Comparison of changes in the pH of calcium hydroxide pastes associated with different vehicles

Lucas Felipe Moreira da **CUNHA**[1]
Igor Fernando Ribeiro **EHLERS**[1]
Sérgio Henrique Staut **BRUNINI**[2]

ABSTRACT

Introduction: The antimicrobial effect of calcium hydroxide has been assigned to its capacity to produce an alkaline shift in pH. This property is affected when calcium hydroxide is combined with other substances, such as 2% chlorhexidine gel and zinc oxide, which makes the action of the paste last longer. **Objective:** This study assessed whether calcium hydroxide paste associated with chlorhexidine gel and zinc oxide promote pH shifts at short time intervals. **Methods:** Calcium hydroxide pastes prepared with three vehicles: saline solution (paste A); propylene glycol (paste B); and 2% zinc oxide chlorhexidine gel (paste C) were placed into vials containing 15 ml of deionized water. A pH meter was used to detect pH shifts of combinations in different vehicles at seven time intervals: 15 and 30 minutes; 1, 24 and 48 hours; as well as 7 and 14 days. **Results:** All three pastes presented a sharp increase of pH values at the first time interval and remained relatively stable at a value of about 12 from 24 hours to 7 days. After this period, the pH of pastes A and B decreased to 9.50, whereas that of paste C remained at 12. **Conclusions:** Pastes A and B produced a faster alkaline shift of the solution, whereas paste C kept an elevated pH for a longer time, however, differences were not statistically significant.

Keywords: Calcium hydroxide. Intracanal dressing. Endodontics.

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[1]Degree in Dentistry, Paranaense University (UNIPAR).
[2]Adjunct professor, UNIPAR.

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Contact address: Sérgio Henrique Staut Brunini
Rua Bartira, 2745 – Jardim São Marcos – Umuarama/PR — Brazil
CEP:87.501-440 – Email: brunini@unipar.br

Introduction

Numerous studies in the literature report that some pathologies cannot be reversed even after endodontic treatment is performed. Such clinical condition may be associated with the persistence of microorganisms inside or outside the root system, in which case some substances are necessary not only to complement the disinfection started by cleaning and shaping procedures, but also to reduce endodontic microbiota by creating conditions that are unfavorable for the development of bacteria and favorable for the repair of periapical tissues.[1,2]

Calcium hydroxide is among the substances recommended for intracanal dressings. It is considered an effective substance because it induces hard tissue formation, produces intratubular barriers, presents good antibacterial and anti-inflammatory properties as well as a capacity to dissolve tissues,[3] act upon lipopolysaccharides and absorb CO_2.[4]

Calcium hydroxide has two fundamental properties: inhibition of enzymes that are essential for bacterial survival, which explains its antimicrobial activity; and activation of tissue enzymes, such as alkaline phosphatase, which promote mineralization.[5]

When dissolved in water, calcium hydroxide is dissociated into hydroxyl ions and calcium ions, being the former responsible for the alkaline shift of the solution. High pH values are probably responsible for the antimicrobial activity of calcium hydroxide paste, and this is the reason why calcium hydroxide paste depends on the concentration of hydroxyl ions in the solution. Therefore, the slower the dissociation of the paste, the longer the concentration of hydroxyl ions will remain constant in the solution, and the antimicrobial action inside the canal will last longer.[6]

The release of hydroxyl ions from the calcium hydroxide paste is essential for bacterial control. For this reason, the vehicle used in association with it should accelerate ion dissociation and keep pH values at high levels during long periods of activity.[5]

In certain clinical conditions, such as treatment of root resorption, trauma and incomplete root formation, calcium hydroxide paste should be kept in the root canal for a longer period of time and be replaced at regular intervals, so as to remain active.

Recent studies have found that a paste combining 2% chlorhexidine gel, calcium hydroxide and zinc oxide does not require replacements at regular intervals. Its antimicrobial characteristics include the capacity to keep pH values at an alkaline level, rapid diffusion in root dentin and consequent inhibition of bacterial growth on external root surfaces.[7]

This study aimed at assessing whether a calcium hydroxide paste in chlorhexidine gel and zinc oxide promotes changes in pH at short time intervals, reaching and sustaining ideal pH values over time in comparison with other combinations described in the literature.

Material and Methods

Three calcium hydroxide-based pastes (Biodinâmica, Ibiporã, Brazil) were prepared with three different vehicles:

- Paste A – calcium hydroxide with saline solution.
- Paste B – calcium hydroxide with propylene glycol (*Fórmula Exata* Compounding Pharmacy, Campo Mourão, Brazil).
- Paste C – calcium hydroxide with 2% chlorhexidine gel(Biodinâmica, Ibiporã, Brazil) and zinc oxide (Biodinâmica, Ibiporã, Brazil).

The pastes were prepared using a measuring spoon to standardize the amount of calcium hydroxide in each preparation. For pastes A and B, the vehicle was added so as to obtain a tooth paste consistency. As for paste C, calcium hydroxide, chlorhexidine gel and zinc oxide were combined in a 2:1:2 ratio so as to obtain a putty consistency.

After the materials had been combined, the pastes were stored in 5-mm-high plastic rings made from anesthetic cartridges. The samples were placed in 15 ml of deionized water previously stabilized at pH 7 for the analysis of ion dissociation at the following time intervals: 15 and 30 minutes; 1, 24 and 48 hours; 7 and 14 days. Measurements were taken by means of a pH meter calibrated with buffer solutions standardized at pH 7 and pH 4. The values were recorded for ANOVA statistical analysis.

Results

The pH values of the calcium hydroxide pastes in different vehicles are shown in Table 1.

The pH values of each paste under analysis were different from each other and between time intervals. All three pastes presented a sharp increase of

Table 1. Values of pH for the calcium hydroxide pastes in different vehicles.

	15 minutes	30 minutes	1 hour	24 hours	48 hours	7 day	14 days
Paste A	10.70	10.98	11.19	12.13	12.40	12.39	9.55
Paste B	9.60	10.20	11.68	12.14	12.80	11.60	9.65
Paste C	10.20	10.30	10.67	11.66	12.90	12.10	11.99

pH values at the first time interval and remained relatively stable at a value of about 12 from 24 hours to 7 days. After that, the pH values of pastes A and B decreased to 9.50, whereas the pH values of paste C remained at 12, thus demonstrating its efficacy as an intracanal dressing that lasts longer. The differences between the pH values of the calcium hydroxide pastes were not statistically significant.

Discussion

One of the etiological factors behind the need for endodontic treatment is the presence of microorganisms in the root canals. Cleaning and shaping, aided by the use of chemicals with antimicrobial properties, should remove microorganisms and their products. However, microorganisms may remain viable in inaccessible areas and may induce and perpetuate inflammation, thus hindering repair. In these cases, treatment success depends on the elimination of infection, in which case the use of intracanal dressings is essential to reduce microbial infection and ensure treatment success.[1,8]

Calcium hydroxide pastes have several advantages including antimicrobial properties, pH values close to 13;[9,10,11] formation of a physical and chemical barrier;[10] inactivation of endotoxins present on the cell walls of gram-negative bacteria associated with pain and resorption;[12] and diffusion through dentin tubules.[13]

In some clinical cases, calcium hydroxide should be kept in the canal for longer periods of time, as it is the case of endodontic treatment for teeth with incomplete root formation and pulp necrosis, root resorption and dental trauma. A paste in which the vehicle promotes slow dissociation should be used in such cases, so that an elevated pH value is maintained. However, this may be considered as a disadvantage, given that several visits are necessary for the dentist to replace the intracanal dressing. According to Frank,[14] the time that calcium hydroxide remains in the canal for the treatment of those cases may range from 5 to 20 months. It should be noted that during this period, the tooth has a temporary restoration and, for this reason, the risks of infiltration are imminent. Additionally, the cost of this type of treatment is also high, and so it is the risk of patients dropping out.[14] For this reason, studies have investigated different vehicles that can be used with calcium hydroxide at more extended intervals between visits without affecting its efficacy.

This study found that the combinations with saline solution and propylene glycol had increasing pH values up to 7 days, and decreasing values up to 14 days. The combination with 2% chlorhexidine gel and zinc oxide had a constant increase over all time intervals, in agreement with findings reported by Montagner,[15] Bretas,[16] Nerwich[3] and Maniglia-Ferreira.[17]

In spite of the apparent advantage of the combination of calcium hydroxide and chlorhexidine gel in maintaining alkaline pH values, some limitations of the use of this paste should be noted. According to Kuga,[18] chlorhexidine at high concentrations generates oxidative radicals that damage the cell wall and, consequently, reduce the biological compatibility of the paste.

Conclusion

Based on the results of this study it is reasonable to conclude that

» All pastes under study affected the pH of the solution and made it alkaline.

» The pastes with saline solution and propylene glycol had a faster alkaline shift, and the paste of calcium hydroxide in 2% chlorhexidine gel and zinc oxide kept an elevated pH value for a longer period, but differences were not statistically significant.

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