Effect of sodium hypochlorite and calcium hydroxide on fracture resistance of root dentin

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ABSTRACT

Objective: The aim of this study was to assess the influence of different concentrations of sodium hypochlorite (NaOCl) solution and of calcium hydroxide [$Ca(OH)_2$] paste on the strength of root dentin during endodontic treatment. **Methods:** Eighty roots of bovine mandibular incisors were randomly assigned to eight groups: C- Control (no intervention); PS- Physiological saline; 1% NaOCl; 5% NaOCl; PS/EDTA; PS/EDTA/$Ca(OH)_2$; 1% NaOCl/EDTA/Ca(OH)2; and 5% NaOCl/EDTA/$Ca(OH)_2$. All groups were prepared with hand K files using the crown-down technique, except for the control group. The irrigating solution in each group was kept in the canal for 2 h, being replaced every 15 min. EDTA was applied for 3 min in the corresponding groups. $Ca(OH)_2$ was kept in the root canals for 30 days. The specimens were subjected to compressive strength testing until fracture in an EMIC universal testing machine. The data were subjected to analysis of variance. The significance level was set as alpha = 0.05. **Results:** No statistically significant difference was found across the experimental groups ($P>0.05$). **Conclusions:** The use of NaOCl for 2h and $Ca(OH)_2$ for 30days did not influence the strength of root dentin.

Keywords: Sodium hypochlorite. Calcium hydroxide. Endodontics. Root canal irrigants.

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Introduction

Mechanical instrumentation combined with irrigating solutions is necessary during endodontic treatment for better cleaning of the root canal system.[1] Selection of solutions that can kill bacteria and inactivate toxins without interfering negatively in the healing process is of paramount importance for successful treatment[2].

Sodium hypochlorite (NaOCl) is one of the irrigants most widely used during chemomechanical preparation as it has tissue-dissolving capabilities and antimicrobial properties, in addition to being used as root canal lubricant.[3-6] However, NaOCl is toxic to periapical tissues, especially in higher concentrations, in case of inadvertent extrusion beyond the apical foramen.[7]

Chemomechanical preparation is sometimes unable to eliminate all microorganisms from the infected root canal system[8] and, therefore, intracanal medication between treatment sessions is required as a complement to disinfection procedures.[9] Calcium hydroxide [$Ca(OH)_2$] is used as temporary dressing since it has antibacterial properties, induces the formation of mineralized tissue, and is biocompatible.[10]

The use of a chelating solution containing ethylenediamine tetraacetic acid (EDTA) is recommended in combination with NaOCl and also prior to the administration of intracanal medicaments in order to maximize organic material dissolution, facilitate the removal of inorganic components from the smear layer formed during root canal instrumentation, and enhance the antimicrobial effect of intracanal medicaments.[11-13]

Nevertheless, while these substances are essential for controlling infection in the root canal system, studies have demonstrated that both NaOCl and $Ca(OH)_2$ are considered to have a solvent effect on dentin, occasionally leading to changes in its mechanical properties.[14] These changes may undermine the root structure and eventually predispose to vertical root fracture.[15] However, endodontic literature on this matter is controversial[14-17] and warrants further investigation.

Therefore, the aim of this in vitro study was to assess the effect of different NaOCl concentrations, used either in isolation or combined with EDTA and $Ca(OH)_2$, on the resistance of bovine roots to fracture.

Material and methods

Eighty bovine incisors, supplied by a meat-packing plant from Santa Maria, a town in the state of Rio Grande do Sul, southern Brazil, were selected, cleaned, stored in distilled water, and kept under refrigeration.

The specimens were analyzed under a stereo microscope at 10X magnification and by transillumination in order to check for the presence of root defects, excluding those with cracks or fractures.

After selection, the crown segment was sectioned perpendicularly to the long axis of the tooth with carborundum discs (KH Sorensen Ind. Com. Ltda., Barueri, SP, Brazil) (Fig 1A) for standardization of root remnants to 16 mm, which was established as the working length (WL).

The initial apical file (IAF) size was determined with the aid of K files (Dentsply, Maillefer, Ballaigues, Switzerland) passively inserted into the root canal to estimate the anatomical diameter. The specimens were randomly distributed into eight experimental groups (n=10) using a specific software (Random Allocation Software, Isfahan, Iran) and taking the IAF size into consideration (stratified randomization).

» C: Control, teeth without any intervention;

» PS: Physiological saline;

» 1% NaOCl: 1% sodium hypochlorite (Novaderme, Santa Maria, RS, Brazil);

» 5% NaOCl: 5% sodium hypochlorite (Novaderme, Santa Maria, RS, Brazil);

» PS/EDTA: Physiological saline + EDTA (Novaderme, Santa Maria, RS, Brazil);

» PS/EDTA/Ca(OH)2: Physiological saline + EDTA (Novaderme) + Calen-PMCC® calcium hydroxide (SS WHITE, Rio de Janeiro, RJ, Brazil);

» 1% NaOCl/EDTA/Ca(OH)2: 1% sodium hypochlorite (Novaderme) + EDTA (Novaderme) + Calen-PMCC® calcium hydroxide (SS WHITE);

» 5% NaOCl/EDTA/Ca(OH)2: 5% sodium hypochlorite (Novaderme) + EDTA (Novaderme) + Calen-PMCC® calcium hydroxide (SS WHITE).

The specimens were placed in chemically polymerized acrylic resin (JET Clássico, São Paulo, SP, Brazil), in a PVC cylinder (15 mm in height and 25 mm in diameter). Three millimeters of the most coronal segment of the root was delimited to simulate crestal bone height. After that, each root was immersed in dental wax 7 (Newwax; TechNew, Rio de Janeiro, RJ, Brazil) melted in a heater (Termodepiladora Junior; Randay, São Paulo, SP, Brazil) at a constant temperature of 78 °C, to cover the root with a 0.2-to-0.3-mm wax layer. After the wax cooled down, a rotary instrument (Protaper Universal; Dentsply Maillefer, Ballaigues, Switzerland) was inserted into the root canal and the instrument/root assembly was fitted into a dental parallelometer. Thus, the long axis of the instrument and of the root were parallel to each other and perpendicular to the horizontal plane (Fig 1B). The chemically polymerized acrylic resin (JET Clássico) was then prepared and poured into the plastic cylinder up to the 3-mm mark. After resin polymerization, the root was removed from the "socket" and the wax was removed from the outer surface of the root. For simulation of the periodontal ligament[18], a polyether-based impression material (Impregum Soft - medium body, 3M, ESPE, St Paul, MN, USA) was molded, inserted into the "socket," and the root was placed back into acrylic resin. Finally, the excess material was removed with a scalpel blade (Fig 1C-1D).

The root canal was prepared with the crown-down technique in all specimens, except for those in the control group. Five K files (Dentsply) with a diameter greater than that of the IAF were inserted into the canal in decreasing order until they reached the WL. After that, three K files (Dentsply) were used in increasing order at the WL in order to determine the final apical file (FAF) size. One milliliter of distilled water was used between each instrument. Irrigation was performed with a disposable syringe and irrigation needle (EndoEze, Ultradent Products Inc., Indaiatuba, SP, Brazil).

After instrumentation, the root canals were filled with the irrigating solution according to each protocol. Physiological saline and NaOCl were kept in the canal for 2 h, being replaced every 15 min.[16]

In the corresponding groups, the root canals were irrigated with 2 mL of 17% EDTA (Novaderme) for 3 min, washed with 2 mL of physiological saline to remove possible EDTA (Novaderme) residues, and dried with paper points. Thereafter, $Ca(OH)_2$-based intracanal medication (Calen-PMCC®, SS WHITE) was injected into the canal using a Mario Leonardo® syringe (SS White Duflex, Rio de Janeiro, RJ, Brazil), filling the whole root length. Later, the canal was sealed with temporary filling material (Coltosol, Vigodent S/A Ind., Rio de Janeiro, RJ, Brazil) and the roots were stored for 30 days.

The resin blocks were placed in the metal mold of the DL-1000 (EMIC, São José dos Pinhais, PR, Brazil) universal testing machine. At a constant speed of 1 mm/min, the device applied force in the canal by means of a 1-mm metal framework until a failure occurred. The operator followed the force (Newton) vs. distance (mm) graph generated by the testing machine program and paid careful attention to any noise produced by the specimen during the test, which would indicate some sort of failure. The maximum load supported by the specimen until its fracture was recorded at this stage.

The Shapiro-Wilk test confirmed the normality of data. A parametric test, ANOVA (analysis of variance), was used to compare fracture resistance values. The significance level was set as alpha=0.05. The statistical analysis was performed with the PASW Statistics 18 software (SPSS Inc., Chicago, IL, USA).

Results

The mean fracture resistance values are described in Table 1. The experimental groups had similar results to those of the control group (P>0.05). No statistically significant difference was observed across the experimental groups (P>0.05).

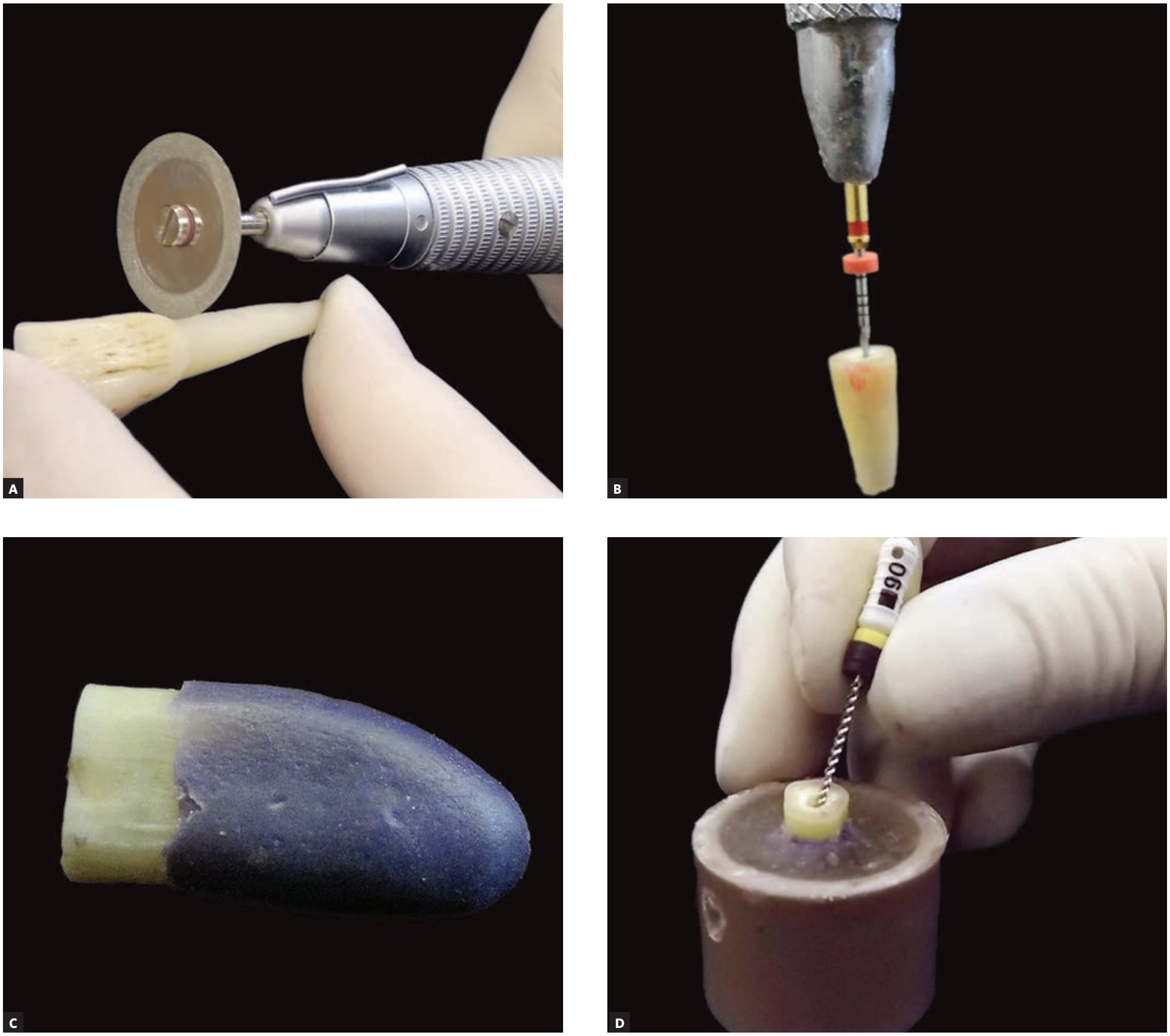

Figure 1. Experimental setting: (**A**) Standardization of root length; (**B**) Instrument/root assembly fitted into a dental parallelometer; perpendicular to the horizontal plane; (**C**) Simulation of the periodontal ligament with polyether-based impression material; (**D**) Root canal preparation in a tooth inserted into the simulated alveolar socket.

Table 1. Mean force and standard deviation of roots subjected to fracture resistance testing, according to each experimental group.

Groups	Mean force (Newton)	Standard deviation
Control	706.25	223.47
Physiological solution	727.13	190.78
NaOCl 1%	769.93	232.79
NaOCl 5%	562.54	174.88
NaOCl 1%/EDTA	691.25	209.81
NaOCl 5%/EDTA	677.53	265.91
NaOCl 1%/EDTA/$Ca(OH)_2$	914.87	213.55
NaOCl 5%/EDTA/$Ca(OH)_2$	710.19	224.50

No statistically significant difference across the experimental groups, according to ANOVA ($P>0.05$).

Discussion

The mechanical properties of dentin, such as microhardness, elasticity modulus, flexural strength, and fatigue strength, can be affected by the use of different irrigating solutions during endodontic treatment.[14,16,19] Nevertheless, the combined effects of irrigation with NaOCl and EDTA and calcium hydroxide-based intracanal medicament on collagen degradation and changes in the mechanical properties have not been fully investigated. Thus, the aim of the present study was to assess the effect of different concentrations of NaOCl, EDTA, and Ca(OH)2 on the resistance of bovine roots to fracture.

Bovine teeth were chosen because, according to earlier studies,[20-22] they are good substitutes for human teeth, as their dentin has a similar structure, composition, and number of dentinal tubules. Moreover, the choice was also based on the difficulty in obtaining human teeth in good conditions.

In the present study, the bovine teeth were classified according to the anatomical diameter of the root canals, selected by the file "locked" in the canal. However, dentin thickness was not measured, which represents a methodological limitation. As pointed out by Sathorn et al,[23] reduction in dentin thickness can predispose teeth to fracture. Thus, this factor may have influenced the results obtained herein.

The findings of the present study indicate that resistance of bovine teeth is not affected by irrigating solutions and by intracanal medication. NaOCl has been the irrigating solution of choice for endodontic treatment for many years. However, studies claim that NaOCl may reduce the mechanical properties of dentin proportionally to time and to the amount used.[24] Concentrations of 1% and 5% were tested in the present study, showing that roots subjected to 5% NaOCl for 2 h exhibit lower fracture resistance when compared with the control group, even though this difference is not statistically significant. According to Marending et al,[25] immersion of dentin bars in 5 mL of 1% NaOCl for 1 h did not cause significant changes in the elasticity modulus and flexural strength of root dentin when compared with immersion in water, which is consistent with the findings of the present study.

EDTA is a chelating agent that can dissolve inorganic particles because it reacts with the calcium ions present in the dentin and forms soluble calcium chelates.[26] However, Zhang et al[24] argue that EDTA alone cannot reduce the resistance of root dentin to fracture. The results obtained by these authors concur with the ones found in the present study. Also, Mai et al[27] concluded that the apparent aggressive action of EDTA on root dentin, causing erosion, is attributable to the prolonged initial contact of dentin with NaOCl. Thus, despite evidence that NaOCl and EDTA may cause changes in dentin at molecular[28] and superficial levels,[14,27] this is not likely to impair root strength.

NaOCl is used in the pulp chamber and in root canals throughout chemomechanical preparation. On the other hand, 17% EDTA is often used as final irrigant for complete removal of debris from the canal walls.[29] Therefore, in the present study, NaOCl concentrations were used as initial irrigant for 120 min, being replaced every 15 min[16], whereas EDTA rinse time was constant (3 min). The authors are aware that root canal preparation is becoming increasingly faster with the use of engine-driven nickel-titanium systems. However, this extensive contact time aims to simulate long-lasting sessions required to prepare multi-rooted teeth with complex root canal systems or situations where it is not possible to use engine-driven instruments.

Previous publications showed that treatment with $Ca(OH)_2$ could increase the risk of fracture lines on the dentin surface.[17,30] Nevertheless, in the present study, the groups treated with $Ca(OH)_2$ were not less resistant to fracture than the control group, even after NaOCl exposure. The findings of this study are consistent with those of Andreassen et al.[30] who did not find a statistically significant reduction of fracture resistance of sheep teeth in 1 month but in 2 months or longer periods.

Several studies assessed the length of action of $Ca(OH)_2$ and its effect on the root dentin of human and bovine teeth.[16,17,29,31] Their conclusions indicate that the negative effect of Ca(OH)2 can be observed after 60 days or more of exposure.[31] Inconsistent results regarding its action were reported for 4-week periods or shorter periods.[17] $Ca(OH)_2$ is rarely used as intracanal medication for more than 30 days in teeth with complete root formation.

Thus, this study supports the idea that in routine clinical practice, $Ca(OH)_2$ does not impair root dentin strength and may be safely used after irrigation with NaOCl and EDTA.

Conclusions

By taking into account the results obtained here and the methodological limitations of this study, it can be concluded that the use of irrigating solutions and intracanal medication do not cause structural changes in endodontically treated teeth, since there was no statistically significant reduction in fracture resistance of root dentin after exposure to NaOCl, EDTA and $Ca(OH)_2$-based intracanal medication.

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