

## Evaluation of the Effect of Microwave Irradiation and Die Hardener Application on Surface Hardness of Type IV Dental Stone

Suha Fadhil Dulaimi. <sup>(1)</sup>

Lateef E. A. Al-Jorani. <sup>(2)</sup>

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die hardener,  
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stone, surface  
hardness,  
microwave  
irradiation, die  
stone.

### Abstract

Type IV dental stone play an important role during fabrication of indirect dental restoration. It should be accurate in every respect, dimensionally stable over time, hard enough to with stand fabrication process resistant to the inadvertent abrasions caused by fabrication. The aim of present study was to evaluate the effect of microwave irradiation and die hardener application on surface hardness of type IV dental stone. Two commercial brands of type IV dental stone (Spofadental/ Czech, Zhermack/ Italy) were evaluated. 30 samples were prepared from each brand and left to dry for 24hr. After that divided into three groups, control group (10 samples without treatment), 10 samples subjected to microwave irradiation at 650 watt output power and 2450 MHZ for 10 mint. And 10 samples painted with die hardener. Surface hardness measured with Shore C (Durometer, Digital hardness tester). The die hardener application not affect surface hardness of both brands ( $P>0.05$ ). However microwave irradiation increase surface hardness of Spofadental Type IV dental stone. But reduce surface hardness of Zhermack Type IV dental stone. After 24hr. of pouring Type IV dental stone (Spofadental / Czech, Zhermack / Italy) die hardener application not affect surface hardness. However surface hardness of Spofadental Type IV dental stone may be improved with microwave irradiation. But Zhermack Type IV dental stone showed reduction in surface hardness after microwave irradiation.

### Introductio

Gypsum products are important materials in dentistry for the fabrication of indirect dental prostheses. In dentistry gypsum materials must be able to reproduce fine details in impressions so that the gypsum models will be as accurate as possible. For high strength die reproduction of details is especially critical because a precision casting will be fabricated on the gypsum die <sup>(1)</sup>.

Die used to fabricate indirect dental restoration are often cast in Type IV or V gypsum materials to get a hard and accurate surface on which to fabricate the wax pattern of the restoration. Therefore it's essential to obtain a strong cast with smooth and hard surface characteristic, in order to allow for wax sculpting especially at the cervical margin without cast abrasion <sup>(2)</sup>.

One of the methods to increase surface hardness is application of surface coating with resin film called die hardener. It's recommended to improve gypsum hardness or abrasion resistance. This becomes popular technique because of

(1) Ass. Pro., Dental technologies Department, Collede of health and Medical technology.

(2) Ass. Pro., Dental technologies Department, Collede of health and Medical technology.

ease of application and low cost. Different materials such as cyanoacrylate and epoxy resins have been utilized as die hardener<sup>(3, 4)</sup>.

However there is a conflict in results of studies regarding their effect on surface hardness of dental stone. Some studies stated that die hardener improve surface hardness. While others found that die hardener application didn't improve surface hardness of dental stone<sup>(5, 6)</sup>.

Microwave energy was first used for drying gypsum products in 1985. But authors found that drying extremely wet or water-soaked casts may crack or destruct the cast because of rapid boiling of free water<sup>(7)</sup>. After 2 hr. of pouring gypsum microwave energy could improve surface hardness, but still 24hr. air drying produce harder gypsum<sup>(8)</sup>.

Another benefit of microwave irradiation of stone casts is better disinfection than chemical disinfection of gypsum products<sup>(9, 10)</sup>.

Therefore the purpose of the present study was to evaluate the effect of microwave irradiation and die hardener application on surface hardness of two commercial brands of Type IV dental stone.

## Materials and method:

Preparation of dental stone samples:

A total of 60 samples were made from type IV dental stone. For each commercial brand of type IV dental stone (Elite Rock, Zermack, Italy, Convertin, Spofadental, Czech) 30 samples were prepared from hand mixing dental stone with distilled water according to manufacturer instruction (water\powder ratio) 100g\30ml. An electronic balance (Beurer, Germany) and measuring cylinder were used to perform accurate water \powder ratio. The mixed stone were poured down the side of a plastic mold with dimension of (43mm diameter and 4mm in height) which was vibrated using vibrator (Mestra, Spain) to remove air bubbles. Then all samples were allowed to set for 1 hr, in air at room temperature range of  $23 \pm 2c$ , after that all specimens were removed from the mold and left to dry for 24 hr, at room temperature range of  $23 \pm 2c$ <sup>(11,12)</sup>.

## Samples grouping:

Group I: (Spofadental type IV dental stone).

Group IA: control group 10 samples air dried for 24 hr.

Group IB: after air drying for 24 hr 10 samples were placed in microwave oven (Samsung, Korea) at 650 watt output power and 2450 MHZ for 10 mints.<sup>(11, 13, 14)</sup>. A cup with 200 ml water was

Placed in the microwave oven to protect magnetron<sup>(15)</sup>.

Group IC: after air drying for 24 hr. 10 samples were coated with die hardener (hardening bath, Renfert, Germany).

Group II: (Zhermack type IV dental stone).

Group II A: control group 10 samples dried for 24 hours.

Group II B: after air drying for 24 hr. 10 samples were placed in microwave oven (Samsung, Korea) at 650 watt output power and 2450 MHZ for 10 mints.<sup>(11, 13, 14)</sup>. A cup with 200 ml Water was placed in the microwave oven to protect magnetron (15).

Group II C: after air drying for 24 hr. 10 samples were coated with die hardener (hardening bath, Renfert, Germany).

## Testing procedure:

Shore C (Durometer) hardness test was performed using (Digital hardness tester HT\_6510C Shore C Shenzhen Handsome Technology G. Ltd. China). For each samples hardness was measured at 3 points in different positions .the average hardness number for each sample was then calculated separately and same procedure was conducted for the remaining test samples<sup>(16)</sup>.Fig (1)

## Statistical Analysis

The data obtained from the study was subjected to both descriptive and analytic statistics. The Student's T-test was used to evaluate the significant of difference between each pair of groups for effect of microwave irradiation and die hardener application for the two commercial types of Type IV dental stone, using a significance level of 5%. All computations

were conducted with Spss software version 18.0 (SPSS, IL, USA).

## Results:

1. Surface hardness of Type IV dental stone (Spofadental). Descriptive statistic of the results for evaluation of surface hardness of type IV dental stone (Spofadental) appears in Table (1) Fig (2). Paired sample T-test between control and experimental groups Table (2) showed that die hardener application showed no significant difference from control (P-value 0.79  $p > 0.05$ ). While microwave oven irradiation showed significant increase in surface hardness (P-value 0.000  $p < 0.001$ ).
2. Surface hardness of Type IV dental stone (Zhermack). For type IV dental stone (Zhermack) descriptive statistical of results for evaluation of surface hardness appear in Table (3) Fig (3). Paired sample T-Test between control and experimental groups Table (4) showed that die hardener application showed no significant difference from control (P-value 0.266  $P > 0.05$ ). While microwave oven irradiation caused significant reduction in surface hardness (P-value 0.010  $P < 0.01$ ).

## Discussion:

The present study evaluate surface hardness of two commercial type IV dental stone (Spofadental, Zhermack) subjected to two different experimental condition (microwave irradiation, die hardener application) that could be subjected under usual laboratory work.

The Shore (Durometer) hardness test performed in present study conforms to all international standards and is easy to use. Each durometer type is made to a specific scale (i.e. A, B, C, D) and capable of producing a value between 0 and 100. Shore hardness is a measure of the resistance of a material to penetration of a spring loaded needle like indenter. The indenter is attached by a lever to a scale that is graduated from 0 to 100 units. If the indenter completely penetrates, the specimen a reading of (0) is obtained, and if no penetration occurs a reading of (100) units results. Shore C hardness test use maximum force (4533 g). ([www.shoreinstrument.com](http://www.shoreinstrument.com))

For Spofadental type IV dental stone showed no significant effect with application of die hardener on surface hardness. Also for Zhermack type IV dental stone with P value  $P > 0.05$ .

Die hardener application or coating is recommended to increase hardness and abrasion resistance of dental stone<sup>(17)</sup>. The result of present study disagree with, previous studies have different results regarding the effect of die hardener on surface hardness of dental stones. This may be caused by differences in measurement method used since hardness is physical property of materials. The influence of die coating is potentially more important as an approach to reduce surface abrasion and Water absorption of die stone<sup>(4)</sup>.

Khan et.al. (2012) found that die hardener application (cyanoacrylate resin) to type IV dental stone can increase surface hardness measured by abrasion test<sup>(5)</sup>. Nano indentation study with SEM (scanning electron microscope) explained the effect of die hardener application on dental stone surface. They stated that die hardener liquid infiltrated into the surface of the specimen to a depth of 3 – 5  $\mu\text{m}$  to form die hardener penetrated layer, filling subsurface voids and sealing the gypsum surface by capillary effect. The possible mechanism of increase abrasion resistance with the die hardener coating could be that the resin film acted as a solid lubricant and decrease the friction between indenter and stone surface. The possible reason could be that these studies used high load and have a deeper penetration depth crossing the thin layer of stone crystal and die hardener resin<sup>(18)</sup>. They explained why some reports concluded that die hardener reduce the surface hardness<sup>(3)</sup>.

Microwave sterilization is an alternative method for cast sterilization against pathogens that could be transmitted from oral cavity to impression surface and further to the casts<sup>(10)</sup>.

Also repeated microwave irradiation does not have any negative effects on dimensional accuracy of stone casts<sup>(19,9)</sup>.

In addition microwave oven may be used as drying technique of gypsum casts<sup>(20)</sup>. Microwave irradiation for type IV dental stone (Spofadental) cause significant

increase in surface hardness of dental stone ( $P < 0.001$ ) while (Zermack type IV dental stone showed significant reduction in surface hardness ( $P < 0.01$ ).

Our results agree with Anaraki et.al.(2014) (19) they found two brands of type IV dental stone respond differently to repeated microwave irradiation, one not affected and the other showed increase in surface hardness after microwaving. The reasons for conflict in result in present study and previously mention study between the different brands of dental stone explained.<sup>(21) (22)</sup>. They stated that it could be due to environmental condition during experiment as well as storage condition, which are factors that might influence the hardness of final stone body. In the present study all these factors were standardized. But the setting expansion is different between the brands of dental stone<sup>(21)</sup> setting expansion and surface hardness is closely related properties for gypsum product as stated by<sup>(23)</sup>.

During setting procedure of gypsum product setting expansion of stone mass is improved by progressive conversion of hemihydrates molecules to dihydrate crystals giving harder surface<sup>(19, 21)</sup>. Therefore the deposition and cross joining of dihydrate crystals need enough time in the presence of water. Removal of water at early hours after pouring prevents expansion of the cast to the optimal value<sup>(2, 8)</sup>.

According to previously mention information in the present study for type

IV dental stone (Spofadental) after 24 hr of pouring might reach its optimal setting expansion and microwave irradiation remove the remind excess water that cause significant increase in surface hardness mean (97  $P < 0.001$ ) in comparison with control.

While the (Zermack) type IV dental stone after 24 hr pouring might not reach optimal setting expansion and microwave irradiation remove water before complete growth of dihydrate crystals of stone that cause significant reduction in surface hardness 89.8 mean  $P < 0.01$  in comparison to control. Further study should be done to investigate the setting expansion of Spofadental type IV dental stone and Zermack type IV dental stone.

### Conclusion:

Within the limitation of present study the following conclusion can be shown:

1. Surface hardness of type IV dental stone (Spofadental, Zermack) not affected by die hardener application.
2. Type IV dental stone (Spofadental) showed increased in surface hardness after microwave irradiation after 24 hr from pouring.
3. Type IV dental stone (Zermack) shown reduction in surface hardness after microwave irradiation after 24 hr from pouring.

Conflict of interest: the authors have no conflict of interest with any organization or institute.



Fig. (1): Testing procedure : Digital hardness tester used to measure surface hardness of stone sample

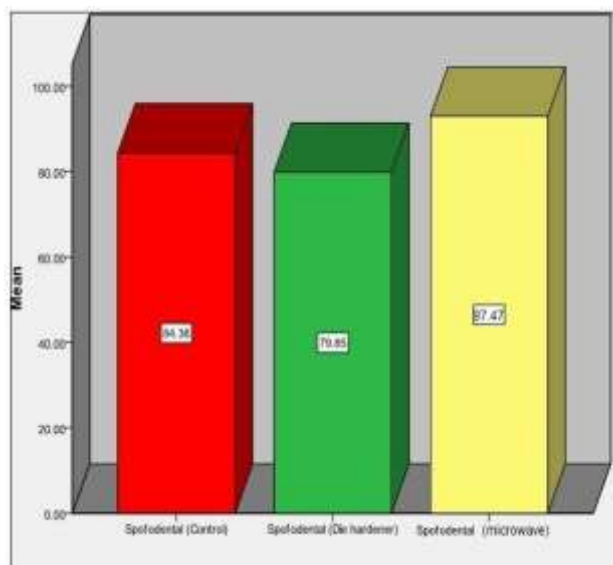


Fig (2): Mean values of Surface hardness of Type IV dental stone (Spofadental).

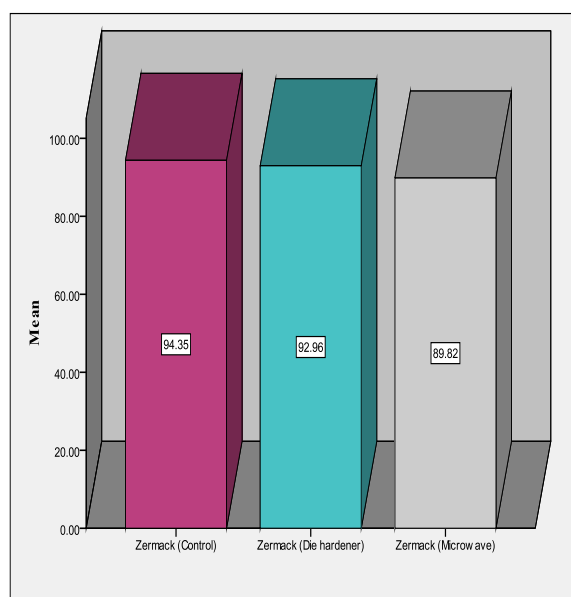


Fig (3): Mean values of Surface hardness of Type IV dental stone (Zermack).

Table (1): Descriptive statistics of surface hardness of type IV dental stone (Spofadental)

Statistics parameters	Group I		
	Control IA	Die hardener IB	Microwave IC
Mean	84.3600	79.8500	97.4700
Std. Deviation	0.98002	6.59482	1.45911
Minimum	83.40	71.70	95.70
Maximum	86.20	86.90	99.70

Table (4): Paired sample T-test for Zhermack

Zhermack Groups	t	P-Value	C.S
Control & Die hardener	1.186	0.266	P> 0.05(NS)
Control & Microwave	3.224	0.010	P<0.01(HS)

Table (3): Descriptive statistics of surface hardness of type IV dental stone( Zhermack)

Statistics parameters	Groups of study		
	(Control)	(Die hardener)	(Microwave)
Mean	94.3500	92.9600	89.8200
Std. Deviation	1.12076	3.29956	4.73423
Minimum	92.60	87.40	81.60
Maximum	95.40	96.80	94.10

Table (2): Paired sample T-test for Spofodental

Spofodental Groups	T	P-Value	C.S
Control & Die hardener	1.978	0.079	P> 0.05(NS)
Control & Microwave	18.638	0.000	P<0.001(HS)

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