

Influence of Different Vehicles on the pH and Surface Tension of Calcium Hydroxide Pastes

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Abstract

The aim of this study was *in vitro* evaluation and comparison of pH levels and surface tension of calcium hydroxide [Ca(OH)₂] paste prepared with different vehicles such as distilled water, citanest, glycerin, and procaine.

Forty extracted human maxillary incisors were used for pH analysis in the study. Teeth were randomly divided into 4 groups as follows: Group I: Ca(OH)₂ and distilled water paste; Group II: Ca(OH)₂ and glycerin paste; Group III: Ca(OH)₂ and citanest paste and Group IV: Ca(OH)₂ and procaine paste. In all groups, pH measurements were performed at the 15th, 30th and 45th minutes; 2nd, 24th and 48th hours, and 7th and 14th days.

The powder of Ca(OH)₂ and liquids were mixed to the weight ratio 3:2 (3 ml liquid and 2 g powder) for the surface tension measurements. The surface tension of Ca(OH)₂ mixtures was measured using a tensiometer device. All measurements were repeated five times for each sample and by arithmetic means were calculated. The data were recorded and statistical analysis was performed with a significance level set at p<0.05.

The combination of Ca(OH)₂ with procaine resulted in significantly higher pH values compared to the other pastes. Distilled water mixed with Ca(OH)₂ represented the highest surface tension values (77,5 dynes/cm). The mixture of procaine or citanest with Ca(OH)₂ powder presented the lowest surface tension values of all the groups (61,6 and 56,1 respectively).

Considering the pH values obtained in this study, procaine might be used as a vehicle for Ca(OH)₂ powder. Citanest, with the lowest

surface tension values, seems to be the most favorable vehicle for Ca(OH)₂.

Keywords: Calcium hydroxide, citanest, pH, procaine, surface tension

Introduction

Eliminating the bacteria and their by-products from the root canal system is one of the purposes of endodontic treatment. Complete chemo-mechanical preparation is thought to be a crucial step in root canal disinfection. However due to the complex anatomy of the root canal system, the ability of microorganisms to survive under adverse conditions, and resistant microorganisms, the total elimination of bacteria from the root canal is difficult to achieve (1,2). Hence, an antimicrobial intracanal medicament is necessary to overcome the resistant and surviving microorganisms.

Calcium hydroxide (Ca(OH)₂), introduced by Herman in 1930, has antibacterial activity and potential to stimulate hard tissue formation and therefore is considered to be the gold standard among intracanal medicaments (3). The antimicrobial activity of Ca(OH)₂, due to the high pH, is determined by the release of hydroxyl ions. Direct or indirect contact in dentinal tubules for an optimal time is required for effective destruction of microorganisms (4). Ca(OH)₂ eliminates bacteria through the effects of hydroxyl ions, and its efficacy depends on the availability of these ions in the solution, which is also dependent on the vehicle in which the Ca(OH)₂ carried (5). With the use of Ca(OH)₂ as a root canal dressing, the pH increases in the surrounding tissues as a result of the release of hydroxyl ions. The availability of the hydroxyl ions at the application site is one of the most important factors and is responsible for its efficacy. For this reason, hydroxyl ions should reach the surrounding tissues via diffusing from the material through the dentinal tubules or the apical foramen. In order to provide its efficacy, Ca(OH)₂ in combination with a carrying vehicle should be adequately placed and condensed into the root canal space (6).

Because the result could influence its effectiveness, the knowledge of the influence of substances on ionic dissociation of Ca(OH)₂ and the capacity of hydroxyl ions to diffuse into the dentinal

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tubules is critical. Thus, evaluation of some physicochemical properties of Ca(OH)₂, such as surface tension, is essential.

The aim of this study was *in vitro* evaluation and comparison of the surface tension and pH level of Ca(OH)₂ paste in combination with different vehicles such as distilled water, citanest, glycerin and procaine.

Materials and methods

pH analysis

Forty extracted human maxillary incisors were decoronated to a standardized length. To determine the working length (WL), a #10 K-file (Dentsply Maillefer, Switzerland) was inserted into the canal until it became visible at the apical foramen. The WL was calculated to be 1 mm shorter than the length attained by the initial appearance of the file. Biomechanical root canal preparation was performed to working length with an apical preparation up to file #40, followed by step-back instrumentation up to file #60. Root canal irrigation was performed with 2 ml of 2.5% NaOCl between each instrument change. After the completion of the preparation, the smear layer was removed using 17% ethylenediaminetetraacetic acid (EDTA) solution (Pulpdent, USA).

Following preparation of the root canals, teeth were randomly divided into four groups as follows:

Group I (n=10) - Ca(OH)₂ and distilled water paste;

Group II (n=10) - Ca(OH)₂ and glycerin paste;

Group III (n=10) - Ca(OH)₂ and citanest paste;

Group IV (n=10) - Ca(OH)₂ and procaine paste.

After the pastes were filled into the root canals using a lentulo, apical foramen and root canal openings were sealed with a temporary filling material and stored in distilled water at room temperature. Using a pH/ISE meter (ORION, model 710A, USA), pH values were measured at the 15th, 30th, 45th minutes; 2nd, 24th, 48th hours; and 7th, 14th days. The electrode of the pH meter was rinsed with deionized water and dried with absorbent paper for each measurement.

Surface tension analysis

The surface tension of Ca(OH)₂ mixed with different vehicles was evaluated in four groups:

Group I - Ca(OH)₂ and distilled water paste;

Group II - Ca(OH)₂ and glycerin paste;

Group III - Ca(OH)₂ and citanest paste;

Group IV - Ca(OH)₂ and procaine paste.

Samples were prepared by mixing Ca(OH)₂ powder with vehicles to the weight ratio 3:2 (3 ml liquid and 2 g powder). The mixing procedure is carried out on a mixing glass using a spatula by the same operator. Immediately after the mixture was prepared, the Ca(OH)₂ paste was filled in a dappen dish and surface tension measurements were performed.

Figure 1: Variation of mean pH values for the groups with time

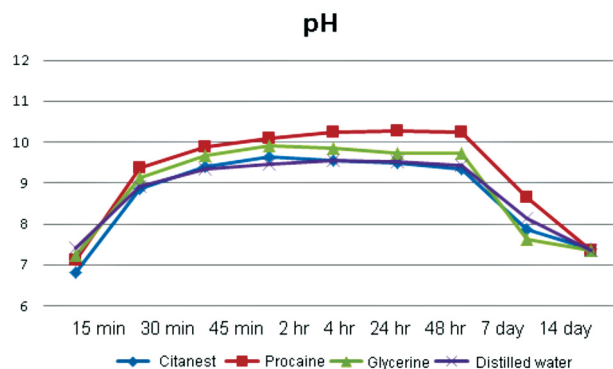
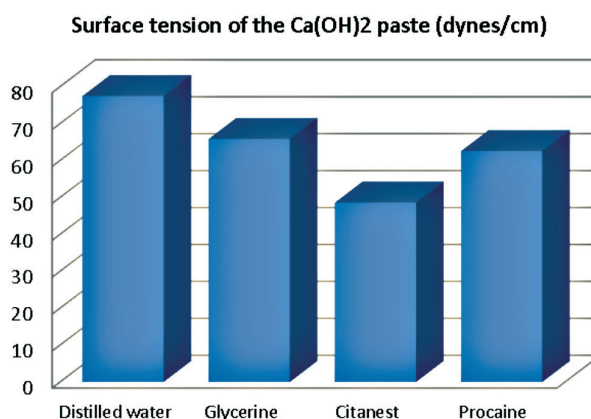


Figure 2: Surface tension values of Ca(OH)₂ paste groups



The surface tension of samples were measured using a tensiometer device (Krüss K9, Krüss GmbH, Germany), at a room temperature of 25°C. This method consisted of application of forces to separate a platinum ring immersed in the substances. All glass equipment was cleaned by immersion into the cleaning solution and the platinum ring was cleaned by flaming. All measurements performed by the same operator were repeated five times for each sample and arithmetic means were calculated.

Statistical analysis

The data were recorded and statistical analysis was performed with the Statistical Package for Social Sciences for Windows 15.0 software package (SPSS, USA) using one-way ANOVA, and Tukey HSD for significance. A p value <0.05 was considered statistically significant.

Results

The variation in pH with time for the different pastes is presented in Figure 1. The combination of Ca(OH)₂ with procaine resulted in significantly higher pH values compared to the other pastes. The highest pH values obtained in Groups I, II, III, IV were 9.56, 9.90, 9.65, and 10.28, respectively. There were no statistically significant differences between the pH values of the mixtures at the 14th day.

Considering the applied methodology, the results of the surface tension analysis are as follows: distilled water mixed with Ca(OH)₂ represented the highest surface tension values (77.5 dynes/cm). This is followed by the surface tension values of the glycerin and Ca(OH)₂ mixture (65.9 dynes/cm). The mixture of procaine or citanest with Ca(OH)₂ powder represented the lowest surface tension values of all the groups (61.6 and 56.1 respectively).

Discussion

The ability of Ca(OH)₂ to release calcium and hydroxyl ions determines its antibacterial effect. The antibacterial activity of hydroxyl ion is dependent on the formation of a potent alkaline medium leading to the destruction of lipids which are the main components of bacterial cell membrane and causing structural damage to bacterial proteins and nucleic acids (7). Byström et al. (8) reported *Enterococcus faecalis* to be a resistant bacterium in root canals, surviving at pH 11.5, but being killed at pH 12.5. Therefore, in order to achieve antibacterial effect, a high pH value is desired for a long time period.

As different vehicles permit hydroxyl ions to release from Ca(OH)₂ to different degrees (9), the mixing vehicle determines the pH values of Ca(OH)₂ mixtures (10). The ability of a medicament to dissolve and diffuse in the root canal system is crucial for the success of its action (11). A saturated Ca(OH)₂ suspension, which has a high pH, has great cytotoxic potential limited to the tissue area in direct contact with Ca(OH)₂. On the other hand, its biocompatibility arises from its low water solubility and diffusibility which makes it difficult to reach a rapid and significant increase in the pH to eliminate bacteria located within dentinal tubules and enclosed in anatomical variations (12).

The results of this study demonstrated that Ca(OH)₂ and procaine paste had the best alkalinizing properties that affected surrounding medium. Procaine intervenes as oxidizing principle in the process of cellular respiration, as calcium substance acting on the cell membrane and as inductor of bioelectrical potential. With this new supply of energy to the basic tissues, previously inhibited autonomic functions are once again set in motion. As a result the cell returns to being a functioning unit again (13).

An intracanal medicament should ideally be placed into the canal spaces deeply and densely by spreading the medication thoroughly. Several studies evaluated the diffusion of Ca(OH)₂ through dentinal tubules (14-22). The Ca(OH)₂ reaches areas contaminated by microorganisms, sites of root resorption and surrounding tissues by diffusion via dentinal tubules, apical foramen, secondary and accessory canals and demonstrates its antimicrobial and anti-resorptive action (14,16,23). Surface tension is a deterministic factor in spreading and diffusion of the intracanal medicament in the irregularities of the root canal and the dentinal tubules (3). The biological and antimicrobial properties, and also the diffusion capacity of Ca(OH)₂ is influenced by the vehicles used in Ca(OH)₂ pastes (14,16,17). Liquid penetration into the inaccessible areas is increased by the low surface tension (3).

In this study, the various vehicles used were shown to influence the surface tension of the Ca(OH)₂ mixtures. According to the results of this study, distilled water mixed with Ca(OH)₂ paste represented the highest surface tension values to be 77.5 dynes/cm. This can be

explained by the fact that water has the highest surface tension of the known liquids. The mixture of procaine or citanest with Ca(OH)₂ powder represented the lowest surface tension values of all the groups (61.6 and 56.1, respectively). The results demonstrated that pastes prepared with anesthetic solutions had the lowest surface tension values among the Ca(OH)₂ mixtures. Citanest, with the lowest surface tension values, seemed to be the most favorable vehicle for Ca(OH)₂.

Procaine, with regard to its low surface tension and efficacy in neural therapy studies, should further be evaluated for other properties such as ion exchange in studies concerning Ca(OH)₂. Considering the pH values obtained in this study and chemical properties of procaine, it might be used as a vehicle for Ca(OH)₂ powder.

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