

SURFACE TENSION OF CALCIUM HYDROXIDE ASSOCIATED WITH DIFFERENT SUBSTANCES

TENSÃO SUPERFICIAL DO HIDRÓXIDO DE CÁLCIO ASSOCIADO A DIFERENTES SUBSTÂNCIAS

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ABSTRACT

The purpose of this study was to evaluate the surface tension of calcium hydroxide (CH) associated with different substances (deionized distilled water, camphorated paramonochlorophenol, 2% chlorhexidine digluconate, Otosporin, 3% sodium lauryl ether sulphate; Furacin, PMC Furacin) using tensiometer. The action of the substances studied on the dentinal structure enhances the property of surface tension. This method consists in the application of force to separate a platinum ring immersed in the substances. Thus, torsion was applied to the screw until the platinum ring separated during substances testing. Considering the methodology applied, the following can be concluded: distilled water alone or associated with CH presented a high surface tension (70.00 and 68.40 dynes/cm); calcium hydroxide in association with anionic detergent showed low surface tension (31.60 dynes/cm); camphorated paramonochlorophenol plus CH presented low surface tension (37.50 dynes/cm); 2% chlorhexidine associated with calcium hydroxide showed high surface tension values (58.00 dynes/cm); Otosporin plus calcium hydroxide showed low surface tension (35.40 dynes/cm); paramonochlorophenol Furacin mixed with calcium hydroxide presented surface tension equal to 45.50 dynes/cm; sodium hypochlorite presented high surface tension (75.00 dynes/cm). Antimicrobial agents more indicated in endodontics, i.e. CH, chlorhexidine and hypochlorite, presented the highest surface tension.

Uniterms: Calcium hydroxide; Root canal dressing; Surface tension.

RESUMO

Estudou-se a tensão superficial do hidróxido de cálcio associado a diferentes substâncias (água destilada deionizada, paramonoclorofenol canforado, digluconato de clorexidina 2%, Otosporin, sulfato éter lauril sódio 3%, furacin, PMC furacin) usando tensiômetro. O modelo experimental consistiu na aplicação de uma força para separar um anel de platina imerso na superfície das substâncias, exercido por um tensiômetro. Considerando a metodologia aplicada, pode-se concluir: a água destilada isolada ou associada com o hidróxido de cálcio apresenta alta tensão superficial (70,00 e 68,40 dinas/cm); hidróxido de cálcio associado ao detergente aniônico mostrou baixa tensão superficial (31,60 dinas/cm); paramonoclorofenol canforado mais hidróxido de cálcio apresentou baixa tensão superficial (37,50 dinas/cm); clorexidina 2% associada com hidróxido de cálcio mostrou um alto valor de tensão superficial (58,00 dinas/cm); Otosporin mais hidróxido de cálcio mostrou baixa tensão superficial (35,40 dinas/cm); paramonoclorofenol furacin misturado com hidróxido de cálcio apresentou tensão superficial igual a 45,50 dinas/cm; hipoclorito de sódio apresentou alta tensão superficial (75,00 dinas/cm).

Unitermos: Hidróxido de cálcio; Medicação intracanal; Tensão superficial.

INTRODUCTION

Since the use of Calxyl by Herman in 1920, calcium hydroxide has been extensively employed in endodontic therapy.

Calcium hydroxide paste has been widely used as a root canal dressing in the treatment of apical periodontitis. The reason for its application is based on its antimicrobial and mineralizing properties.

Calcium hydroxide (CH) is a strong base obtained from the calcination of calcium carbonate until its transformation into calcium oxide. CH is then obtained by hydration of calcium oxide and the chemical reaction between CH and carbon dioxide forms calcium carbonate. It is a white powder with a high pH (12.5) and is only slightly soluble in water (solubility of 1.2 g/l, at a temperature of 25°C)⁶.

The effectiveness of calcium hydroxide on microorganisms and tissue is directly related to its ionic dissociation into calcium and hydroxyl ions. Estrela, et al.⁸ (1995) discussed this action explaining that its high pH inhibits enzyme activities that are essential to bacterial life, i.e. metabolism, growth and cellular division. The effect of pH on the transportation of nutrients and organic components through the cytoplasmic membrane determines its toxic action on bacteria. This also activates the hydrolytic enzyme alkaline phosphatase, which is closely related to the process of tissue mineralization. Thus, this medication presents two fundamental enzyme properties: the inhibition of bacterial enzymes leading to an antimicrobial effect and the activation of tissue enzymes such as alkaline phosphatase leading to a mineralizing effect.

Different substances (distilled water, saline solution, propylene glycol, camphorated paramonochlorophenol, chlorhexidine, glycerin, iodoform, barium sulfate, corticosteroid-antibiotic, antibiotics, anesthetic solution, methylcellulose, glycerin, detergent) have been associated with calcium hydroxide^{2,3,5-14}.

However, the change in dentinal pH caused by hydroxyl ions is slow and depends on several factors that can alter the rate of ionic dissociation and diffusion, such as the level of hydrosolubility of the vehicle employed, difference in viscosity, acid-base characteristic, dentinal permeability, and level of existing calcification^{8,12,13,18}.

The viability of microorganisms is influenced by high pH values. The pH of vehicles and calcium hydroxide pastes have presented interesting results, such as the low pH (5.0) of camphorated paramonochlorophenol (CMCP), the intermediate pH (7.8) resulting from the association of calcium hydroxide and CMCP and the high pH (12.6) of calcium hydroxide pastes associated with distilled water, sodium lauryl diethylene ether sulfate, Tween 80 and polyethylene glycol⁵.

The knowledge of the influence of substances on ionic dissociation of calcium hydroxide and the capacity of hydroxyl ions to diffuse into the dentinal tubules is critical because the result could affect its effectiveness. Thus, it is essential to evaluate some physicochemical properties of calcium hydroxide, as surface tension.

The purpose of this study was to evaluate the surface tension of CH associated with different substances (deionized distilled water, camphorated paramonochlorophenol, 2% chlorhexidine digluconate[®], Otosporin[®], 3% sodium lauryl ether sulphate, Furacin[®], PMC Furacin[®], 1% sodium hypochlorite[®]).

MATERIALS AND METHODS

In the present study, the surface tension and pH in 20ml of several substances were analyzed: deionized distilled water, camphorated paramonochlorophenol (SS White, Rio de Janeiro, RJ, Brazil), 2% chlorhexidine digluconate[®] (F.G.M., Joinville, SC, Brazil), Otosporin[®] (Hydrocortisone, neomycin and polymixin B, Wellcome Zeneca Ltda., Rio de Janeiro, RJ, Brazil), 3% sodium lauryl ether sulphate (Natu Pharmas, Goiânia, GO, Brazil); Furacin[®] (Schering-Plough S.A., RJ, Brazil), PMC Furacin[®] (Biodinâmica, Ipirorá, PR, Brasil), alone and associated with calcium hydroxide (P.A., Quimis, Mallinkrodt Inc., St. Louis, MO, USA), at a ratio of 14g/l (1.4%); 1% sodium hypochlorite[®] (Hi-Clor, Halex Istar Ind. Farm. Ltda, Goiânia, GO, Brasil) was analyzed alone.

The surface tension of several substances was measured using tensiometer (Fisher Scientific, USA), at a room temperature of 25°C.

All equipments were completely cleaned, and distilled water was used for zero calibration prior to beginning of this experiment. This method consists in applying forces that cause separation of a platinum ring immersed in different substances. Thus, torsion was applied to the screw until the platinum ring separated in the test substances. Analyses of these substances' pH were measured with a digital pH meter (Digimed, SP, Brazil). All assays were repeated three times. The results were calculated by arithmetic means.

RESULTS

The results of the surface tension values are shown in Table 1.

DISCUSSION

Different properties of medications of endodontic use have been studied: antimicrobial effectiveness, biocompatibility, tissue solvency, pH, solubility, molar conductivity and surface tension. Thus, importance was assigned to the biological behavior of endodontic materials, due to their current importance. However, for an endodontic substance to properly develop its mechanism of action, it needs first to reach the proper site. It is therefore essential to know the surface tension of the different substances of endodontic use in order to select them based on their ability of penetrating the dentin.

Distilled water alone or associated with calcium hydroxide presented high surface tension (70.00 and 68.40 dynes/cm).

Calcium hydroxide in association with anionic detergent showed low surface tension (31.60 dynes/cm). Camphorated paramonochlorophenol plus calcium hydroxide also presented low surface tension (37.50 dynes/cm); 2% chlorhexidine associated with calcium hydroxide showed high surface tension value (58.00 dynes/cm).

Surface tension is a force existing between the surface molecules that makes a drop of liquid spread or concentrate when placed on a surface. This phenomenon depends on the values of its cohesive forces (force of attraction resulting from the forces that the liquid molecules exert between themselves) and adhesive forces (forces that the surface molecules exert in contact with those of a liquid)¹⁸.

The literature registers some works that evaluated surface tension of different medicaments^{11,15-19}. It is important to understand that this method consists in application of force to separate a platinum ring immersed in substances. Thus, torsion was applied to the screw until the platinum ring separated during substances testing. Another important factor to consider is the experimental model. In this experiment, the surface tension was analyzed in solutions, not in paste form. The literature indicates calcium hydroxide as a root canal dressing in paste form.

Although camphorated paramonochlorophenol plus calcium hydroxide showed surface tension equal to 37.50 dynes/cm, the pH value was 7.8. Nevertheless, distilled water with calcium hydroxide presented high surface tension (68.40 dynes/cm), but the pH value is higher (12.80). Estrela, et al.² determined the influence of vehicles (saline solution, camphorated paramonochlorophenol, chlorhexidine, 3% sodium lauryl sulphate, Otosporin®) on the antimicrobial efficiency of calcium hydroxide paste. Antimicrobial effect occurred after 48h on the cultures of *S. mutans*, *E. faecalis*, *S. aureus*, *P. aeruginosa*, *B. subtilis*, *C. albicans* and the mixed culture, irrespective of the root canal dressing. Under the conditions of this study, the various vehicles associated with calcium hydroxide pastes did not influence the time required for microbial inactivation, what suggests that they play a supportive role in the process by providing appropriate

conditions for dissociation and diffusion as well as enhancing complete filling of the root canal; these are important factors for antimicrobial potential and tissue healing capability.

Holland, et al.¹² (1999), analyzing the effect of hydrosoluble (saline solution) and non-hydrosoluble vehicles (CMCP) associated with calcium hydroxide in the healing process of dogs' teeth with periapical lesions, observed that 6 months after root canal obturation, the best repair rates were obtained with a root canal dressing with saline solution as the vehicle. In another research, Holland, et al.¹⁴ (2003) studied the healing process in dogs' teeth with apical periodontitis after root canal treatment in one or two appointments. Dogs' premolars and anterior teeth had their root canals opened to the oral environment for 6 months before being treated. After root canal treatment they were filled by the lateral condensation technique with gutta-percha points and Sealapex in one appointment or after dressing with calcium hydroxide for 7 and 14 days. Six months after treatment, the animals were killed and the tissues prepared for histomorphological analysis. Scores attributed to the different histomorphological events were submitted to statistical analysis, which resulted in ranking the experimental groups from the best to the worst in the following way: a) calcium hydroxide 14 days; b) calcium hydroxide 7 days; c) one appointment. The use of calcium hydroxide as root canal medicaments between appointments helps to achieve better results in the treatment that in one appointment.

It is expressive to consider that some bacteria are capable to survive at high pH, as *Enterococcus faecalis*. Evans, et al.¹⁰ (2002) studied the mechanisms involved in the resistance of *E. faecalis* to calcium hydroxide. The authors confirmed that *E. faecalis* (bacteria commonly isolated from refractory endodontic cases) is resistant to elimination by calcium hydroxide at or below pH 11.1. An adaptive response in alkaline pH and stress-induced protein synthesis appears to play minor roles in cell survival; however, a functioning proton pump with the capacity to acidify the cytoplasm is

TABLE 1- Surface tension values of calcium hydroxide associated with different substances

Substances	Surface Tension (dynes / cm)	pH
Distilled Water	70.00	6.2
Distilled Water + Ca(OH) ₂ (14g/l)	68.40	12.8
Camphorated Paramonochlorophenol	37.60	5.0
Camphorated Paramonochlorophenol + Ca(OH) ₂ (14g/l)	37.50	7.8
2% Chlorhexidine®	55.50	5.9
2% Chlorhexidine® + Ca(OH) ₂ (14g/l)	58.00	10.2
Otosporin®	37.50	5.4
Otosporin® + Ca(OH) ₂ (14g/l)	35.40	7.6
3% Sodium Lauryl Ether Sulphate	33.10	6.1
3% Sodium Lauryl Ether Sulphate + Ca(OH) ₂ (14g/l)	31.60	12.5
Paramonochlorophenol Furacin®	45.60	7.0
Paramonochlorophenol Furacin® + Ca(OH) ₂ (14g/l)	45.50	10.0
1% NaOCl	75.00	12.6

critical for survival of *E. faecalis* at high pH.

Buck, et al.¹ (2001) evaluated the detoxification of endotoxin by endodontic irrigants (chlorhexidine, sodium hypochlorite, chlorhexidine chloride, ethanol, EDTA, water) and calcium hydroxide. The results showed that the biologically active portion of endotoxin, lipid A, is hydrolyzed by highly alkaline chemicals, namely calcium hydroxide or the mixture of chlorhexidine, sodium hypochlorite and ethanol. EDTA, sodium hypochlorite, chlorhexidine, chlorhexidine chloride, ethanol and water (control) showed little or no detoxifying ability in lipid A.

Özcelik, et al.¹⁷ (2000) compared the surface tension of calcium hydroxide mixed with different vehicles (glycerin, Ringer's solution, anesthetic solution and saline), alone and the calcium hydroxide combinations. The results showed that anesthetic solution is the most favorable vehicle with the lowest surface tension values (44.00 and 51.00 dynes/cm).

The association of chlorhexidine plus calcium hydroxide showed a high surface tension (58.00 dynes/cm) and pH values equal to 10.2. Estrela, et al.⁷ (2003) verified antimicrobial effect of 2% sodium hypochlorite and 2% chlorhexidine by different methods. The data show that both substances have antimicrobial effect against biological indicators tested (*S. aureus*, *E. faecalis*, *P. aeruginosa*, *B. subtilis*, *C. albicans* and a mixed). The magnitude of antimicrobial effect was influenced by the experimental methods, characteristics of the microorganisms and the exposure time.

Despite the association at 3%, sodium lauryl ether sulphate plus calcium hydroxide presents a low surface tension (31.60 dynes/cm) and high pH (12.5). Estrela, et al.³ (2001) observed no significant differences when comparing the molar conductivity of solutions containing sodium lauryl ether sulfate, tween 80 and deionized water combined with calcium hydroxide. As irrigant solution, calcium hydroxide plus detergent (lauryl diethylene glycol ether sodium sulphate) did not show a stronger antimicrobial action when compared with sodium hypochlorite or chlorhexidine.

Estrela and Holland⁴ (2003) established important parameters on calcium hydroxide's properties based on a literature review. They concluded that calcium hydroxide's characteristics come from its dissociation into calcium and hydroxyl ions. The action of these ions on tissues and bacteria explains the biological and antimicrobial properties of this substance. It is necessary, whenever possible, to provide time for calcium hydroxide paste to manifest its potential of action on the microorganisms present in endodontic infections. The maintenance of a high concentration of hydroxyl ions can change bacteria enzymatic activity and promote its inactivation. The site of action of hydroxyl ions of calcium hydroxide includes the enzymes in the cytoplasmic membrane. This medication has a large scope of action, and therefore is effective on a wide range of microorganisms, regardless of their metabolic capability. In microbial world, cytoplasmic membranes are similar, irrespective of microorganisms' morphological, tinctorial and respiratory characteristics, which means that

this medication has a similar effect on aerobic, anaerobic, Gram-positive and Gram-negative bacteria.

The surface tension values and pH of Otosporin alone or in association with calcium hydroxide were low. Paramonochlorophenol Furacin, alone and combined with calcium hydroxide, showed higher values than sodium lauryl ether sulphate and lower values than distilled water. Sodium hypochlorite presented a high surface tension (75.00 dynes/cm) and high pH (12.6).

Although these results cannot be directly extrapolated to the clinical setting, it is important to know the surface tension values of endodontic substances. Further studies must be developed to support greater clinical application of these results. The lack of studies on this physicochemical property of substances investigated made the discussion more difficult.

CONCLUSIONS

Considering the experimental model used, the following can be concluded:

01. Expressive antimicrobial substances (calcium hydroxide, sodium hypochlorite and chlorhexidine) showed the highest values of surface tension. Distilled water alone or associated with calcium hydroxide presented high surface tension (70.00 and 68.40 dynes/cm); calcium hydroxide in association with anionic detergent showed low surface tension (31.60 dynes/cm); camphorated paramonochlorophenol plus calcium hydroxide presented a low surface tension (37.50 dynes/cm); 2% chlorhexidine associated with calcium hydroxide showed high surface tension value (58.00 dynes/cm); Otosporin associated with calcium hydroxide showed low surface tension equal to 35.40 dynes/cm; paramonochlorophenol Furacin mixed with calcium hydroxide presented surface tension of 45.50 dynes/cm and sodium hypochlorite presented high surface tension (75.00 dynes/cm).

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