

EFFECT OF CALCIUM HYPOCHLORITE AS DISINFECTING ADDITIVE ON THE DIAMETRAL TENSILE STRENGTH OF DENTAL STONE TYPE III USING DIFFERENT DRYING METHODS ⁺

تأثير هايبو كلوريت الكالسيوم كمادة معقمة على قوة الشد القطرية لمادة الجبس الحجري الصلب
نوع ٣ باستخدام طرق تجفيف مختلفة

Hawraa Khalid Aziz *

Abstract:

This In-vitro study was conducted to evaluate the effect of calcium hypochlorite as a disinfectant solution in different concentration on the diametral tensile strength (DTS) of type III dental stone by using microwave and air-drying methods.

Calcium hypochlorite [Ca(OCL)₂] solution was prepared in the concentration from 0.3 to 1.8% and cylinder specimens of type III dental stone were constructed according to manufacturer's recommendation. Half of specimens were dried in open air, the other dried in a microwave oven for 10 minutes. All these specimens were tested under diametral tensile strength using Instron testing machine with cross head speed 0.5 cm/min. ANOVA, least significant difference and student T-Test were used for statistical comparisons.

The results indicated that the strength of stone was decreased with increased of concentration of disinfectant with exception that there was no significant difference between 0.3% and control group. In addition to the strength values for dental stone dried in microwave oven were higher than those dried in open air. The conclusion of this study it is possible to mix 0.3% Ca(OCL)₂ solution with dental stone, as well as the use of microwave oven for drying stone had positive effect on the tensile strength.

المستخلص :

أجريت هذه الدراسة المختبرية من اجل تقييم تأثير مادة هايبوكلوريت الكالسيوم كمادة معقمة وبتراكيز مختلفة على قوة الشد القطرية لمادة الجبس نوع ٣ باستخدام طريقتين مختلفتين للتجفيف أما بالهواء أو بفرن المايكروويف. حضر محلول هايبوكلوريت الكالسيوم بتراكيز تتراوح من ٠,٣ - ١,٨ %، صنعت العينات اسطوانية الشكل من مادة الجبس بحسب توصيات الشركة المصنعة. نصف هذه العينات تم تجفيفها في الهواء والنصف الأخر تم تجفيفها بفرن المايكروويف لمدة ١٠ دقائق، وبعد ذلك تم تحديد قوة الشد القطرية لجميع العينات باستخدام جهاز Instron وبسرعة ٠,٥ سم / دقيقة .

أظهرت النتائج ان قوة مادة الجبس تقل بزيادة التركيز ماعدا لايوجد فرق معنوي بين استخدام تركيز ٠,٣ % وعدم استخدام المادة المعقمة بالإضافة إلى قيم قوة الشد لمادة الجبس التي تم تجفيفها بفرن المايكروويف كانت أعلى من قيم المجاميع التي تم تجفيفها في الهواء. تبين من النتائج ان من الممكن مزج محلول هايبوكلوريت الكالسيوم بتركيز ٠,٣ % مع مادة الجبس بالإضافة إلى استخدام المايكروويف كان له تأثير ايجابي على قوة الشد لمادة الجبس.

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*Lecturer/ College of Health and Medical Technology

Introduction:

The oral environment harbors a large number of micro organisms in the saliva and blood that may contain infections microbes and cause infections diseases that may incurable, such as those caused by the hepatitis C and HIV virus [1]. On the other hand, several dental materials, instruments and equipments cannot be easily sterilized. Thus a potential for bacterial cross contamination between the dental operator and the prosthetic laboratory has been established, constituting a potential health hazard in prosthesis from the dental laboratory as well as a potential pathogenic hazard to both professional staff and patients [2]. So the gypsum casts made from contaminated impressions can be a medium for cross-contamination between the patients and dental Personnel [3,4] therefore the American dental association (ADA) and the centers for disease control and prevention have suggested methods for the disinfection of dental casts, including immersion in or spraying with a disinfectant [5,6].

Dental stone with superior mechanical properties such as high compressive strength and fracture resistance should be produced [7,8]. Generally, the compressive strength of gypsum products is related to water/powder ratio, mixing time, volume of mixture, chemical composition [9], and may effected by incorporating additive [10] or mixing the stone with different solution [11]. Because the disinfection used for immersion of dental casts are diluted in water thus creating problems that altered surface properties that caused negative effect on the surface integrity and strength problems of dental casts [12]. As well as the spray technique for disinfecting the surface of casts appear to eliminate the surface detail [1], and the inability to assume that every impression presented to the laboratory has been disinfected, therefore incorporating of the disinfectant directly into the stone is needed to develop dental stone have disinfecting properties with adequate compressive and tensile strengths [1]. In previous studies, different disinfectant solutions added to dental stone cast and the physical and mechanical properties like the compressive strength [13,14,15] and tensile strength were evaluated [16,17].

Although, the manufactures advised to wait 24 to 48 hours before manipulating gypsum casts [18] because the wet casts usually have inadequate strength and surface hardness but the dentists find it necessary to work with casts soon after they are poured therefore drying dental stone in microwave oven can save the time but the strength of the material may be affected [19]. In previous studies, different kinds of gypsum products and investment materials were dried in air, conventional oven and microwave oven, and their compressive strengths [7,8,20] and surface hardness values were compared [21]. The diametrical tensile test (DTS) of dental stone was evaluated because it successfully with material that exhibit limited plastic deformation [22]. This can be maintenance by the compressive load introduces a tensile stress in the plane at force application and the tensile stress can be measured in direct proportion to compressive load applied [19]. The objectives of this study was to evaluate the effect of calcium hypochlorite solution as disinfecting additive in different concentration on diametral tensile strength of dental stone that dried in either air or microwave oven.

Materials and Methods:

In this study, type III dental stone was used (Geastone, Italy). The calcium hypochlorite (BDH, England) was added in different concentration from 0.3 – 1.8% and diametral tensile strength was evaluated using two different drying methods.

The calcium hypochlorite [Ca(OCL)₂] solution was prepared according to the manufacture's instructions regarding the dilution, manipulation and storage. The calcium hypochlorite solutions were prepared in four concentration (0.3, 0.8, 1.3 and 1.8%) by weight (Table 1)

Table (1): Concentration of Ca(OCL)₂ solution used in this study.

Ca(OCL) ₂	Distilled water	Solution concentration
0.3 gm	100 ML	0.3%
0.8 gm	100 ML	0.8%
1.3 gm	100 ML	1.3%
1.8 gm	100 ML	1.8%

The total number of specimens were prepared and divided into five main groups according to the concentration of calcium hypochlorite from 0.3-1.8% , and each group subdivided into two groups according to the way of dryness as following:

- Group A → A₁: stone powders mixed with distilled water and air-dried
(control group) → A₂: stone powders mixed with distilled water and microwave-dried.
- Group B → B₁: stone powders mixed with 0.3% Ca(OCL)₂ and air-dried
→ B₂ : stone powders mixed with 0.3% Ca(OCL)₂ and microwave-dried.
- Group C → C₁: stone powders mixed with 0.8% Ca(OCL)₂ and air-dried
→ C₂ : stone powders mixed with 0.8% Ca(OCL)₂ and microwave-dried.
- Group D → D₁: stone powders mixed with 1.3% Ca(OCL)₂ and air-dried
→ D₂ : stone powders mixed with 1.3% Ca(OCL)₂ and microwave-dried.
- Group E → E₁: stone powders mixed with 1.8% Ca(OCL)₂ and air-dried
→ E₂ : stone powders mixed with 1.8% Ca(OCL)₂ and microwave-dried.

All the test specimens were mixed according to the manufacture recommended water/powder ratio, each 100 gm of dental stone powder was weighed using electronic balance and mixed with 30 ML of tested solutions. The standard mix was made by adding dry powder to the recommended amount of the testing solutions (distilled water or Calcium hypochlorite solutions) in clean rubber bowl. The mixture was allowed to soak for 20 seconds and then mixed for 30 seconds to a smooth consistency using a Mechanical Vacuum Mixer. The Mixing procedure was done following ADA specification No.25 for gypsum products [23]. The silicone rubber mold which has cylindrical shape of 10 mm in height and 5 mm in diameter was used to prepare the specimens. The Mixture was poured into the mold and vibrated for 30 sec. , and glass slab was placed over the mold and pressed firmly to the top surface to ensure parallel flat ends .

The constructed specimens were removed from the mold after setting period . Half of these specimens were stored in air at room temperature range $20 \pm 2C^{\circ}$ that was controlled by using thermometer that checked the temperature from time to time daily, and the other half after 10 minutes of initial setting in the silicone rubber mold they dried in microwave oven for 10 minutes and then left at room temperature for remaining time period [19] .

The diametral compression test was conducted on an Instron universal testing machine (Instron , England) at cross head speed 0.5 cm/min. The specimens were placed on the testing machine between the table at the bottom and the fracturing section, the cylindrical specimens

were compressed until fracture occurred. The maximum load carried by each specimen was taken from a digital screen of the machine and calculation of the diametral tensile strength value was obtained from the maximum load at the point of specimen fracture according to the following formula :

$$\text{Diametral tensile strength (DTS)} = \frac{2P}{\pi DT} \quad [24]$$

Where P is the Load , D the diameter specimen , and T the specimen thickness . The results were recorded in Mpa. Analysis of variance test (ANOVA) was used to compare the significance of the results among all groups. The least Significant Difference test (LSD) to compare between the different concentration of Ca(OCL)₂ groups, and the T-test to compare between air-dried and microwave-dried groups .

Results :

The mean DTS values for each tested group of different concentration of Ca(OCL)₂ from 0.0-1.8% and different drying methods are presented in Figure 1 .

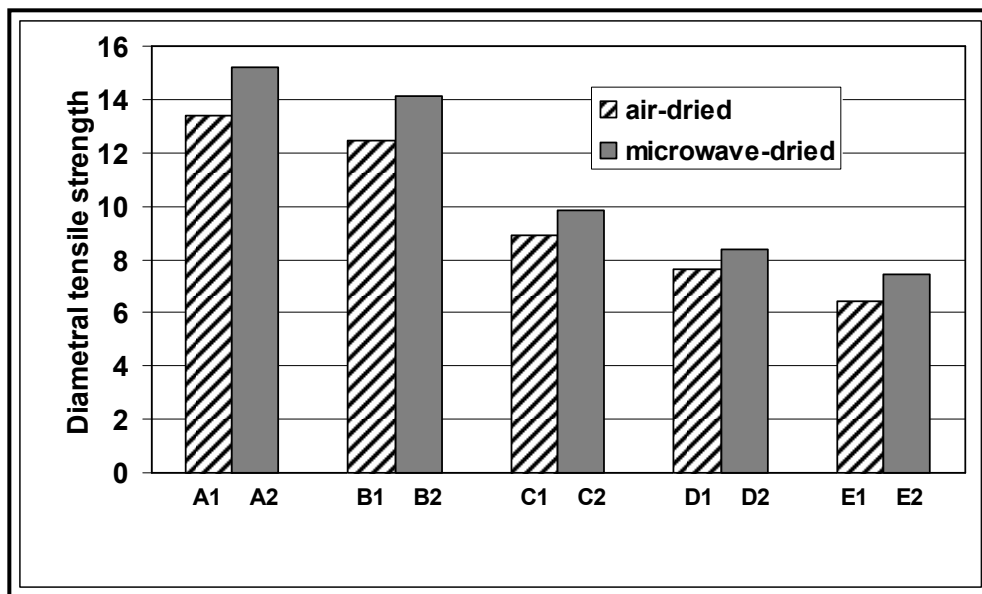


Figure (1) : Bar chart showing mean values of Diamtral tensile strength for each tested group.

The effect of addition of calcium hypochlorite solution on the strength showed the highest mean values of DTS were recorded to the control group without adding of Ca(OCL)₂ then the group of 0.3% Ca(OCL)₂ , then group of 0.8% of Ca(OCL)₂ then the group of 1.3% of Ca(OCL)₂ and finally group of 1.8% Ca(OCL)₂ (Table 2) . While the effect of the drying methods showed the mean DTS values for air-dried dental stone were 13.37 , 12.48 , 8.91 , 7.66 , 6.42 MPa from the control group to 1.8% of Ca(OCL)₂ respectively , and the microwave-dried dental stone exhibited higher mean values were 15.21 , 14.14 , 9.83 , 8.40 , 7.44 MPa from control group to 1.8% of Ca(OCL)₂ , respectively (Table 2) .

Table (2) Mean , Minimum and Maximum values of DTS , standard deviation and Standard Error for each group

Studied groups		No	Mean	Mini. value	Max. value	Std. value	Std. Error
Group A	Stone + distilled water air-dried(A ₁)	5	13.37	12.10	14.65	1.0056	0.449
	Stone + distilled water Microwave-dried(A ₂)	5	15.21	14.01	16.56	0.934	0.417
Group B	Stone + 0.3% Ca(OCL) ₂ air-dried (B ₁)	5	12.48	11.46	13.37	0.726	0.324
	Stone + 0.3% Ca(OCL) ₂ Microwave-dried (B ₂)	5	14.14	13.50	14.65	0.502	0.224
Group C	Stone+0.8%Ca(OCL) ₂ air-dried (C ₁)	5	8.91	7.64	10.19	1.007	0.450
	Stone+0.8%Ca(OCL) ₂ Microwave-dried (C ₂)	5	9.83	8.92	11.34	0.985	0.440
Group D	Stone+1.3%Ca(OCL) ₂ air-dried (D ₁)	5	7.66	6.37	8.92	0.955	0.427
	Stone+1.3%Ca(OCL) ₂ Microwave-dried (D ₂)	5	8.40	7.00	9.68	1.110	0.496
Group E	Stone+1.8%Ca(OCL) ₂ air-dried (E ₁)	5	6.422	5.37	7.26	0.748	0.334
	Stone+1.8%Ca(OCL) ₂ Microwave-dried (E ₂)	5	7.44	6.50	8.41	0.730	0.326

ANOVA was used to test the main effect of calcium hypochlorite concentration and drying method that showed there was highly significant differences between all tested groups (Table 3) .

Table (3): ANOVA test of DTS values for all groups.

	Sum of squares	df	Mean square	F	P-value	Sig.
Between groups	444.252	9	49.361	62.552	0.000	Highly Sig. P<0.01
Within groups	31.565	40	0.789			
Total	475.817	49				

The effect of adding disinfectant to the dental stone on the strength showed when the concentration increased cause decreased in the strength (Table 4) that showed there was highly significant differences between the control group and groups of (0.8%,1.3% and 1.8% of Ca(OCL)₂) with the exception for the group of 0.3% of Ca(OCL)₂ and control group showed non significant difference (P>0.05) in the diametral tensile strength values.

Table (4): the least significant difference (LSD) for multiple comparison test of DTS of dental stones with different concentration of Ca(OCL)_2 .

Studied groups		P-Value	Sig.
Distilled water 0% Ca(OCL)_2 Air-dried (A_1)	0.3% Ca(OCL)_2 air-dried (B_1)	0.120	Non sig. $P>0.05$
	0.8% Ca(OCL)_2 air-dried (C_1)	0.000	Highly Sig. $P<0.01$
	1.3% Ca(OCL)_2 air-dried (D_1)	0.000	Highly Sig. $P<0.01$
	1.8% Ca(OCL)_2 air-dried (E_1)	0.000	Highly Sig. $P<0.01$
0.3% Ca(OCL)_2 Air-dried (B_1)	0.8% Ca(OCL)_2 air-dried (C_1)	0.000	Highly Sig. $P<0.01$
	1.3% Ca(OCL)_2 air-dried (D_1)	0.000	Highly Sig. $P<0.01$
	1.8% Ca(OCL)_2 air-dried (E_1)	0.000	Highly Sig. $P<0.01$
0.8% Ca(OCL)_2 Air-dried (C_1)	1.3% Ca(OCL)_2 air-dried (D_1)	0.032	Sig. $P<0.05$
	1.8% Ca(OCL)_2 air-dried (E_1)	0.000	Highly Sig. $P<0.01$
1.3% Ca(OCL)_2 Air-dried (D_1)	1.8% Ca(OCL)_2 air-dried (E_1)	0.032	Sig. $P<0.05$
Distilled water microwave-dried (A_2)	0.3% Ca(OCL)_2 microwave-dried (B_2)	0.064	Non sig. $P>0.05$
	0.8% Ca(OCL)_2 microwave-dried (C_2)	0.000	Highly sig. $P<0.01$
	1.3% Ca(OCL)_2 microwave-dried (D_2)	0.000	Highly sig. $P<0.01$
	1.8% Ca(OCL)_2 microwave-dried (E_2)	0.000	Highly sig. $P<0.01$
0.3% Ca(OCL)_2 microwave-dried (B_2)	0.8% Ca(OCL)_2 microwave -dried (C_2)	0.000	Highly sig. $P<0.01$
	1.3% Ca(OCL)_2 microwave -dried (D_2)	0.000	Highly sig. $P<0.01$
	1.8% Ca(OCL)_2 microwave -dried (E_2)	0.000	Highly sig. $P<0.01$
0.8% Ca(OCL)_2 microwave-dried (C_2)	1.3% Ca(OCL)_2 microwave -dried (D_2)	0.015	Highly sig. $P<0.01$
	1.8% Ca(OCL)_2 microwave -dried (E_2)	0.000	Highly sig. $P<0.01$
1.3% Ca(OCL)_2 microwave-dried (D_2)	1.8% Ca(OCL)_2 microwave -dried (E_2)	0.093	Non sig. $P>0.05$

While the effect of drying method on the dental stone strength. The statistical comparison showed there was highly significant differences between the air-dried dental stone and the microwave-dried dental stone (Table 5). Except groups of 1.8% Ca(OCL)_2 there was non significant differences in the diametral tensile strength values.

Table (5): Student t-test to compare the DTS values of air-dried and microwave-dried groups.

Studied groups		P-Value	Sig.
Distilled water air-dried (A ₁)	Distilled water microwave-dried (A ₂)	0.006	Highly Sig. P<0.01
0.3% Ca(OCL) ₂ air-dried (B ₁)	0.3% Ca(OCL) ₂ microwave-dried (B ₂)	0.003	Highly Sig. P<0.01
0.8% Ca(OCL) ₂ air-dried (C ₁)	0.8% Ca(OCL) ₂ microwave-dried (C ₂)	0.002	Highly Sig. P<0.01
1.3% Ca(OCL) ₂ air-dried (D ₁)	1.3% Ca(OCL) ₂ microwave-dried (D ₂)	0.007	Highly Sig. P<0.01
1.8% Ca(OCL) ₂ air-dried (E ₁)	1.8% Ca(OCL) ₂ microwave-dried (E ₂)	0.177	Non Sig. P>0.05

Discussion:

The techniques recommended by the ADA for disinfecting dental casts include immersion or a topical spray with a solution of hypochlorite or iodophore [2], but the potentially damaging effects of the immersion technique, difficulty in covering the entire surface of the cast with spray disinfecting solution, so the disinfecting solution have been incorporated with stone mixture should be evaluated, therefore calcium hypochlorite was chosen as an additive because of its well known disinfecting properties, and because it was hypothesized that the calcium salt would have less effect on structure and properties of calcium sulfate dihydrate compared to sodium hypochlorite [1].

The addition of calcium hypochlorite to the stone at the concentration starting from 0.3% because it is the lowest concentration of the disinfection (from 0.3% and higher) that resulted inactivation of bacillus subtilis phi 29 and correlates to being able to inactivate viruses such as hepatitis B and C [25].

The results showed the addition of calcium hypochlorite caused a reduction in the diametral tensile strength of dental stone this result in agreement with result of Berko [15] who concluded that the addition of different disinfectant solutions in the dental stone produced a reduction in compressive strength. Also Ivonovski *etal* [16] and Abdelaziz *etal* [17], they reported a decrease in the compressive and tensile strength of dental stone with the addition of sodium hypochlorite.

The reduction in the tensile strength could be attributed to the reduction in the inter crystalline cohesion [26]. It may also due to the alteration in the crystal morphology which could effect the ability of the crystals to intermesh and grow loding to improper inter-meshing and reduction in inter crystal cohesion [27]. Also this result disagreement with Al-Shakily [13] and Paul *etal* [14] they investigated the properties of gypsum after incorporation of disinfectant and resulted increased in the compressive strength of dental stone.

One the other hand, the result showed that the dryness of dental stone in air had lower mean DTS values than those dried in microwave the cause of that during the drying process of dental stone there is free water found in the cast material that weakening its structure and even

after 1 hour after mixing of type III dental stone there is approximately 7% excess of water remains in air dried gypsum material [27], so the specimens dried in the microwave oven in all groups more resistance to the compressive force than air dried specimens this result in agreement with the result of Hersek *etal* [19] who concluded that the drying dental stone in a microwave oven produced higher diametral tensile strength than air dried method.

Conclusions:

Within the limitations of this in vitro study, it is possible to prepare dental stone that contains disinfectant (0.3% calcium hypochlorite) has adequate strength, and dry in microwave for 10 minutes produce strength higher than air-dried. So with the importance of the time required to obtain stronger stones microwave oven is used for drying the dental stone.

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