

The Effect of Addition of Calcium Hypochlorite Disinfectant on Setting Expansion and Surface Hardness of Dental Stone

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Abstract

Background and Aim: Addition of disinfectants to dental stones is one method to prevent cross-contamination between patients and laboratory personnel. This study aimed to evaluate the effect of addition of calcium hypochlorite disinfectant on setting expansion and surface hardness of dental stone.

Materials and Methods: In this experimental study, calcium hypochlorite aqueous solution with 0.5% concentration was added to type V dental stone. Setting expansion was measured by extensometer in millimeter and surface hardness was measured by Rockwell hardness test machine. Data were statistically analyzed using t-test with 0.05 level of significance.

Results: The mean setting expansion values were 2.49 ± 0.0017 mm and 0.27 ± 0.0094 mm in the test and control groups, respectively and had a statistically significant difference. The mean Rockwell hardness number was 74 ± 1.93 and 85 ± 3.09 in the test and control groups, respectively with no statistically significant difference.

Conclusion: Setting expansion and surface hardness of type V dental stone increased and decreased, respectively by the addition of 0.5% calcium hypochlorite. Thus, this disinfection method needs modification for routine use in the laboratory setting.

Key Words: Calcium hypochlorite, Calcium sulfate, Disinfectants, Hardness

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Introduction

Transfer of infected materials from the clinic to the laboratory leads to cross-contamination. Previous studies have demonstrated isolation of pathogenic microorganisms from casts made of contaminated impressions [1, 2]. Several methods have been suggested for disinfection of dental casts. Most of these techniques are based on the immersion of casts in disinfecting solutions [3-5] or spraying the casts with the disinfectants [6].

Some authors have concluded that immersion of casts in the disinfecting solution may affect the final cast quality [7]; whereas, spraying the cast with the disinfectant has no adverse effect on its surface. The problem of spraying is its possible inefficacy due to the cast surface porosities [6]. Addition of chemicals to dental stone at the time of mixing [7-10] or use of acetones containing disinfecting agents [11] is another technique for disinfection of casts. However, it has been reported that

these techniques affect the mechanical properties of the casts namely setting time, compressive strength and dimensional stability [8]. Twomey et al. reported that addition of 0.5% calcium hypochlorite $\text{Ca}(\text{OCl})_2$ increased the compressive strength of dry type V dental stone [12]. This finding suggests that addition of a specific concentration of calcium hypochlorite to dental casts is clinically beneficial. Moreover, this concentration is capable of cast disinfection. Over 0.3% concentrations of calcium hypochlorite can lead to complete inactivation of microorganisms such as *B. subtilis* and the required amount of chlorine for inactivation of *B. subtilis* is equal to the amount required for inactivation of Hepatitis B and C viruses.

Dimensional stability of dental casts is extremely important because significant alterations of cast surface leads to the fabrication of low quality prosthesis. Use of stable low-expansion dental stone for the master cast can improve the adaptation and fit of indirect restorations [13]. Setting expansion for type V dental stone according to the ADA standard ranges from 0.01%-0.30% [14].

Disinfection should be done without changing the final quality of the casts. To the best of our knowledge, no study has evaluated the setting expansion and hardness of type V dental stone mixed with calcium hypochlorite. Thus, this study sought to assess the effect of calcium hypochlorite as disinfectant on setting expansion and hardness of type V dental stone.

Materials and Methods

Type V dental stone (Glastone® 3000, Dentsply Intl., York, PA) was used in this in-vitro experimental study.

Sample size was calculated using the t-test formula for sample size calculation. Test conditions were in accord with the ADA specification 25 and similar to relevant previous studies [15-17] at $23\pm 2^\circ\text{C}$ and $50\%\pm 10$ humidity. Instruments were stored in the mentioned conditions for at least 15h prior to testing.

For the setting expansion test, an extensometer made of stainless impermeable materials was used. This device had a V-shaped vent that was fixed on a jig and a removable steel cube with $30\pm 1\text{mm}$ dimensions weighing $200\pm 10\text{g}$. The continuous thickness of the vent was 4mm and the internal

width of each side was $30\pm 1\text{mm}$; the two reciprocal sides formed a 90° angle.

The vent was close-ended at one side and open ended at the other. To measure the expansion of specimens, a micrometer (Ericsson, Hudiksvall, Sweden) with 0.005mm readability fixed in place with an aluminum headstock was used. At first, the distance from the removable part of steel cube and fixed part of V-shaped vent was adjusted at $100\pm 0.1\text{mm}$ using a digital caliper (CCCP, Russia) with 0.05mm readability. The bottom of the V-shaped vent was covered with a rubber dam latex sheet (Dentorama, Stockholm, Sweden) with 0.1mm thickness to allow gypsum expansion [18].

Next, 100cc of water was mixed with 21g of dental stone powder according to the manufacturer's instructions using a vibrator (Whip Mix Corp., Louisville, KY) and poured into the V-shaped vent. This was performed in 2 groups of test and control. In the test group, 0.5% calcium hypochlorite (Petrochemical Co., Shiraz, Iran) was added to dental stone powder and in the control group dental stone powder was mixed with distilled water.

After pouring the mixture into the V-shaped vent, the vent was covered with a rubber dam latex sheet to prevent water vaporization from the mixture. Measurements were made one minute prior to the setting and 2h after the onset of mixing [15-17]. This test was repeated 10 times for each group and after each test, the percentage of expansion was calculated using the following formula:

$$L_F = \frac{L_F - L_0}{L_0} \times 100$$

Where L_0 is the primary length and L_F is the final length

For surface hardness testing, a rectangular stainless steel die measuring $38\times 8\times 8\text{mm}$ was used. Impressions were made using medium viscosity polyvinyl siloxane (Panasil® monophase medium, Kettenbach GmbH & Co., KG, Schoenberg, Germany) and acrylic resin special tray (Figure 1). A total of 20 impressions were made and divided into 2 groups. In group 1, dental stone powder was mixed with 0.5% calcium hypochlorite and in the control group, dental stone powder was mixed with distilled water according to the manufacturer's instructions on a vibrator and poured into the impressions. Specimens were then evaluated and those with fractures or voids were excluded and replaced with

new specimens. After 24h, each specimen was subjected to Rockwell hardness testing in a hardness tester (Hardness Tester 751, Instron Wolpert, UK) using a 1.16 inch diameter metal ball indenter with a primary load of 3kg and final load of 30kg at 5 points with 4mm distances. Based on the depth of penetration, the Rockwell hardness number was calculated by the machine.

The test results were analyzed using SPSS version 16 software and t-test at $P=0.05$ level of significance.

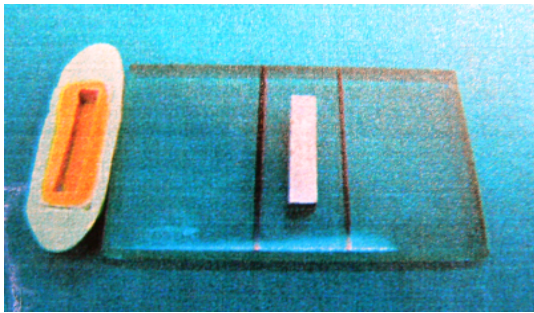


Figure 1. Metal die and acrylic resin tray used for surface hardness testing

Results

The mean setting expansion was 0.27 ± 0.0094 mm in the control and 2.49 ± 0.0017 mm in the test group; this difference was statistically significant ($P < 0.001$).

The mean surface hardness was 85 ± 3.09 in the control and 74 ± 1.93 in the test group; this difference was also statistically significant ($P < 0.001$).

Discussion

Dentists are exposed to pathogenic microorganisms in the saliva and blood. In prosthodontic dentistry, a direct cooperation between the dental office and laboratory is necessary for manufacturing dental prostheses. Disinfection of casts is important for obtaining contamination-free models because the transmission of infectious agents from the blood and saliva is possible via cast impressions [1]. Immersion disinfectants need to be diluted in water; which causes potential problems. Rudd et al. showed that immersion of dental casts in water for 15min changed the surface characteristics of the casts [19]. Casts are recommended to be immersed in the solution for over 30min for complete

surface disinfection; however, this method may have adverse effects on the cast surface [20].

The spraying technique for cast surface disinfection does not have the problems (such as decreased surface accuracy and hardness) associated with the immersion technique. A study on 3 disinfecting sprays of phenol, iodophor and glutaraldehyde showed that they can be safely and effectively applied to dental stone products without compromising their compressive strength [6]. The main drawback of spray disinfection is its inability to completely cover the entire surface of the cast in the expected time. Depending on the angle of spray tip, undercuts in the proximal areas may not be completely disinfected. Moreover, the porous nature of stone casts necessitates complete immersion of surface into the disinfecting solution; which is extremely difficult, if not impossible, with spraying [6]. The destructive potential of immersion technique and incomplete surface coverage in the spray technique led to the development of a new method based on direct incorporation of the disinfecting material into the hemi-hydrated calcium sulfate. This method has yielded promising results in previous studies [3, 7, 8].

Tebrock et al. mixed type V dental stone with sodium hypochlorite and observed no growth of *B. subtilis* in the disinfected casts [3]. Mensfield et al. showed that within an hour after the application of sodium hypochlorite and glutaraldehyde, number of pathogenic microorganisms decreased to the level of negative control group. Although application of sodium hypochlorite can effectively disinfect the casts, its effect on the physical properties of casts raises some concerns [7]. Ivonovski et al. reported a reduction in compressive strength following the incorporation of sodium hypochlorite as the disinfecting agent [8]. Abdelaziz et al, also reported a reduction in compressive and tensile strengths of type III and V dental stones following the incorporation of sodium hypochlorite [10]. It is assumed that sodium ions from the sodium hypochlorite interfere with the calcium compounds in the gypsum structure and affect its strength. In our study, calcium hypochlorite was used as an additive due to its significant disinfecting properties. It appears that calcium salt has a less significant effect on the structure and properties of calcium sulfate dihydrate compared to sodium hypochlorite.

Previous studies have shown that incorporation of 0.5% sodium hypochlorite into type V dental stone increased its compressive strength in dry conditions and completely inactivated microorganisms like *B. subtilis*. We also evaluated two other physical properties namely setting expansion and surface hardness of type V dental stone following the incorporation of 0.5% sodium hypochlorite as the disinfectant. The results revealed that application of 0.5% calcium hypochlorite significantly decreased surface hardness and increased setting expansion.

Adaptation, fit and success of cast restorations depend on the characteristics of die material namely dimensional accuracy, setting expansion, strength and the ability to reconstruct the details. If the die possesses the mentioned properties, restoration margin will have better contact with the finish line [21] and consequently problems due to the marginal misfit of the restoration namely dissolution of cement [22], development of caries [23, 24], pulp injury [25], microbial plaque accumulation [26], alteration of subgingival microbial flora [27] and gingival inflammation [13-28] are minimized. Precision and stability of master cast are of the primary requirements for the fabrication of implant-supported prosthesis. Marginal misfit and inadequate seal in implant supported restorations increase cement dissolution at the margin and lead to the application of eccentric lateral loads to the implant [15].

Moreover, marginal misfit can cause plastic distortion of metal framework, ceramic separation, fracture of implant system components and plaque accumulation and subsequently compromise the longevity of restoration [29, 30].

The results of our study regarding setting expansion were in contrast to those of Abbas et al, who showed that incorporation of 0.5% calcium hypochlorite into type III dental stone decreased setting expansion [31]. However, our findings confirmed the results of Breault et al, [9], Ivonovski et al, [8] and Abdelaziz et al, [32]. Changed morphology of gypsum crystals may change the orientation of crystals and consequently alter the setting expansion [8].

In our study, surface hardness of dental stone in the test group was less than in the control group and the Rockwell hardness number was 74 ± 1.93 in the test and 85 ± 3.09 in the control group. In the study

by Abbas et al, the Brinell hardness number was 2.3 and 3 in the test and control groups, respectively [31] and similar to our study, the hardness number decreased in the test group. However, their study was performed on type III dental stone. Addition of calcium hypochlorite may affect the internal crystalline structure and decrease the internal bonds.

In our study, Rockwell hardness test was used due to its high popularity, enabling direct reading of the penetration depth and ease of use. Considering the results of our study and previous ones, further investigations on this method of cast disinfection seem necessary in order to come up with strategies to eliminate its shortcomings. Future studies are recommended to focus on different concentrations of disinfectants, different types of dental stones and mechanical properties of gypsums.

Conclusion

1. The setting expansion of type V dental stone mixed with 0.5% calcium hypochlorite was higher than that of type V dental stone mixed with distilled water.

2. Surface hardness of type V dental stone mixed with 0.5% calcium hypochlorite was less than that of type V dental stone mixed with distilled water.

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