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# THE EFFECT OF NaOCl GEL ACTIVATED BY ULTRASONIC DEVICE ON BOVINE DENTAL PULP DISSOLUTION: AN *IN VITRO* STUDY

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## ABSTRACT

**Introduction:** The main objective of pulp therapy is to prevent and treat lesions. Sodium hypochlorite (NaOCl) became the primary and most preferred irrigation solution in the daily practice of dental clinics because of its ability to dissolve pulp tissues.

**Objectives:** This study aimed to compare the ability to dissolve dental pulp tissue with or without ultrasonic activation between NaOCl solution and gel.

**Material and methods:** The study consisted of 50 pieces of dental pulp removed from bovine teeth, divided into five equal groups ($n$ = 10). The pulps were removed from the upper molars after cleaning the teeth and were cut to obtain appropriate samples using a punch of 2 mm in diameter and 2 mm in length. The samples were placed in plastic containers and submerged in one of the following combinations – group 1: 2.2% NaOCl solution; group 2: 2.2% NaOCl gel; group 3: 2.2% NaOCl solution with ultrasonic activation; group 4: 2.2% NaOCl gel with ultrasonic activation, and group 5: saline as a negative control. The experiment was filmed with a digital camera to accurately determine the time of dissolution.

**Results:** All pulp tissue samples were completely dissolved within the one-hour test time, except for the negative control. One-way ANOVA analysis showed significant difference between the groups ($p$ = 0.000). LSD test showed significantly higher dissolution for all NaOCl groups compared to the negative control. NaOCl solution had significantly lower dissolution time compared to the gel type regardless of the activation ($p$ = 0.000). Ultrasonic activation significantly shortened the time of dissolution to its half in both NaOCl solution and gel.

**Conclusions:** NaOCl gel was inferior to the NaOCl solution in its ability to dissolve pulp tissue. Ultrasonic activation was able to shorten the time duration to approximately more than half the period for the samples to complete dissolution.

**Key words:** sodium hypochlorite gel, ultrasonic activation, dissolution.

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## INTRODUCTION

The main objective of pulp therapy is to prevent and treat lesions [1]. Dissolving the pulp tissues and cleaning the dental canals is considered an essential requirement to achieve this objective.

Sodium hypochlorite (NaOCl) became the primary and most preferred irrigation solution in the daily practice of dental clinics due to its antiseptic, antibacterial, and antifungal properties, in addition to its ability to dissolve pulp tissues [2]. The efficacy of NaOCl is related to its concentration, application time, temperature, and

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movement [3, 4]. However, an increased concentration of NaOCl is associated with an increased risk of toxicity [5]. Therefore, increasing the intensity by activating the liquid through stirring and raising the temperature of the liquid, decreases this time [6].

The activation of NaOCl solution is more effective when washing root canals, so the use of ultrasound device with NaOCl will help to wash the root canal system [7]. The vibrations caused by an ultrasound device provide a continuous flow of fluid. Thus, allows to remove residues and raise the fluid temperature [8], which improves tissue dissolution properties through its cavitation and acoustic streaming effect [9].

Zand *et al.* reported that NaOCl gel could be used instead of the solution in an attempt to reduce correlated problems [10]. The gel was significantly effective in removing a smear layer in synergy with EDTA [11] and easily-controlled [12].

To the best of our knowledge, this is the first study to evaluate the potential pulp tissue dissolution with NaOCl gel with or without ultrasonic activation.

## MATERIAL AND METHODS

Sample size was calculated based on a pilot study using the program (G* Power 3.1.7 software, Heinrich-Hein-Universität Düsseldorf, Germany; http://www.gpower.hhu.de/), and a total of 50 dental pulp samples were divided into five groups, with 10 samples per group.

This *in vitro*, randomized, single-blinded experiment was conducted after an approval from the affiliate institutional scientific research ethics committee.

### STUDY GROUPS

The study consisted of 50 pieces of dental pulp removed from bovine teeth, divided into five equal groups ($n = 10$).

Groups by subject:

- group 1: NaOCl solution 2.2% (Clorox®, USA);
- group 2: NaOCl gel 2.2% (Clorox®, USA);
- group 3: NaOCl solution 2.2% (Clorox®, USA) activated by an ultrasonic device;
- group 4: NaOCl gel 2.2% (Clorox®, USA) activated by an ultrasonic device;
- group 5: saline, the negative control.

### PREPARATION AND PRESERVATION OF THE SAMPLE

Upper molars were obtained from a butcher shop. Therefore, the study did not have any effect on the animals' lives and this research is consistent with the ethical principles of the Helsinki Declaration published in 2016 [13].

After extraction, the teeth were washed immediately with running water. The blood and soft tissues attached to the teeth were removed.

The teeth were then kept in sealed plastic containers with 0.5% chloramine-T solution for disinfection. After cutting the molars horizontally with separating discs, the pulps were removed from the upper molars.

The dental pulp was cut to obtain appropriate samples using a punch of 2 mm in diameter and 2 mm in length. Pulp pieces were placed in tightly sealed containers submerged in distilled water, and preserved at 4°C until their use [14]. The ambient temperature was 25°C when the experiment was initiated.

### RANDOMIZATION AND BLINDING

An assistant doctor was requested to give a number from 1 to 50 for each sample using random sampling of samples at https://www.randomizer.org. He was also asked to place the samples in plastic containers and submerge them into one of the five studied materials without the knowledge of the researcher. The groups identity was not revealed until the completion of statistical process in order to maintain the credibility of work without any bias.

### MEASURING THE TIME REQUIRED FOR PULP DISSOLUTION

The experiment was filmed with a digital camera (Nikon®, D3200) to determine the time of dissolution of the sample accurately and thoroughly.

The samples in all groups were transferred to plastic tested tubes with 3 ml of tested materials. The samples were vortexed with the use of a wooden stick, each for 2 minutes until complete dissolution of the pulp.

For groups with an ultrasonic activation, the head of the ultrasound P25 activation device K25 (P5 Booster, Acteon, India) was placed in a tube, and then operated at speed 7, activated for a whole 60 seconds, and repeated for 2 minutes.

### STATISTICAL ANALYSIS

IBM SPSS Statistics 23.0 (IBM Corp., Armonk, USA) was used to analyze data at 95% confidence interval. Kolmogorov-Smirnov test showed that the distribution of groups' data was normal, allowing one-way ANOVA analysis and post-hoc test for LSD.

## RESULTS

After the evaluation of descriptive statistics, the values of mean, standard deviation, minimum, and maximum within the 95% confidence interval of the time of dental pulp dissolution were assessed (Table 1).

All pulp tissue samples were completely dissolved within the 1-hour test time, except for the negative control.

**TABLE 1.** The descriptive results of one-way ANOVA test including mean, standard deviation, and minimum and maximum limits of dissolution of tooth pulp (minutes)

| Variable 1 – Variable 2 | Mean difference | Standard error | Significance |
|---|---|---|---|
| NaOCl 2.2% solution – NaOCl 2.2% gel | –24.07* | 00.36 | 0.000* |
| NaOCl 2.2% solution – NaOCl 2.2% solution with activation | 2.30* | 00.36 | 0.000* |
| NaOCl 2.2% solution – NaOCl 2.2% gel with activation | –08.01* | 00.36 | 0.000* |
| NaOCl 2.2% solution – saline | 6.25* | 00.36 | 0.000* |
| NaOCl 2.2% gel – NaOCl 2.2% solution with activation | 26.37* | 00.36 | 0.000* |
| NaOCl 2.2% gel – NaOCl 2.2% gel with activation | 16.05* | 00.36 | 0.000* |
| NaOCl 2.2% gel – saline | 30.32* | 00.36 | 0.000* |
| NaOCl 2.2% solution with activation – NaOCl 2.2% gel with activation | –10.31* | 00.36 | 0.000* |
| NaOCl 2.2% Solution with activation – saline | 03.55* | 00.36 | 0.000* |
| NaOCl 2.2% Gel with activation – saline | 14.27* | 00.36 | 0.000* |

**Statistical significance*

**TABLE 2.** The results of the post hoc LSD test (minutes)

| Groups | Minimum | Maximum | Mean ± SD | *p* value |
|---|---|---|---|---|
| Group 1: NaOCl 2.2% solution | 5.43 | 6.59 | 6.25 ± 0.26 | *0.000 |
| Group 2: NaOCl 2.2% gel | 25.57 | 33.37 | 30.32 ± 2.59 | |
| Group 3: NaOCl 2.2% solution with activation | 3.21 | 4.20 | 3.55 ± 0.20 | |
| Group 4: NaOCl 2.2% gel with activation | 14.10 | 14.46 | 14.27 ± 0.13 | |
| Group 5: Saline | 0.00 | 0.00 | 0.00 ± 0.00 | |

*SD – standard deviation. *Statistical significance*

When performing one-way ANOVA analysis between different durations of the groups, the value of significance was $p = 0.000$ (Table 1).

The post-hoc LSD test showed significantly higher dissolution for all NaOCl groups compared to the negative control. NaOCl solution had significantly lower dissolution time in comparison to the gel type ($p = 0.000$), and the ultrasonic activation significantly shortened the time of dissolution in both NaOCl solution and gel ($p = 0.000$) (Table 2).

## DISCUSSION

This study aimed to evaluate the effect of commercial sodium hypochlorite gel on the breakdown of dental pulp tissues.

Sodium hypochlorite is used by many dentists as irrigation solution, with concentrations ranging from 0.5% to 6% due to its antibacterial properties and its ability to breakdown the pulp tissue [15, 16]. Several studies have shown that an increase of concentration of sodium hypochlorite leads to an increased ability to dissolve pulp tissues [6, 17]. However, at the same time, it increases its side effects.

The NaOCl gel was selected not only because of its availability, but because of its transparent texture, which facilitates the performance of experiment. Clorox® gel used in our study is reported to consists of 2.2% sodium hypochlorite and 0.25% of sodium hydroxide solutions with viscosity enhancers. One of the positive characteristics of sodium hypochlorite gel is its ability for easy management and control [12], which is an important factor, particularly in pediatric dentistry.

When treating the canals of primary teeth, low viscosity solutions should be used in irrigation in order not to cross the apical foramen and damage the buds of permanent teeth [18]. NaOCl gel showed an equal antibacterial efficacy in concentration of 2.5% as compared to the same concentration of NaOCl solution [12].

Al Nesser and Bshara study indicated that NaOCl gel can significantly reduce the apical extrusion as compared to a solution when the diameter of apical foramen was ≤ 2.5 mm [19]. The present study showed that the complete dissolution of pulp tissue with 2.2% NaOCl solution took 6.25 min. This was significantly lower than NaOCl gel, which took 30.32 min for a complete lysis. Such a significantly longer dissolution time in NaOCl gel could be attributed to its higher viscosity. A study done by Almeida *et al.* [20] demonstrated that adding surfactants to NaOCl regardless of its concentration, enhances its efficacy of tissue dissolution, and this might be due to lower viscosity that allows for better contact of NaOCl particles on the surface of tissues.

Activating both NaOCl solution and gel significantly lowered the time of dissolution to approximately its half-

time, which was consistent with Stojicic *et al.* study [6]. Ultrasonic activation promotes tissue dissolution effects of NaOCl solution through rising its temperature, and by the improvement of irrigant contact to root canal walls, in addition to its cavitation and acoustic streaming effects; moreover, the rapid movement of this device enhances the shear stress of pulp tissue [21, 22]. A study by Niewierowski *et al.* also reported reduced dissolution time to its half with an ultrasonic device [23], which is in agreement with the present study. Additionally, it was reported that ultrasonic activation of NaOCl can accelerate chemical reactions and promote superior cleaning action [24]. Even though Leichtweis *et al.* showed a lower dissolution time when NaOCl solution was activated with ultrasonic device when compared to manual agitation, no significant difference was observed between these two investigated methods [25]. This difference in the results could be attributed to higher agitation time with ultrasonic used in the present study when compared to their research.

Based on the aforementioned, we conclude that sodium hypochlorite solution yielded better results with a concentration of 2.2% than sodium hypochlorite gel with a concentration of 2.2%. The activation via ultrasonic device was an efficient way to decrease the time to almost half.

## CONCLUSIONS

The 2.2% sodium hypochlorite gel was inferior to the sodium hypochlorite solution and its ability to dissolve the bovine's pulp tissue. In addition, the activation of ultrasonic device was able to shorten the duration of time to approximately more than half the period for the samples for complete dissolution.

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## CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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