Assessment of Calcium Hydroxide Pastes to Maintain Alkalinity in Combination with Different Vehicles

Alvin Saju[1], Payalben Kansara[2], Arjun Kini[3], Raksha Bhat[4], Preethesh Shetty[4], Prajwal Shetty[5], Shehin Abootty[6], Anush Bekal[7], Bapanaiah Penugonda[8]

1. New York University College of Dentistry, Clinic 5AB, New York.
2. New York University College of Dentistry 345 East, 24th Street, Clinic 5AB, New York.
3. New York University College of Dentistry, Clinic 7W Comprehensive Dentistry, New York.
4. Nitte (Deemed to be University), AB Shetty Memorial Institute of Dental Sciences(ABSMIDS), Department of Conservative Dentistry and Endodontics, Mangalore, India.
5. Department of Conservative Dentistry and Endodontics, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India.
6. Department of Conservative Dentistry and Endodontics, Kannur Dental College, Anjarakandy, Kerala University of Health Sciences, Kerala.
7. Department of Electronics and Communication Engineering, Sahayadri College of Engineering and Management, Mangalore.
8. Clinic 5 AB Group B, New York University College of Dentistry, 345 East, 24th Street, Clinic 5AB, New York.

Abstract

Antimicrobial action of calcium hydroxide relies on maintenance of high pH over a period of time. The present study aimed to evaluate the ability of calcium hydroxide to retain alkalinity over extended periods in combination with different vehicles.

Two grams of calcium hydroxide powder was mixed with three vehicles; Group 1: Distilled water, pH-7.9, Group 2: Lidocaine, pH-4.7, Group 3: Alkaline water, pH-11.8. The pH of pastes was measured utilizing the Ex-Stik pH meter to observe decay over 28 days. Testing was done over five intervals: Day 1, 7, 14, 21, 28. The pH meter was thoroughly washed with deionized water and wiped dry between readings. Measurements were repeated three times for each specimen, and mean values were calculated. All samples were stored in closed vials in 37°C incubation to eliminate temperature variations until the time of measurement. Statistical evaluations of results were performed with Students t-test.

Results demonstrated a statistically significant difference, with pH being greater in Group 3 at all times, even at 28 days, maintaining an average pH of 12.20.

Calcium hydroxide powder, when mixed with alkaline water, helps maintain an alkaline pH, enhancing disinfection and preventing postoperative flare-ups.

Experimental article (J Int Dent Med Res 2021; 14(3): 929-932)

Keywords: Calcium Hydroxide, pH, endodontics, tooth.

Received date: 03 July 2021. **Accept date:** 04 August 2021

Introduction

The main goal of root canal treatment of infected teeth is to sterilize the root canal system. Nevertheless, this is not possible only with mechanical instrumentation of the canal system and irrigating with different types of irrigation solutions, so the synergistic action of intra canal medicaments is required[1]. Calcium hydroxide medicament pastes are used widely in endodontics as the hydroxyl ion release exerts a broad spectrum antimicrobial activity against most pathogens found in the root canal system[2]. The hydroxyl ions integrates into the biofilms, restraining the inflammatory actions of endotoxins and other molecules, assisting to dissolve necrotic tissues[3].

The calcium hydroxide powder can be mixed with different vehicles, which are water based and oil based. These vehicles includes normal saline, distilled water, camphorated monochlorophenol, cresatin, propylene glycol and glycerin. The dissociation of calcium hydroxide into OH− and Ca2+ ions depends on the vehicle used to prepare the paste. The vehicles should provide measured, constant and provide efficient dissociation of hydroxyl ions for better action of calcium hydroxide[4,5]. Gomes et al. have dem-

Corresponding author:
Raksha Bhat, Lecturer
Nitte (Deemed to be University)
AB Shetty Memorial Institute Of Dental Sciences(ABSMIDS)
Department of Conservative Dentistry and Endodontics, Mangalore.
E-mail ID: drrakshabhat@nitte.edu.in

onstrated that the release of hydroxyl ions were influenced by type of vehicles used[6]. Some studies measured pH of calcium hydroxide pastes and hydroxyl ions diffusion by using pH indicating papers or solutions, pH measurement of immersion media and pH value measurement of ground dentin[7].

For successful antimicrobial activity, hydroxyl ions must be released from calcium hydroxide[8,9]. There must be a release of adequate amount of hydroxyl ions, thereby activating alkaline phosphatase to repress the buffering effects of the dentin, providing a sufficiently alkaline pH environment continuously maintained within the closed root canal system[10,11]. Flahaut et al. described that common pathogenic organism in the root canal system, Enterococcus faecalis can withstand an environment with a pH of 10 but is deactivated at 11.5 to 11.9 pH value[12].

Increasing the duration of alkaline environment thereby upraising the alkalinity can be effective means to reduce the cultivation of microbes and reduce postoperative discomfort, hence enhancing the long-term success of root canal treatment[13].

There is a need to examine the pH of calcium hydroxide mixed with alkaline water for up to 30 days. The present study evaluates the pH of calcium hydroxide when mixed with distilled water, lidocaine and alkaline water at the interval of 7, 14, 21 and 28 days. The present study hypothesizes that there was no difference in pH value between calcium hydroxide pastes mixed with three different vehicles.

Materials and methods

Calcium hydroxide powder (Spectrum chemical, USA) was mixed with various solvents and divided into three experimental groups.

Group 1: 2 grams of calcium hydroxide powder was mixed with distilled water, Milli Q water- Double Deionized water passed through a second ion exchanger (pH 7.9) to a viscous consistency.

Group 2: 2 grams of calcium hydroxide powder was mixed with lidocaine, lidocaine with adrenaline 1; 100000 (pH- 4.7) to a viscous consistency.

Group 3: 2 grams of calcium hydroxide powder was mixed with alkaline water, pHenomenal alkaline water concentrate, pHenomenal water, USA, (pH-11.8) to a viscous consistency.

The pH of the paste was measured utilizing the Ex-Stik pH meter (Ex Tech, USA) to observe the decay over a period of 28 days. Testing was done over five intervals: Day 1, 7, 14, 21, 28. Prior to testing the solutions, the pH meter was calibrated with Fischer buffer solutions of pH 4, 7, and 10. The pH meter was thoroughly washed with deionized water and wiped dry between readings. Measurements were repeated three times for each specimen, and the mean values were calculated.

All samples were stored in closed vials in a 37°C incubator to eliminate environmental variables, such as temperature variations, until the time of measurement. Alkaline water, Milli Q water were stored in a cool dark environment. Statistical evaluations of the results were performed with the Students t-test.

Results

The trend of the pH reveals how the solvents had steadily declined over 28 days, from 11.89 to 11.81 for alkaline water, 7.09 to 6.78 for distilled water, and 4.72 to 4.64 for lidocaine. The pH of the calcium hydroxide pastes over 28 days was shown to decrease from 12.85 to 12.22 with alkaline water, 12.09 to 11.97 with distilled water, and 12.01 to 11.71 with lidocaine. Over the interval, samples had shown fluctuation in their pH values. This mostly occurred around day 7 or 14 of the study. When comparing the sets of data, a t-test was used that assumed equal variances. The t value when comparing alkaline water to distilled water was ~2.15 with 8 degrees of freedom, indicating the P (one tail) to be ~.03. The t value when comparing alkaline water to lidocaine was ~3.87 with 8 degrees of freedom, indicating the P (one tail) to be ~.002. Both of these results reject the null hypothesis for their respective comparisons, indicating that the difference with alkaline water was statistically significant.

	Day 1	Day 7	Day 14	Day 21	Day 28
Distilled water	7.09	7.85	7.45	6.63	6.78
Lidocaine	4.72	4.96	4.73	4.67	4.64
Alkaline water	11.89	11.74	11.78	11.71	11.81

Table 1. Mean of pH changes and differences among different vehicles.

	Day 1	Day 7	Day 14	Day 21	Day 28
Distilled water	12.09	12.16	12.07	12.01	11.97
Lidocaine	12.01	11.87	11.87	11.96	11.71
Alkaline water	12.85	12.55	12.66	12.58	12.22

Table 2. Mean of pH changes and differences among calcium hydroxide mixtures with different vehicles.

Discussion

Calcium hydroxide paste provides a high alkaline ambient environment over the long duration, restricting infections and slowing down apical inflammation. It is extensively utilized in endodontics as it releases hydroxyl ions rendering a broad spectrum of antimicrobial activity against most microbes found in the root canal pathologies. These hydroxyl ions act by diffusing through the dentin and penetrating the biofilms, providing an anti-inflammatory effect of endotoxins and dissolving the organic tissues[13,14]. This effect is directly proportional to the pH of the paste. The higher the pH over a longer period, the higher the bacterial inactivation[15].

The hydroxyl ions which are released by calcium hydroxide determine the antibacterial activity of the paste. The OH – are highly oxidant free radicals and highly reactive. This reactivity is nonselective, so these radicals mostly stay at the site of generation. The antibacterial effect of the radicals is due to leakage of the biological membrane of microorganisms and the destruction of bacterial DNAs. The hydroxyl ions possess antimicrobial effects. However, the elevated pH over more extended periods is a must to be maintained to destroy pathogenic bacteria and achieve complete disinfection of the root canal system[16,17].

To eliminate environmental factors until the time of measurement and to mimic the oral environment, all samples were stored in closed vials in an incubator at 37°C. In addition, this procedure helped the standardization of the method. In the previous studies, authors used different methods to measured pH includes flame photometry, fluorimeter and ultraviolet spectrophotometer[18]. In the present study, a digital pH meter like Pacios et al. was used because of its cost benefits and availability[19].

Calcium hydroxide cannot maintain its efficiency in root canal disinfection for a more extended period of time due to its physicochemical properties. Nevertheless, calcium hydroxide has to be present in a highly efficient state for several weeks in the conditions like root resorption, failed root canal treatment, periapical abscess. Abbott states that the intra-canal medicament can remain in the canal for 6-12 months, being replaced every three months[19]. Chamberlain suggests that one has to replace calcium hydroxide pastes over two to three weeks because, after that, the pH decreases gradually. In accordance with this knowledge, it was decided that, for planning the study design, the maximum evaluation time would be 28 days[20]. The type of vehicles used was divided into three categories: aqueous, polar and oily. Aqueous solutions are preferred as vehicles because of the fast and more extended-release of hydroxyl ions. In the present study, the use of distilled water, anaesthetic solution and alkaline water confirmed this. Pacios et al. evaluated the pH of calcium hydroxide pastes mixed with different vehicles over five-time intervals up to 21 days and stated no significant difference in the pH at different time intervals[19]. In this study, all paste formulations were water-soluble. Furthermore, it has been proved that paste formulation of calcium hydroxide was highly effective as it sustained in the root canal for a more extended period and delayed recontamination.

As described by Kranz et al., there must be a pH value of 11.5 because only at a pH value of 11.5, Enterococcus faecalis was inactivated. In their experiment, initially, the E. faecalis were survived at 11.1 pH, but after 30 minutes of exposure to the same pH value, some cells (0.4%) were survived[10]. However, at pH 11.5, less than 0.01% of cells survived. The present study confirms that paste with alkaline water as a vehicle were able to maintain a pH value of 12 over 28 days, thus highly efficient in disinfection of root canal system.

The anaesthetic solution has a different chemical composition, configurations and pH. Anaesthetic solutions with or without adrenaline can be used as a vehicle. In the present study, lidocaine was used with 1; 100000 adrenaline because it is readily available in the clinics. However, being an acidic solution, it was unable to maintain constant effective pH over 28 days.

The alkalinity of alkaline water on pH scale is 11.5. The notion for using alkaline water as a vehicle was its ability to maintain constant

pH over 28 days. This alkaline water is a regular water H2O (two hydrogens, one oxygen) that is missing one hydrogen. After mixing with calcium hydroxide powder, it binds with free hydrogen molecules responsible for the production of acid and maintains alkalinity over a longer period of time.

The difference between the present study and the previous one could be attributed to the experimental condition, measuring time, and composition of Ca(OH)2 mixtures and immersion solutions[21-23].

Conclusions

Although the pH of the samples had a steady decline over the period of 28 days, the calcium hydroxide paste mixed with alkaline water demonstrated a greater capability in maintaining an alkaline environment for a longer period, indicating its pronounced ability in acting as an intracanal medicament in comparison to other solvents. It might be better to use calcium hydroxide powder mixed with alkaline water when high pH is required for better disinfection and prevent postoperative flare-up.

Declaration of Interest

The authors report no conflict of interest.

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