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RESEARCH ARTICLE

Comparative Evaluation of Effect of Microwave Disinfection on Compressive and Diametral Tensile Strength of Various Type IV Dental Stones–An *In Vitro* Study

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ABSTRACT

Aim: To evaluate the effect of microwave disinfection on compressive and diametral tensile strength of various type IV dental stones.

Materials and methods: In this study, a total of 160 samples of type IV dental stones were made using elite rock, denflo, Neelkanth and ultrarock each with dimensions of 40 mm in height × 20mm in diameter, which were later tested for compressive strength and diametral tensile strength. Samples were divided into two main groups: group A (compressive strength) and group B (diametral tensile strength) containing 80 samples each. Groups A and B is further divided into 8 subgroups which contain 20 samples each. Each subgroup is further divided into two minor subgroups: control and microwave irradiated containing 10 samples each. The diametral tensile strength and compressive strength of the samples were measured by a universal testing machine after seven times of frequent wetting, irradiating at an energy level of 600 W for 3 minutes and cooling. The data collected was tabulated and was subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS) software.

Results: Microwave irradiation resulted in a significant increase in compressive and diametral tensile strength of type IV dental stone. It was seen that out of all materials used, ultrarock was showing the maximum amount of change in both groups (compressive strength and diametral tensile strength).

Conclusion: According to the results, microwave irradiation causes a significant increase in compressive strength and diametral tensile strength when compared with the control group.

Keywords: Compressive strength, Dental stone, Diametral tensile strength, Microwave irradiation.

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INTRODUCTION

Cross infection is a serious concern in dentistry due to transmission of various infectious diseases.[1] Over the years, the possibility of the spread of communicable diseases such as tuberculosis, hepatitis B, herpes, acquired immunodeficiency syndrome (AIDS) has increased many folds in the dental operatory and laboratories.[2]

One of the possible modes of transmission of bacterial infections from the patient to the dentist and vice versa is through impressions, gypsum casts and prosthetic materials[3] and it is even more aggravated when impressions are directly poured without disinfectant in die materials (type IV) by dental technicians for the fabrication of prosthesis.[4]

Commonly used method for disinfection of casts and dies include various over the counter available sprays and disinfectants which are used for immersion. They commonly include chlorine compounds, formaldehyde, phenols, and iodophors. Few authors have advocated mixing of disinfectant solution into die stone before they are mixed in water. But various studies have reported that chemical disinfection greatly affects the properties like setting time; strength and accuracy.[4,5] So a new and safe method of disinfection has to be thought about, few researchers advocated the use of microwave irradiation. Being a new method sufficient studies are not done to study the role of microwave disinfection on various properties of gypsum products.[6,7] Many authors have also suggested that microwave radiations shorten the time for the cast to dry and increase gypsum strength.[8]

A recent approach involving microwave radiation sterilization has been suggested by Rohrer and Bulard what works on the principle of dielectric heating, is one of the less explored sterilization modalities. They advocated that irradiation with microwave could kill fungi, virus, anaerobic and aerobic bacteria including spore forms.[9,10] According to some authors microwave not only kills germs but also disinfects all materials. Microwave basically works on two principals: firstly, conversion of microwave energy into heat by prolonged kinetic motion (thermal effect),

secondly by direct interaction of electromagnetic field and biologic molecule (nonthermal effect).[11]

So, this study was conducted to evaluate and compare the effect of microwave irradiation on compressive strength and diametral tensile strength of routinely used type IV dental stones of four brands.

MATERIALS AND METHODS

The present in vitro study was conducted at the Department of Prosthodontics, Maharishi Markandeshwar College of Dental Sciences and Research, Mullana, Ambala in collaboration with Spectro Analytical Labs Limited Okhla, New Delhi. The materials that were used in this study were all obtained from quality vendors and through proper channel. Four brands of Type IV dental stone, i.e., Ultrarock (Kalabhai, Mumbai, India), Elite (Zhermack, Badia Polesine (RO), Italy), Denflo (India Mart, Kozhikode, India), Neelkanth (India Mart, Kozhikode, India) were used in this study. The water/powder ratio that was used was according to the manufacturer's instruction. A total of 160 samples comprising of 40 samples of each material were prepared using master die. The master die that was used is basically split metal mold. It is made of two parts: The upper part and lower part. Lower part consisted of the metal platform on which the upper part is placed. Upper part further was consisted of two parts which when joined together forms a cylinder-shaped space which is of following dimensions: 20 mm in diameter and 40 mm in height according to American National Standards Institute/adenosine deaminase (ANSI/ADA) no. 25. The powder was pre-weighed and mixed with water in a rubber bowl to have a homogenous mix, and a vibrator was used to remove air bubbles and thereafter it was poured into the metal mold (split mold). The split metal mold was covered with a glass plate to create a parallel and smooth surface. After 20 minutes, the glass plate was removed, and the metal mold was dissembled carefully and stone cylinders were easily separated from the mold. Then all samples were stored at room temperature of (24 ± 1°C) with a relative humidity maintained around 45 to 50%.

A total of 160 samples were fabricated. They were divided into two major groups that are Groups A (compressive strength) (Fig. 1) and B (diametral tensile strength) (Fig. 2). Each group contains 80 samples each. Groups A and B are further divided into eight subgroups which contain 20 samples each. Each subgroup is further divided into two minor subgroups: control and microwave irradiated containing 10 samples each. The household microwave oven (1350 MHz, LG, New Delhi, India) at 600W for 3 minutes was used. In the first stage, half of the samples that were chosen for irradiation were first wetted by spraying water until they did not absorb more water but without any visible water on the surface. This was done in order to prevent micro explosion or cracking of samples. Then the samples were exposed in two phases for 2.5 minutes each making sure that the complete samples were irradiated. To prevent heat shock, the samples were allowed to dry in air. The samples were wetted before irradiation then cooled and wetted again before irradiation and this cycle was repeated seven times. A cup of 400 mL of water was placed inside the oven to protect the magnetron of the microwave from heating up as all moisture of the samples gets evaporated. Samples of all four groups were tested for compressive strength and diametral tensile strength after 7 days of irradiation.

A mechanical testing machine was used for testing irradiated and control samples. Samples were attached in a universal testing machine having a maximum capacity of 100 KN. The test was performed at a crosshead speed of 0.5 cm/minute and results were recorded for all samples.

The compressive strength of the samples was checked by placing them in a perpendicular position in the testing machine, and the maximum force (MPa) for breaking was

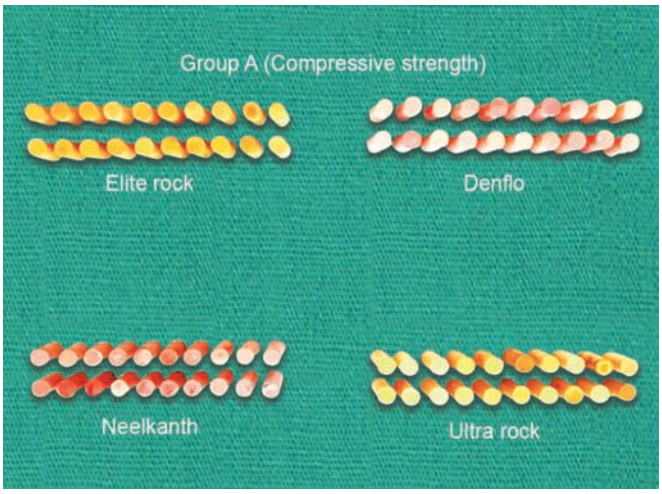


Fig. 1: Grouping of samples for compressive strength

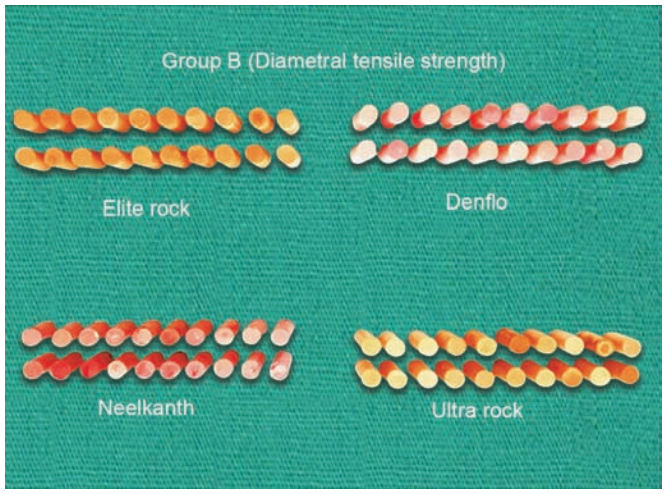
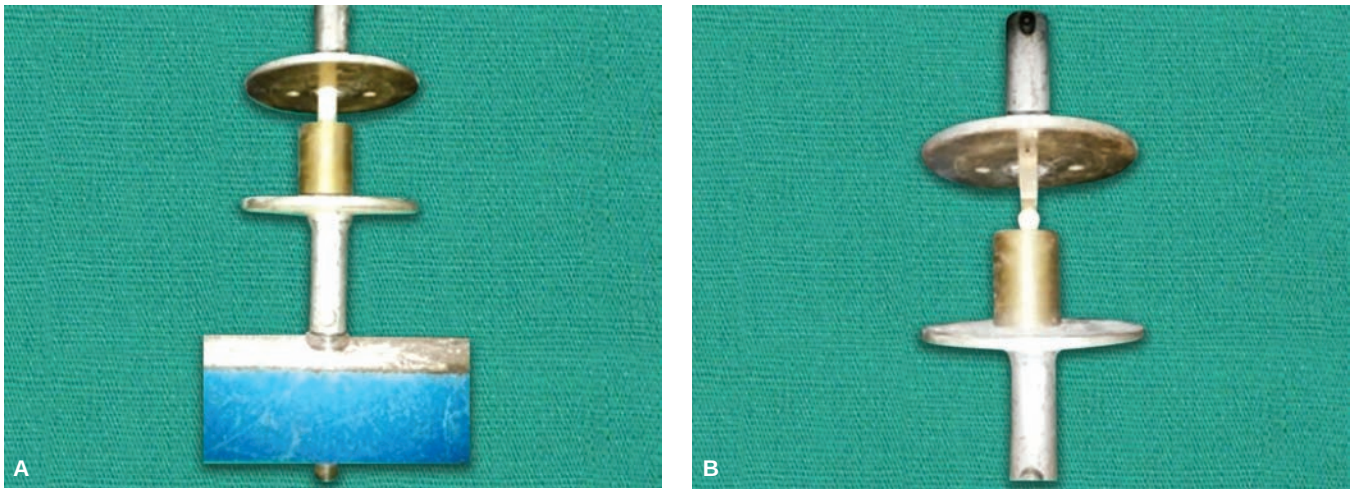


Fig. 2: Grouping of samples for diametral tensile strength



Figs 3A and B: Samples were attached to universal testing machine for evaluation of compressive and diametral tensile strength

recorded (Fig. 3). Compressive strength was calculated using the formula:

Compressive strength = Max force/cross-sectional area

To evaluate the diametral tensile strength of the sample, a horizontal metal fracturing section was designed which was mounted at the end of the vertical rod of the universal testing machine. The cylindrical stone samples were placed diagonally in the testing machine, and MPa for breaking the samples was recorded in (Fig. 3).

Diametral tensile strength was calculated using the formula:

$$DTS = 2F/\varpi DT$$

Where F is the force applied, D is the thickness of the specimen and T is the height of the specimen. The results were recorded in MPa.

Results were tabulated, and statistical analysis was performed using one-way analysis of variance (ANOVA), multiple comparison tests and student Newmans Keuls test.

RESULT

The mean and standard deviation of diametral tensile strength and compressive strength for each tested group were calculated and tabulated in Tables 1 and 2. According to the results, microwave irradiation causes a significant increase in compressive strength and diametral tensile strength when compared with the control group. It was seen that out of all material used, Ultrarock was showing the maximum amount of change Denflo showing the least amount of change in their strength in both groups (compressive strength and diametral tensile strength) after microwave irradiation.

Table 1 shows that the Ultrarock is showing the maximum amount of change followed by Elite rock, Denflo and Neelkanth in group A after microwave irradiation. Denflo is showing the least amount of change when the highest and lowest value are compared.

DISCUSSION

Many studies have been done to determine the disinfection potential of microwave irradiation of dental casts, and it has proved to be an effective method. Kalahasti et al.[12] in 2014 studied the relation of microwave energy and its role in treating patients casts made with gypsum products, and they concluded that microwave oven

Table 1: Descriptive analysis for compressive strength (Mean, ΔE, standard deviation values) in Mpa

Group	*Minor subgroup*	*N*	*Mean*	*Std. deviation*	*Std. error*
Group A (control)	Ia (Elite rock)	10	18.480	0.7569	0.2394
	IIa (Denflo)	10	7.560	0.5777	0.1827
	IIIa (Neelkanth)	10	13.560	0.7989	0.2526
	IVa (Ultrarock)	10	22.110	1.6703	0.5282
	Total	40	15.427	5.6218	0.8889
Group A (after MI)	Ib (Elite rock)	10	22.640	1.2997	0.4110
	IIb (Denflo)	10	11.130	1.3801	0.4364
	IIIb (Neelkanth)	10	16.850	1.3493	0.4267
	IVb (Ultrarock)	10	28.000	1.8838	0.5957
	Total	40	19.655	6.5469	1.0352

Table 2: Descriptive analysis for diametral tensile strength (Mean, ΔE, standard deviation values) in Mpa

Group	*Minor subgroup*	*N*	*Mean*	*Std. deviation*	*Std. error*
Group B (control)	Va (Elite rock)	10	1.490	0.2685	0.0849
	VIa (Denflo)	10	1.090	0.2558	0.0809
	VIIa (Neelkanth)	10	1.260	0.1647	0.0521
	VIIIa (Ultrarock)	10	2.320	0.2821	0.0892
	Total	40	1.540	0.5339	0.0844
Group B (after MI)	Vb (Elite rock)	10	3.600	0.2449	0.0775
	VIb (Denflo)	10	2.630	0.2541	0.0803
	VIIb (Neelkanth)	10	3.030	0.2710	0.0857
	VIIIb (Ultrarock)	10	5.570	0.6290	0.1989
	Total	40	3.707	1.2020	0.1901

disinfection had more potent effect in comparison to chemical disinfection. So routine use of microwave is recommended to reduce transmission of infection in operatory and laboratory. Leubke[13] in the year 1985 found that microwave oven offers a time-saving advantage for drying of gypsum and investment products.

The aim of this study was to compare and evaluate the diametral tensile strength and compressive strength of routinely used Type IV dental stone of four brands before and after microwave disinfection. The result showed that the diametral tensile strength and compressive strength was more in microwave irradiation group when compared with the group that does not undergo any irradiation. The increase in strength may be because type IV dental stone contains α hemihydrates of the densite type. Cuboidal shaped particles and the reduced surface area produce dental stone with high mechanical properties.[14] These results are in concurrence with the study done by Tuncer et al.[15] in 1993 who concluded from his study that low power radiation has resulted in higher compressive strength than air-dried specimens. Hersek et al.[16] in 1999 concluded that microwave oven not only saves time but also increases the diametral tensile strength of type III dental investment material at different time intervals.

The similar results were found in the study carried out by Hasan[17] in 2008 who showed that microwave disinfection causes a significant increase in diametral tensile strength for all type of dental stones. Many previous studies had shown that microwave irradiation at higher power and longer time duration has bactericidal effect, but in the present study lower energy level has been suggested for the process of irradiation of gypsum product, in order to prevent crack and holes formation due to rapid release of water vapor which can lead to fracture of sample. Tuncer et al.[15] in 1993 suggested that, to use a low power level (550W) while drying the gypsum product and did not recommend drying the gypsum casts/dies at the high power level. Also, Anaraki[18] in 2013 studied the effect of the different energy level of microwave on disinfection of dental stone cast and concluded from his study that high-level disinfection of stone cast can be achieved by microwave irradiation at 600 W in 3 minutes.

One consideration in the present study was that sequence of wetting, irradiating and cooling were repeated seven times as this is the average number of times cast is usually disinfected during prosthodontic treatment.[19,20] Other consideration in the study was that all the samples were tested for compressive strength and diametral tensile strength after 7 days, this is because to achieve maximum strength, the excess water of the stone cast will be removed which takes seven days after pouring in the ambient temperature.[21] Type IV dental stone has more gauging water than type III dental stone, so a longer drying period may be necessary to expel the excess water.[22] From this study, it can be concluded that microwave disinfection of gypsum cast at 600 W for 3 minute causes a significant increase in diametral tensile and compressive strength of gypsum product and this procedure could be done safely, quickly with household microwave oven without the need of special skills, or additives.

The results of this *in vitro* study should be viewed cautiously because laboratory testing cannot mimic the clinical situations. A longer period of exposure to microwave irradiation is not to be used because it may lead to the development of cracks on the surface of the material which may further lead to a decrease in strength of materials. Also, factors such as disparity in the formulation of a correctly weighed stone package, divergent storage condition, optical error in the measurement of dimensions may lead to discrepancies too. Thus the effect of microwave exposure on the physical and mechanical properties, dimensional accuracy and surface reproduction of type IV dental stone needs further investigation.

CONCLUSION

Based on the observations and results of the study, the following conclusions were made:

- Microwave irradiation of type IV dental stone at an energy level of 600 W for 3 minutes could enhance their diametral tensile strength and compressive strength.
- Each material is showing a change in both groups A (compressive strength) and B (diametral tensile strength) when the materials in the control group are compared to the same material in microwave irradiation group.
- The maximum increase in strength is seen in Ultrarock in both groups A (compressive strength) and B (diametral tensile strength).
- Minimum increase in strength is seen in Denflo in both groups A (compressive strength) and B (diametral tensile strength).
- This technique could be done safely, quickly with household microwave without the need of special skills, or additives and may improve the quality of the dental cast and may serve the purpose of preventing transmission of infection between patients, dentists, and the laboratory.

CLINICAL IMPLICATION

- The clinical relevance of this study is that microwave disinfection can be performed repeatedly and quickly, without the use of toxic or allergenic chemicals.
- The cast can become contaminated each time during various steps involved in the fabrication of the prosthesis, thus act as a major vehicle for the cross-contamination with the help of microwave energy it can be disinfected throughout the phase of dental treatment.
- The strength of the material is another very important factor that has to be kept in mind. If the strength of the material is not good it may fracture while working on it, so from this study, it was concluded that microwave disinfection has a positive effect on the diametral tensile strength and compressive strength of all the 4 Type IV dental stones tested.

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