Sterilization of Gypsum Cast and Dies by Microwave Irradiation -An in Vitro Study

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ABSTRACT

Introduction: Disinfection of casts after obtaining them from the impressions is important to prevent cross contamination and spread of infections. The study was carried out to evaluate the effect of microwave irradiation method of disinfection on surface details reproducibility and compressive strength of dental casts.

Material and Methods: Type III and IV gypsum samples were subjected to microwave irradiation method of disinfection. Microwave irradiation was given for 3 min at full power of 900 Watts and 2450 MHz's. The control and test group casts were examined to evaluate the effect of disinfection procedure on surface details. Surface details of casts were evaluated under low angle light at X10 magnification with a stereo zoom microscope in terms of degradation of the reproduced 0.05-mm-wide line and graded. The compressive strength test was conducted on an Instron universal testing machine with a 10kg load cell at a crosshead speed of 0.05cm/min.

Results: Microwave irradiation of type III and IV gypsum samples after one hour of pouring reduced the strength of materials significantly ($p<0.05$) with loss of surface details. The compressive strength values of dental stone and die stone were not significantly affected by irradiation at the end of 24 hours ($p>0.05$). Microwave irradiation of the samples at the end of one hour resulted in changes in the surface details but surface details were not altered significantly when irradiated at the end of 24 hours.

Conclusion: We suggest the use of microwave irradiation after 24 hours of air drying to decontaminate the casts prepared by using type III and IV gypsum products since it does not produce significant changes in surface details and is convenient.

Keywords: microwave irradiation, dental casts, disinfection, compressive strength, surface details

INTRODUCTION

Increased awareness of the potential for transmission of numerous infectious microorganisms during dental procedures have led to an increased concern for, and attention to, infection control in dental practice.[1] Patient derived dental impressions and gypsum casts are contaminated with numerous microbes including *Candida*, MRSA, *P. aeruginosa* which are known as opportunistic pathogens responsible for nosocomial and /or life threatening infection in immuno-compromised hosts.[2]

Impression making is one widely used procedure where clinicians must balance the requirement to maintain an intact barrier system with the need to produce accurate dental casts.[3] Dental impressions become contaminated with the micro organisms from patients' saliva and blood, which can cross infect gypsum casts poured against them. Movements of these organisms into dental casts while setting have been demonstrated.[4] Some microbes have been shown to remain viable within gypsum cast materials for up to seven days.[5]

Various methods to disinfect dental casts have been proposed and carried out. These include immersing the casts in disinfecting solutions, spraying the casts with disinfecting solutions,[6,7] incorporating chemicals into gypsum at the time of mixing[3] or using die stone containing disinfectant. It was observed that physical properties such as setting time and setting expansion were affected by incorporating disinfectants into gypsum.[8,9]

Microwave irradiation as an alternative to conventional methods has been reported in literature.[10,11] It is found out that this method is effective and practical and eliminates cross contamination via the cast because it can be repeated at every stage as and when required.[10]

The ideal disinfection procedure should not affect the physical and chemical properties of the gypsum cast unchanged to achieve accuracy of the final prosthesis.[12]

This study was done to explore the effect of microwave irradiation on the mechanical properties, that is, compressive strength properties and surface detail reproduction of type III and type IV gypsum samples.

MATERIAL AND METHODS

Two types of dental gypsum products were subjected to two methods of disinfection. The gypsum products tested included:

Type III gypsum product (Kalstone, Kalabhai Dental P Limited, Mumbai) and Type IV stone (Kalrock, Kalabhai Dental P Limited,Mumbai).

Die fabrication: An aluminium die according to ADA spec-

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ification No. 25[13] was fabricated to be used as a test die for evaluation of surface detail. The test die had a diameter of 30 mm. All its surfaces were polished. 3 parallel lines, x, y, and z, to a depth of 50, 20, and 75 mm, respectively are inscribed for evaluation of surface details. Cross lines cd and c'd' are provided for the determination of dimensional stability (Figure 1). For the measurement of compressive strength measurement, an aluminium split mould die with guide screws was machine milled. It had 3 compartments for sample preparation, each with 40mm length and 20mm diameter, according to ANSI /ADA specification No. 25 (Figure 2).

Mixing and pouring of gypsum samples: The gypsum products were mixed according to manufacturer's instructions. One hundred grams of type III and type IV were weighed to the nearest +/- 0.1 grams using a physical balance and 32 and 24 ml of water was measured to the nearest +/- 0.1 ml for type III and type IV respectively. The powder was added to distilled water in a clean rubber mixing bowl, allowed to soak in water and then hand spatulated for 10 seconds with a round headed steel blade spatula, followed by spatulation for 20 seconds in a mechanical mixer (Motova SL, BEGO, Bremen,Germany) connected to vacuum to obtain a creamy, bubble free mix.

The mixed dental stone was poured on to the metal die in small increments placed on a mechanical vibrator (Vibromaster; BEGO, Bremen, Germany). The vibration frequency and amplitude were set at 6000 cycles/min and step 3 amplitude (0.4 mm) respectively to prevent formation of air bubbles. The collar was covered with a glass slab to ensure that the base was parallel to the test surface. The casts were allowed to set for 1 hour at room temperature. The casts that were to be checked after 24 hours were removed from the die and allowed to air dry for 24 hours on a table top.

Disinfection using microwave irradiation: The prepared samples of the microwave irradiation group were kept on the glass plate in the microwave oven and timer set to 3 min at full power of 900 Watts and 2450 MHz (Onida Power Convection Microwave). After irradiation the casts were allowed to cool down to room temperature and then subjected to the tests respectively. A pilot study done to establish the optimum time for microwave irradiation of dental casts revealed that the specimens were completely dried with the removal of excess water within 3 minutes. Hence for the present study 3 minutes of irradiation time was selected.

(a) Sample preparation for surface detail evaluation: A collar was fabricated with elastic material (Impregum Penta Soft Polyether Impression Material; 3M ESPE, St. Paul, Minn) to box the test die to retain the poured gypsum product.

The test casts that did not reproduce the entire length of the 0.05-mm-wide line were discarded. Thirty test casts each of the type III and IV were reproduced from the metal die directly.

The samples, thus prepared were classified into 2 groups as follows:

- Group 1 (Microwave irradiation for 3 minutes at 900 W, 2450 MHz). Ten samples of each type were tested at 1 hour.
- Group 2 (Microwave irradiation for 3 minutes at 900 W, 2450 MHz). Ten samples of each type were tested at 24 hours.

Compressive strength evaluation: The compressive strength test was conducted on an Instron universal testing machine (Instron Corp.,Canton, Mass.) with a 10kg load cell at a crosshead speed of 0.05cm/min. The samples were placed on the platform and the load applied. The samples were then crushed between the load and the platform. The results obtained were recorded in MPa.

(b) Sample preparation for compressive strength evaluation: Compressive strength of type III and IV was determined on the cylindrical samples made according to ANSI/ ADA specification. The split metal mould were filled with dental stone under mechanical vibration. The cylindrical test samples were allowed to set for 1 hour and then retrieved.

The samples prepared for each type of gypsum products were classified into four groups as follows and were then crushed (Figure 3):

- Group 1 (control). Ten samples of each type were tested at 1 hour.
- Group 2 (control). Ten samples of each type were tested at 24 hours.
- Group 3 (Microwave irradiation for 3 minutes at 900 W, 2450 MHz). Ten samples of each type were tested at 1 hour.
- Group 4 (Microwave irradiation for 3 minutes at 900 W, 2450 MHz). Ten samples of each type were tested at 24 hours.

Figure-1: Aluminium die for surface detail evaluation

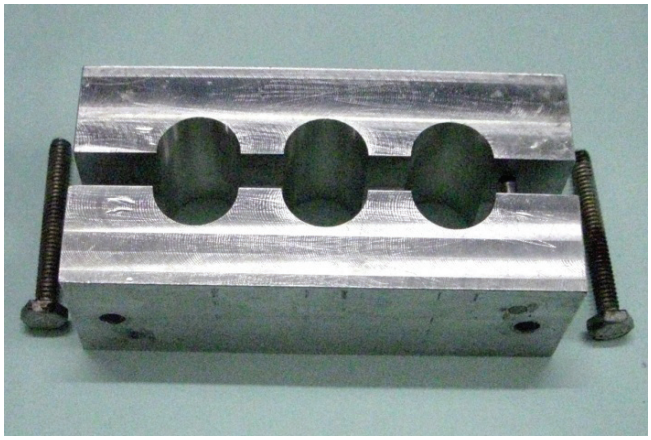

Figure-2: Aluminium split mold die for compressive strength evaluation

Surface detail evaluation: The control and test group casts were used to evaluate the effect of disinfection procedure on surface details. The effect on the casts in terms of degradation of the reproduced 0.05-mm-wide line was examined under low angle light at X10 magnification with a stereo zoom microscope (Motic® type 102 M Stereozoom microscope, Vancouver, Canada). Same investigator performed all the microscopic studies of the casts. The casts were evaluated based on the graded scoring system with rating values of 1 through 4 (Figure 4).

- Rating 1 indicated a well-defined, sharp continuous line
- Rating 2 indicated a continuous line, but with some loss of sharpness
- Rating 3 indicated a loss of continuity of the line
- Rating 4 indicated complete obliteration of the line.

STATISTICAL ANALYSIS

The observations made on compressive strength of each sample were statistically evaluated using independent t test for one hour groups and one way ANOVA multiple comparison Tukey HSD post hoc test for 24 hours groups. For statistical analysis of the surface details the chi-square test was used to determine the significance of relationship between the numbers of scores. All computations were conducted in the SPSS software (version 11.5).

RESULTS

The effects of microwave irradiation on samples were evaluated.

Compressive strength

Table – 1 shows the readings of compressive strength evaluation after microwave irradiation of dental stone and die stone.

Type III stone samples: At one hour interval, the mean compressive strength of samples of control group was significantly higher compared to microwave irradiation group ($p<0.05$). However at 24 hours, compressive strength values of dental stone showed no significant difference between control group and microwave irradiated group ($p>0.05$).

Description	1Hr Control	1Hr Microwave	24Hr Control	24Hr Microwave
Dental Stone				
Mean (MPa)	18.57	15.93	23.95	23.25
S.D	1.16	3.03	2.18	1.34
Die Stone				
Mean (MPa)	24.04	16.80	33.81	33.49
S.D	3.04	1.45	1.86	1.75

Table-1: Readings of compressive strength evaluation after microwave irradiation of dental stone and die stone

Description	Dental Stone				Die stone			
	1	2	3	4	1	2	3	4
1Hr Control	10	-	-	-	10	-	-	-
1Hr Microwave	4	5	1	-	9	1	-	-
24Hr Control	10	-	-	-	10	-	-	-

Table – 2: Scores for surface detail evaluated after microwave irradiation of the dental stone and die stone.

Type IV die stones: At one hour interval, the mean compressive strength of samples of control group was significantly higher compared to microwave irradiation group ($p<0.05$). At 24hours compressive strength values of control group and microwave irradiated samples were not significantly different ($p>0.05$).

Surface details

Summary of results obtained for the detail reproduction of dental stone and die stone samples subjected to microwave irradiation are presented in Table 2.

All the samples of dental stone and die stone in the control group exhibited better surface detail reproduction and were able to reproduce a line of 50µm thick clearly as indicated by 100% score in score 1. When the samples were microwave irradiated at one hour, dental stone samples have shown minimum changes in the surface details as noted from the scored obtained which lie mainly between score 1 and 2. With die stones, microwave irradiation did not cause any change in the surface detail as seen in 90% samples having score score 1.

Both dental stone and die stone did not show much change in the surface detail when subjected to microwave irradiation at 24 hours as is clear from the 90% and 80% sample having

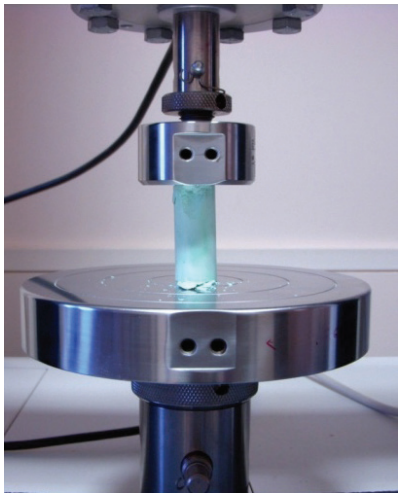

Figure-3: Compressive strength evaluation using Instron Universal testing machine (Instron corp, Canton, Mass)

Figure-4: Surface detail evaluation of prepared samples with Motic type 102 M stereozoom microscope (Motic stereozoom, Canada)

Group	Dependent Variable	(I) Class	(J) Class	Mean Difference (I-J)	p
Dental Stone	HR 24	Control	Micro	0.7000	0.802
Die Stone	HR 24	Control	Micro	0.3190	0.991

Table–3: One way ANOVA multiple comparisons Tukey HSD post hoc test between 24 hours samples for compressive strength for dental stone and die stone.

Test	Value	p
Dental stone Pearson Chi-Square	39.531	0.001 vhs
Die stone Pearson Chi-Square	33.424	0.001 vhs

Table–4: Chi-Square Tests for surface detail comparison between the 24 hours microwave and hypochlorite immersion groups of dental stone and die stone

score 1 respectively for dental stone and die stone.

DISCUSSION

Since the autoclaving process would be damaging to a dental cast, the American Dental Association (ADA) and the Centers for Disease Control and Prevention[14] have suggested methods for the disinfection of dental casts, including immersion or spraying with the disinfectant. It is important that these procedures and materials have no effect on the physical properties of the dental casts.[15] It was observed that the immersion disinfection process affects the surface quality of the casts/dies. It has been shown by Rudd et al (1970)[16] that immersing a stone cast even in tap water for 15 min altered surface properties.

Studies undertaken to evaluate the disinfection potential of microwave irradiation of dental casts have proved it is an effective method.[10,11]

Microwaves comprise the portion of the electromagnetic spectrum extending from the frequency of 300 MHz to 3,00,000 MHz. Most commercial microwave ovens operate at 2450 MHz. Microwaves are generated by magnetron and propagated in a strong line along the wave guide what is called the dominant mode. Microwaves are absorbed in materials containing water and produce friction of water molecules in an alternating electrical field. The energy thus produced is transformed into heat and it is supposed that microorganisms with high water content can be consequently killed in short time.

However, microwave irradiation was found to cause enlargement of the pores on the surface of the cast because of the rapid loss of water as steam which may have an influence on the mechanical characteristics and reproducibility of the surface details.[17] Since the fabrication of a dental prosthesis requires the dental cast to undergo various laboratory procedures, the strength of the dental cast and its ability to retain the surface details is of utmost importance.

Effect of microwave irradiation on compressive strength

The results obtained for compressive strength for one hour were subjected to independent t test whereas the 24 hours samples were subjected to One way ANOVA multiple comparisons Tukey HSD post hoc test. It was noted in the present study, that both dental stone and die stone had a decrease in the compressive strength when subjected to microwave irradiation at one hour. This decrease was more prominent in die stone as compared to that seen for dental stone.

This could be explained by the differences in the crystal shape, density, intermeshing and entanglement of dehydrate crystals in the gypsum tested. In die stone, the number of crystal nuclei formed is much greater and the amount of intermeshing and entanglement is greater compared to dental stone. Such an arrangement results in the formation of a dense mass with less amount of porosity. When type IV gypsum casts are subjected to microwave irradiation, excess water used during mixing, although less compared to dental stone, forms steam and creates cracks or porosities while leaving the surface. Because structure of die stone is dense, the escape of steam creates stress in the material which probably leads to formation of minor cracks in the material. Formation of porosities or micro cracks could be the reason why die stone failed at low stress values. Dental stone, on the other hand, is not as dense as die stone, allows easy escape of the steam and there by showing little change in compressive strength. Compressive strength of dental stone and die stone specimens measured at 24 hours is not significantly different from the compressive strength of microwave irradiated specimens. This is understandable as most of the excess water would have evaporated from the material with 24 hours. Microwave irradiation in these samples may not produce steam which may create cracks or porosities.

In a study conducted by Leubke and Schneider[16] (1985), it was noted that at 2 hours, there was no significant difference in compressive strength of type III dental stone dried in microwave oven when compared with the air dried stone. They also suggested that microwave ovens should not be used to disinfect extremely wet or water soaked casts because rapid boiling of free water may crack the casts. They also observed that the die stones were physically changed by microwave drying because of the appearance of cracks and holes on the surface. In our study we noticed the same effect. Many holes and cracks were easily seen on the outer surface of the specimens, which was easily broken by handling.[16]

Setting the oven at lowest power level has been advocated by Leung RL et al (1983).[4] In a study done by Tuncer et al (1993)[18] it was observed that highest power level resulted in a decrease in the compressive strength of type IV die stone. A pilot study, done to establish the optimum time for microwave irradiation of dental casts showed that. specimens were completely dry with the removal of excess water within 3 minutes after heating in microwave. Hence for the present study 3 minutes of irradiation time was selected after air drying the samples

Effect of microwave irradiation on surface detail reproduction:

Microwave irradiation of dental stone and die stone samples at the end of one hour resulted in changes in the surface details in about 60% samples. However, this effect was not significant when the samples were irradiated with microwaves

at the end of 24 hours. The loss of surface details at one hour can be explained on the basis of porosity or microcracks formed by the steam during microwave irradiation.

Microwave irradiation of samples after one hour of pouring reduced the strength of the materials significantly ($p<0.05$) and also there was loss of surface detail. The compressive strength values of samples were not significantly affected by microwave irradiation at the end of 24 hours ($p>0.05$). Microwave irradiation of the samples at the end of one hour resulted in changes in the surface details in about 60% samples but the surface details were not altered significantly when the samples were irradiated with microwaves at the end of 24 hours.

CONCLUSION

Based on the observations of this study, it can be inferred that microwave irradiation of dental casts after one hour of pouring reduced the strength of materials significantly ($p<0.05$) and also there was loss of surface detail. The surface details and compressive strength were not altered significantly when the samples were irradiated with microwaves at the end of 24 hours.

In view of the seriousness of the diseases like HIV and hepatitis it is worth waiting for 24 hours when using microwave irradiation. We, therefore, recommend the use of microwave irradiation after 24 hours of air drying to decontaminate the dental casts till better alternatives are available

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