study assesses the changes in pH when calcium hydroxide is mixed with different vehicles like 2% chlorhexidine, sodium hypochlorite, povidone iodine and also commercially available RC Cal (premixed) and Metapex. It is an *in vitro* study with time intervals of 24 hours, 48 hours and 1 week.

Results and conclusion: Within the limitations of the study, it is found that calcium hydroxide when mixed with distilled water has given the best results.

Keywords: Alkaline, Calcium hydroxide, Distilled water, pH.

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INTRODUCTION

Pulpal and periradicular infections of the teeth can be controlled and prevented by endodontic therapy. It aims at the reduction or elimination of microorganisms. Root canal disinfection can be achieved by chemomechanical preparation, but the elimination of bacteria completely from the root canal is difficult and can be accomplished to a greater extent with the placement of intracanal medicaments.

Calcium hydroxide is the most widely used intracanal medicament since its introduction by Hermann in 1920. It has an antibacterial effect, dissolves necrotic tissue and induces mineralized tissue.[1] Resorption induced by orthodontic movement[2] or by trauma[3] is also inhibited by calcium hydroxide.

The high pH of $Ca(OH)_2$ is responsible for its antimicrobial action which depends on the release and diffusion of hydroxyl ions (OH).[4,5] Antimicrobial action is promoted by these ions through diffusion into dentinal tubules.[6]

Its water solubility is low [(around 1.2 g L)[1] at 25°C, which decreases with a rise in temperature (Siqueira and Lopes).[7] The dissociation coefficient of $Ca(OH)^2$ (0.17) (Rehman et al.).[8] controls the slow release of calcium and hydroxyl ions. The highly alkaline environment produced by calcium hydroxide makes it difficult for most of the endodontic flora to survive.[9]

Hydroxyl ions released into an aqueous environment is responsible for the antimicrobial property of calcium hydroxide.[7,10,11] These ions are highly oxidant free radicals which show extreme reactivity with several biomolecules.

The aim of this study was to determine the pH changes of five different calcium hydroxide-based intracanal medicaments.

MATERIALS AND METHODS

Twenty freshly extracted human singe rooted in permanent teeth with intact apices were selected for the study. Their canals were cleaned and shaped to a minimum of size 60. They were divided into five experimental groups.

- *Experimental group:* 1.5 to 2 mm of the apical segment of these 20 cleaned and shaped teeth were removed with a carborundum disc running at slow speed under water spray, and the apical opening enlarged using the largest file used in cleaning and shaping the root canal. This group was subdivided into five groups of 4 teeth each.
- *Subgroup 1:* Teeth were obturated with commercially available RC Cal

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- *Subgroup 2:* Teeth were obturated with 100 mg pure calcium hydroxide and 0.12 mL 2% chlorhexidine solution
- *Subgroup 3:* Teeth were obturated with 100 mg pure calcium hydroxide and 0.12 mL povidone-iodine (10%)
- *Subgroup 4:* Teeth were obturated with 100 mg pure calcium hydroxide and 0.12 mL NaoCl solution (5.25%)
- *Subgroup 5:* Teeth were obturated with 100 mg pure calcium hydroxide and 0.12 mL distilled water

The coronal access of all 20 teeth was sealed with composite and nail varnish (2 coats) was applied along the entire surface of the tooth, except for the apical foramen. Each tooth was placed in a glass bottle, with a screw on cap, containing 20 mL of normal saline whose baseline pH had been established earlier using a digital pH meter.

pH ANALYSIS

A calibrated pH meter (Table-top, Digital, Analog; Accuracy 0.02%, pH range: 0–14, Display 3.1/2 digit) was used to measure the pH. The pH of a known solution was tested before the procedure to confirm the accuracy of the machine, following which 5 mL of saline from each bottle of the six groups were pipetted out separately into beakers and the electrode was dipped into the same. The readings on the indicating meter were noted. For each group, the samples were analyzed after 24 hours (Graph 1), 48 hours (Graph 2), and 1 week (Graph 3).

Statistical Analysis

The mean pH+/− standard deviation was determined for each of the above groups and statistical analysis carried out applying Kruskal–Wallis test and post-hoc test.

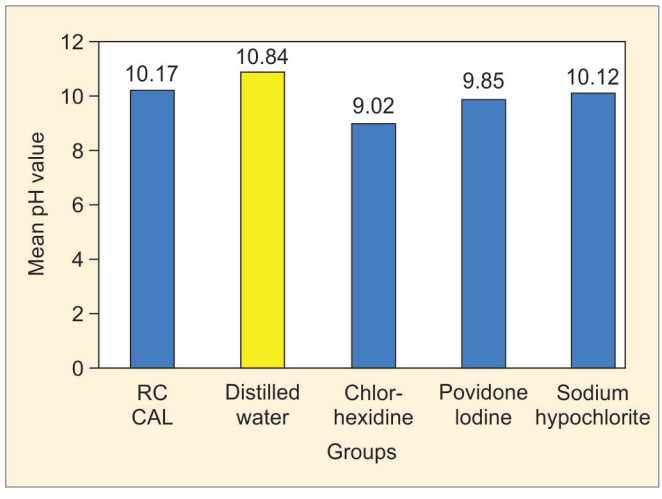
RESULTS

The pH of the samples increased gradually and reached maximum values at 1 week, but calcium hydroxide powder with distilled water as the vehicle was able to achieve maximum value after 48 hours. pH and time showed a positive correlation for all materials. The maximum value was for calcium hydroxide powder with distilled water as vehicle and minimum for calcium hydroxide powder mixed with chlorhexidine. The results were statistically significant ($p < 0.01$).

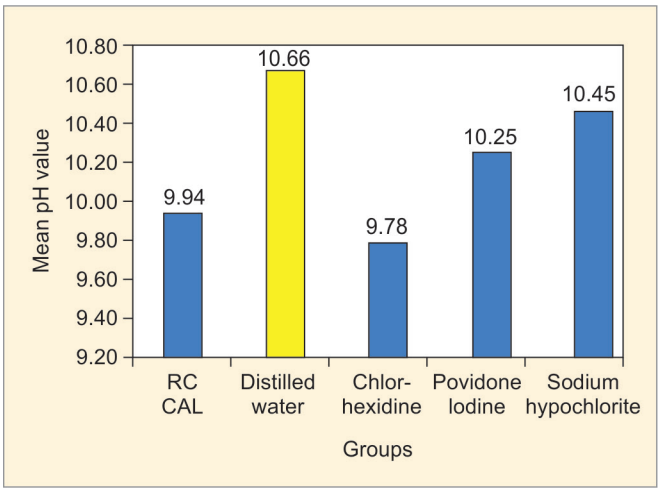
DISCUSSION

In endodontics, many treatment modalities require antimicrobial formulations that have calcium hydroxide as the main ingredient like intracanal medicaments used between appointments, pulp capping agents and root canal sealers.

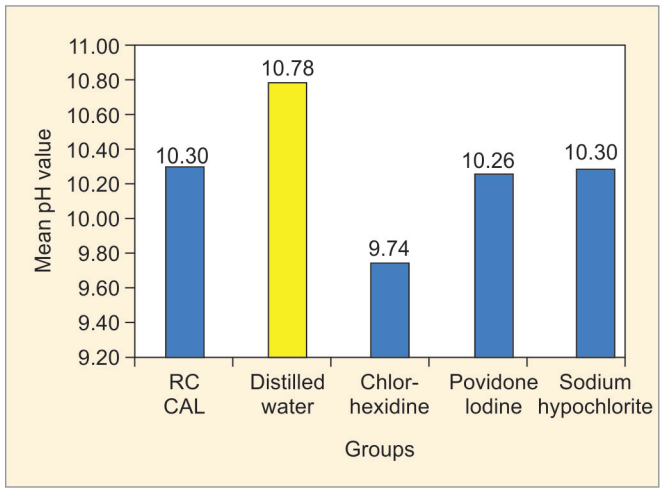
Hydroxyl ions show antibacterial activity as a potent alkaline medium is formed which leads to the destruction of lipids. Lipids are the main component of the bacterial cell membrane, so this, in turn, causes structural damage to bacterial proteins and nucleic acids.[12]



Graph 2: Comparison of pH values between groups in 48 hours



Graph 1: Comparison of pH values between groups in 24 hours



Graph 3: Comparison of pH values between groups in 1 week

Elevated pH of calcium hydroxide activates alkaline phosphatase and the ideal pH range for the activation to occur is 8.6 to 10.3.[13] Inorganic phosphate is liberated from the esters of phosphate on the action of alkaline phosphatase which is a hydrolytic enzyme. Alkaline phosphatase is thought to be associated with the process of mineralization. The mechanism is by separation of phosphoric esters which frees the phosphate ions that, once free, starts reacting with calcium ions from the bloodstream to form a precipitate, calcium phosphate, in the organic matrix. This precipitate is the molecular unit of hydroxyapatite.[14]

In this study, all samples showed gradually increasing pH of all with time, reaching the highest values after one week. Zmener et al.[15] conducted a study to test the changes in pH that happened throughout 30 days using a mixture of calcium hydroxide and distilled water and two commercially available calcium hydroxide products in a simulated periapical environment. The result showed a sudden increase in the pH at 1 hour and 24 hours, followed by a continuous but more gradual increase after 1 week. Enzyme activities that sustain the bacterial life are inhibited by the high pH of calcium hydroxide which was reported by Estrela et al.[14]

Calcium hydroxide powder is mixed with several agents to improve its antibacterial properties. These vehicles determine the velocity of ionic dissociation, thus solubilizing the paste and resorbing it at different rates by the surrounding periapical tissues and also from within the root canal. An ideal vehicle should produce a gradual and slow release of calcium and hydroxide ions. They could be aqueous and oily.

Larsen and Bindslev found that the highest pH and calcium ion liberation was shown by an aqueous suspension. Oily pastes with calcium hydroxide have low solubility and poor diffusability[16] making it difficult to reach maximum pH levels in a short period. The result of our *in vitro* study shows that to achieve maximum therapeutic effectiveness, they should be used for a minimum of 7 days.

From the study, it is seen that there is only a small difference in the pH of hypochlorite based calcium hydroxide than with distilled water.

Taking into consideration the irritating potential of hypochlorite to soft tissues, distilled water is a safer vehicle.

CONCLUSION

In conclusion, based on the results of this *in vitro* study, th e experimental group where calcium hydroxide powder with distilled water as the vehicle has shown to exhibit high pH immediately and also within a time span of one week when compared to the rest of the groups.

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