ORIGINAL ARTICLE

Comparison of Repeated Chemical and Microwave Disinfection on Dimensional Accuracy of Gypsum Casts

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OBJECTIVE: The aim of this experimental study is to compare the dimensional accuracy of gypsum casts after repeated disinfection in microwave at 900 Watts, 2450 MHz (5 minutes) and immersion in 0.5% Sodium hypochlorite (10 minutes). Disinfecting casts is recommended to prevent cross infection but may cause dimensional changes. During fabrication of prosthesis, a cast may get contaminated several times so there is a need of repeated disinfection.
METHODOLOGY: Sample size was 33 (11 in each group), calculated through WHO software for sample size determination by using standard deviation of 0.16 at 95% confidence interval and 80% power of study. Impressions in irreversible hydrocolloid were recorded of an acrylic cast fabricated for this study. The impressions were poured with die stone and were randomly divided into 3 groups; Group I: Microwave disinfection, Group II: Immersion disinfection in 0.5% Sodium hypochlorite, Group III: Control group. For Groups I and II, each cast was disinfected 7 times with 5 minutes interval between two disinfection cycles, after every cycle anteroposterior and mediolateral measurements were recorded using digital Vernier caliper (accuracy upto 0.01 mm). For group III, casts were rinsed with distilled water, dried in open air within temperature range of 28+/-2°C for 10 mins followed by anteroposterior and mediolateral measurements. This procedure was repeated seven times for each cast.
RESULTS: Anteroposterior and Mediolateral differences of dimensional change between and within the Group A, B and C was calculated by One Way ANOVA. Inter/intra examiner reliability was taken into consideration at the time of study. Mean dimensional change in the casts were insignificant through six disinfecting cycles. However, in the seventh cycle, a significant difference (p=0.003) was observed in the anteroposterior dimension (0.03% dimensional change for Group A and 1.26 % for Group B whereas, in mediolateral dimension, dimensional change was 0.35% for Group A and 0.59% for Group B (p=0.004). Dimensional change of >0.5% was considered as the cutoff value for casts to be considered as dimensionally accurate. Casts disinfected through immersion disinfection did not produce dimensionally inaccurate casts in anteroposterior dimension after third cycle and in seventh cycle in mediolateral dimension. However, result is significant only in seventh cycle. Microwave disinfection produced dimensionally accurate casts throughout all cycles.
CONCLUSION: Microwave disinfected casts remained dimensionally stable compared to immersion disinfection.
KEYWORDS: Disinfection, microwave, immersion, dimensional stability, gypsum casts
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INTRODUCTION

Impression recording is the first step in fabrication of oral prosthesis.[1] When a dental impression is recorded, it comes in contact with plaque, saliva and blood which may contain pathogenic microorganisms.[2]

When cast is poured against a contaminated impression, it also gets contaminated and becomes a source of infection for the dental personnel.[3-4] Many studies have shown that pathogenic organisms were recovered from the casts.[5-7] Up to 1991, washing impression under running water was a recommended practice.[8] However, just washing impression does not remove pathogenic organisms causing Hepatitis B,C and Tuberculosis.[9] According to guidelines of infection control in dentistry, all prosthodontic items should be cleaned, disinfected and rinsed with an active disinfectant before

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sending them to laboratory.[10]

Irreversible hydrocolloid is the impression material which is widely used over the entire world.[3] Alginate can be used in recording preliminary impressions, impressions for fabrication of temporary fixed dental prosthesis, study casts, impression of opposing dentition, orthodontic models, impression for fabrication of sports mouth guards and bleaching trays.[11] Alginate is dimensionally unstable material, as hydrocolloids constitutes about 85 % water, they undergo imbibition in the presence of moisture and undergo syneresis when left dry.[12] In past, different studies have been conducted to evaluate the dimensional stability of irreversible hydrocolloid using different disinfectants and different methods. The most common chemical disinfectants routinely used by dentists are alcohols, aldehydes, chlorine combination, phenols, bisguanides, iodide combinations, and ammonium.[13] Disinfection methods used for alginate impression material are

1. Spraying
2. Immersion[12]
3. Incorporation of disinfectant in alginate by manufacturer[14]
4. Mixing alginate with disinfectant[12]

Each method has its own advantages and disadvantages. According to previous studies, spraying causes the least dimensional changes but is not capable of disinfecting all surfaces. On the other hand, Immersion is the most reliable method of disinfection as it comes in contact with all surfaces but produce dimensional changes[15], especially if dental impression is immersed for a long period of time.[4] High level disinfectants cannot be incorporated while mixing impression material because of health hazards rendering third and fourth method not very useful. In most of the studies, chlorhexidine is incorporated while mixing alginate but according to Souza et al. AIDS virus and hepatitis B are deactivated by 2% Glutaraldehyde and 1% Sodium hypochlorite; however, these microorganisms are more resistant and are not eliminated with 0.5% Chlorhexidine.[2]

Keeping in mind the sensitive nature of alginate impression material, the suitable alternative is to disinfect dental casts instead of alginate impression as it is the cast on which prosthesis will be fabricated. Gypsum casts can be disinfected by spraying, immersing into a disinfecting solution, by adding an antimicrobial agent to the plaster mix, by manipulating the plaster with a disinfectant solution[16], microwave disinfection[13] and autoclave disinfection.[17] Different disinfectants used for disinfection of dental gypsum are formaldehyde, chlorine compounds, glutaraldehyde, phenols, iodophors[18] and ozonated water.[19] Immersion in sodium hypochlorite for 10 min at a concentration of 1:10 dilution (0.525%) is recommended for immersion disinfection.[18] As previously mentioned, spraying does not provide effective disinfection whereas autoclave disinfection and incorporation of disinfectant while mixing plaster affects the physical properties of dental casts.[14] Microwave disinfection of dental gypsum cast has shown to reduce the of bacteria on the casts after 5 minutes of microwave oven irradiation in an ordinary household microwave oven set at 900 wattage.[20] So, for the purpose of this study, disinfection methods selected were chemical disinfection by immersion method and microwave disinfection as both of them have proved to be effective in disinfection of gypsum casts.[21] In case of microwave disinfection, there is no effect on the efficacy whether the casts are wet or dry at the time of disinfection.[22] In addition to efficacy, another important requirement of disinfection is that it should not affect dimensional accuracy of casts[23] so, now, there is a need to compare both of these methods in terms of dimensional accuracy.

According to Stern et al, during the fabrication of complete denture, a need may arise to disinfect dental cast seven times.[24] A dental cast can be contaminated when poured against contaminated impressions or during trial of the denture base prosthesis several times in clinic.[25] This study was carried out to compare the effect of repeated microwave disinfection of gypsum cast to repeated immersion disinfection. Both of these disinfection methods have been studied separately and are considered acceptable in terms of efficacy and dimensional accuracy, however there is no study comparing these methods by repeated disinfection. This study was aimed to compare these two methods (microwave disinfection and immersion disinfection) and to determine the best disinfection method for the gypsum cast which produce the least dimensional changes.

METHODOLOGY

This experimental study using non- probability consecutive sampling technique was conducted in Prosthodontics Department of Sardar Begum Dental College and Hospital, Peshawar. Sample size was 33(11 in each group) calculated through WHO software for sample size determination by using standard deviation of 0.162 at 95% confidence interval and 80% power of study. The three groups are:

Group I:

Gypsum casts irradiated in a microwave oven (Samsung, Korea) for 5 minutes at 2,450 MHz and 900 Watt.

Group II:

Gypsum casts immersed in 0.5% Sodium Hypochlorite (Haq chemicals, Pakistan) for 10 minutes

Group III:

Gypsum casts rinsed with distilled water, dried in open air within temperature range of 28+/-2 degrees for10 mins followed by anteroposterior and mediolateral measurements.

SAMPLE SELECTION

Inclusion criteria:

All casts poured in the impression recorded from acrylic cast.

Exclusion criteria:

1. A crevice or deficiency in the midline of palatal vault of impression.
2. An impression short in one or more regions of the sulci, especially around the tuberosities or the labial sulcus.
3. Tray flange showing through the impression material.
4. Impression material detached from the tray.
5. Impressions from incompletely seated tray.
6. Casts having broken, distorted and entrapped air at metal rod duplicates.
7. Any void present in the cast.
8. Cast fractured at the time of separation from the impression material

   The above mentioned conditions act as confounders and if included will introduce bias in the study results.

Acrylic master cast:

An acrylic master cast representing edentulous maxillary arch was constructed in heat cure acrylic (FDS, Pakistan) using long curing cycle. Reference points (A, B, C) for measurements on cast were made on the acrylic cast by inserting metal rods in the approximate position of incisive papilla (A) and in the region of right and left second molar (B and C). A hole was drilled in the position of each reference point and a metal rod was inserted and secured in place with auto polymerized acrylic resin (Figure 1). The distance between points A and C was kept 40 mm, after polymerization shrinkage, this distance was reduced to 39.96 mm. The distance between points B and C was kept 55 mm which was reduced to 54.66 mm after polymerization shrinkage.

Figure 1: Acrylic master cast with three metal rods inserted

Custom tray construction:

For the uniform thickness and distribution of impression material, a custom tray was constructed using auto polymerized acrylic resin (FDS, Pakistan) after application of 4mm spacer on master cast. Perforations were made in the custom tray (Figure 2).

Figure 2: Custom tray fabricated with auto polymerized acrylic resin, perforations were made to mechanically retain impression material

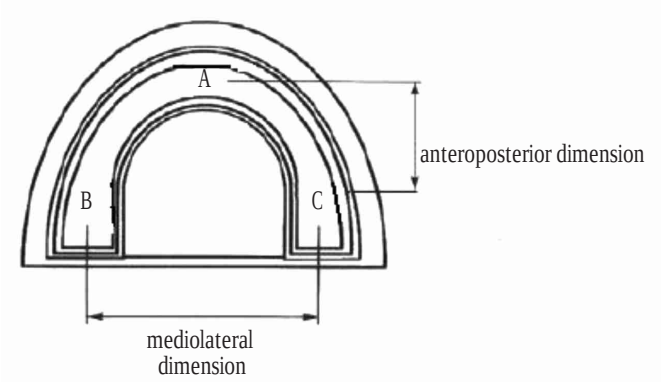
Alginate impression material (Alginmajor, UK) was mixed according to manufacturer's instructions using distilled water. Ions in different concentrations might be present in tap water which can interfere with chemical reaction of irreversible hydrocolloid[27] , that's why distilled water was used. Acrylic master cast impression was recorded in alginate and rinsed under tap water for 10 seconds. The excess water was shaken off and impression was poured with type IV gypsum (Dentamerica, Taiwan).

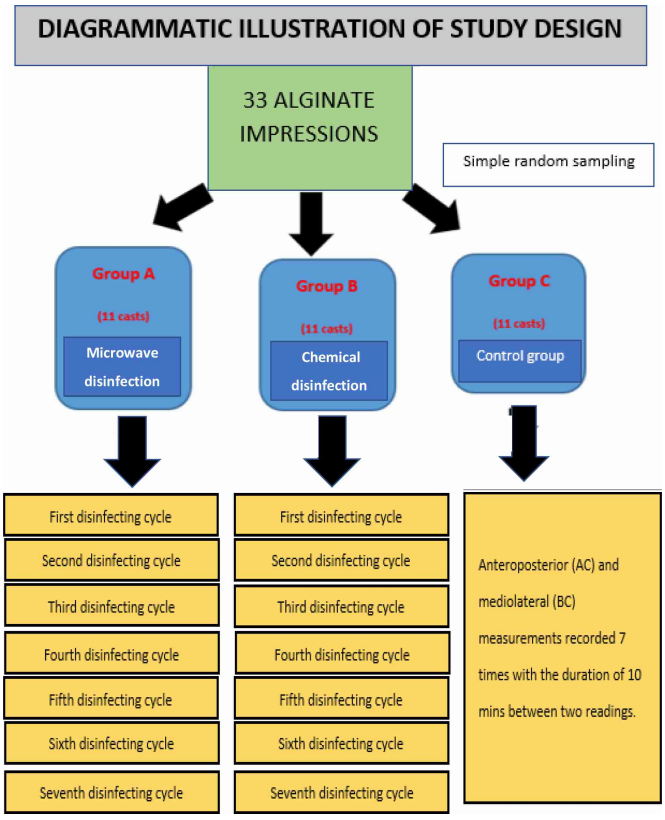
The cast was allowed to set for 40 minutes before removal. Casts were allowed to dry in air for 24 hours, as stone casts may take 24 to 48 hours in losing excess water and gaining enough strength to be handled without damage.[28] After 24 hours, casts were randomly subjected to one of the groups by simple random sampling.

For Group I, cast was irradiated in microwave at 900 watt and 2450 MHz for 5 minutes. After 5 minutes, cast was allowed to cool for 5 minutes. Then, anteroposterior (AB) and mediolateral measurements (BC) were recorded (Figure 3) using digital vernier caliper (Tianhe, China). Same procedure was repeated seven times.

For Group II, gypsum cast was immersed in 0.5% Sodium hypochlorite for 10 minutes. Then, anteroposterior (AB) and mediolateral measurements (BC) were recorded using digital vernier caliper. This procedure was repeated seven times.

Figure 3: Anteroposterior and mediolateral dimensions measured on cast





For Group III, gypsum casts were not disinfected. Anteroposterior (AB) and mediolateral measurements (BC) were recorded using digital vernier caliper seven times with duration of 10 minutes between two readings.

RESULTS

Anteroposterior and Mediolateral differences of dimensional change between and within the Group A, B and C was calculated by One Way Anova, While Paired Sample T Test was used to do Reliability analysis of measurements by rater 1 and 2.

ANTEROPOSTERIOR DIMENSION

Anteroposterior dimension between the points A and C was 39.96mm. Maximum percent dimensional change was 0.43 while minimum value recorded was 0.03 with the range of 0.4 in the Microwave disinfection Group A. Maximum percent dimensional change in the chemically disinfected Group B was 1.26 and minimum change was 0.20 with the range of 1.06. Whereas 0.45 was the maximum and -0.13 minimum percent dimensional change with the range of 0.1 noticed in the Control Group C (Table 1, Figure 4)

Figure 4: Anteroposterior Dimensional changes among the Group A (Microwave disinfection), B (Chemical disinfection) and C (Control group) between the point A and C

(MD= Microwave disinfection, CD= Chemical disinfection, CON=Control group, AP= Anteroposterior dimension)

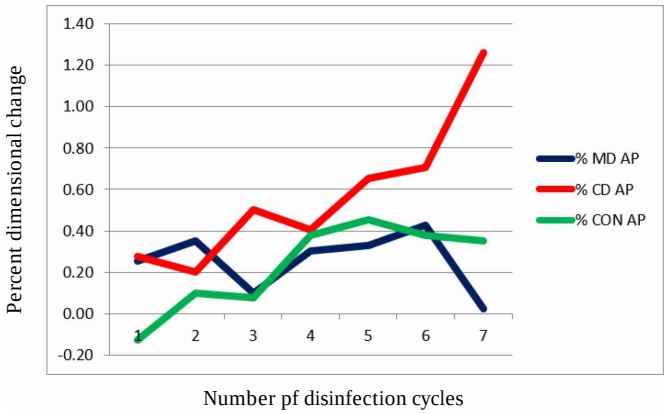


Table 1: Effect on Mean Anteroposterior Dimension (AC) of the cast after each disinfection cycle and value of significance between and within groups

Number of Disinfection Cycle	Group A: Microwave Disinfection (mm)	Group B: Chemical Disinfection (mm)	Group C: Control (mm)	P -Value
First Cycle	39.77±0.27 (0.25 %)	39.78±0.27 (0.28%)	39.62±0.32 (-0.13%)	0.38
Second Cycle	39.81±0.30 (0.35%)	39.75±0.46 (0.20%)	39.71±0.31 (0.10%)	0.78
Third Cycle	39.71±0.25 (0.10%)	39.87±0.45 (0.50%)	39.70±0.31 (0.08%)	0.45
Fourth Cycle	39.79±0.24 (0.30%)	39.83±0.43 (0.40%)	39.82±0.33 (0.38%)	0.95
Fifth Cycle	39.80±0.32 (0.33%)	39.93±0.33 (0.66%)	39.85±0.33 (0.45%)	0.66
Sixth Cycle	39.84±0.26 (0.43%)	39.95±0.32 (0.71%)	39.82±0.33 (0.38%)	0.59
Seventh Cycle	39.68±0.17 (0.03%)	39.14±0.27 (1.26%)	39.81±0.39 (0.35%)	0.00

MEDIOLATERAL DIMENSION

The Mediolateral dimension between the points B and

C (BC) was 54.66mm. Maximum percent mean dimensional change in the Group A was 0.35 and minimum change was 0.16 with the range of 0.19. Maximum percent mean dimensional change in the Group B was 0.59 and minimum was 0.20 whereas 0.31 and 0.11 was the maximum and minimum percent dimensional changes with the range of 0.2 noticed in the Control Group (C). (Table 2, Figure 5).

Figure 5: Mediolateral Dimensional changes among the Group A (Microwave disinfection), B (Chemical disinfection) and C (Control group) between the point Band C

(MD= Microwave disinfection, CD= Chemical disinfection, CON=Control group, ML =Mediolateral dimension)

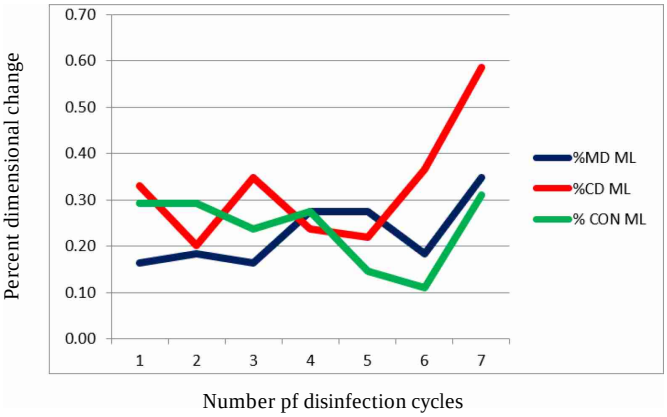


Table 2: Effect on Mean Mediolateral Dimension (BC) of the cast after each disinfection cycle and value of significance between and within groups

Number of Disinfection Cycle	Group A: Microwave Disinfection (mm)	Group B: Chemical Disinfection (mm)	Group C: Control (mm)	P –Value
First Cycle	54.75±0.26 (0.16%)	54.84±0.27 (0.33%)	54.82±0.18 (0.29%)	0.65
Second Cycle	54.76±0.31 (0.18%)	54.77±0.28 (0.20%)	54.82±0.28 (0.29%)	0.88
Third Cycle	54.75±0.15 (0.16%)	54.85±0.22 (0.35%)	54.79±0.19 (0.24%)	0.52
Fourth Cycle	54.81±0.19 (0.27%)	54.79±0.21 (0.24%)	54.81±0.23 (0.27%)	0.95
Fifth Cycle	54.81±0.20 (0.27%)	54.78±0.26 (0.22%)	54.74±0.32 (0.15%)	0.87
Sixth Cycle	54.76±0.18 (0.18%)	54.86±0.22 (0.37%)	54.72±0.27 (0.11%)	0.44
Seventh Cycle	54.61±0.23 (0.35%)	54.98±0.20 (0.59%)	54.83±0.26 (0.31%)	<0.00

INTERGROUP COMPARISONS

Mean dimensional changes in anteroposterior and mediolateral dimension of the casts were insignificant through six disinfecting cycles. However, in the seventh cycle, a significant difference (p=0.003) was observed in the anteroposterior dimension and mediolateral dimension(p=0.004) within and between the groups. (Table 1 and 2). Mean dimensional expansion was observed in chemical disinfection group.

Maximum percent dimensional change observed in the Anteroposterior dimension between Group A and C was 0.02. While minimum percent dimensional change observed was 0.07 with the range of 0.05. Whereas 0.66 and 0.009 was the maximum and minimum differences in the Anteroposterior dimension among the Group B and C respectively with the range of 0.651.

Maximum difference of change observed in the Mediolateral dimension between Group A and C was 0.81mm, while minimum difference observed was 0.07. On the other side 0.147mm and 0.02mm was the maximum and minimum differences in the Mediolateral dimension among the Group B and C respectively.

Paired Sample T test was applied to get the Inter and Intra rater Reliability analysis. Mean difference in the readings by rater 1 and 2 was 0.018 mm ±0.37 while 0.46mm ±1.61 in the Mediolateral Dimension. But, difference between the measurements by rater 1 and 2 was insignificant. Similarly Mean difference observed in the readings by the rater 1 at two different occasions in the Anteroposterior dimension was 0.52mm±1.6 while 0.06mm±0.34 in the Mediolateral Dimension. Similarly there was insignificant difference in the measurements observed by the rater 1 at two different occasions. This shows reliability of the overall results.

DISCUSSION

Cross infection control is mandatory in any field of medicine. Likewise, there is an increased chance of cross infection in dentistry as oral flora constitutes of a number of microorganisms which can be transported to laboratory via impression, casts and prosthesis.[29]

For this reason, disinfection of impressions and casts is considered very necessary to control cross infection.[30] The impression material chosen for this study was irrerversible hydrocolloid because of its hydrophilic nature[31] and sensitivity to disinfection procedures.[32] Disinfection methods selected were microwave disinfection method and immersion method because of their increase efficacy against most of the organisms.[1,33] Acceptable methods to measure dimensional change are travelling microscope, measuring microscopes, micrometers, dial gauges and calipers.[34] Digital caliper was used for the purpose of this study.

This study was carried out to compare the effect of repeated disinfection on dimensional accuracy of gypsum casts using microwave disinfection and immersion disinfection. It is difficult to relate the results of this present study with the literature since there are no available studies that compare the effect of repeated microwave and

immersion disinfection on dimensional accuracy of gypsum casts.

When intergroup comparison was made, mean dimensional changes in mediolateral and anteroposterior dimension of the casts were insignificant through six disinfecting cycles whereas in the seventh disinfecting cycle a significant difference (p=0.003) was observed within and between the groups. This means that up to six cycles both microwave and immersion disinfection were acceptable in terms of dimensional accuracy but in seventh cycle there was a significant difference.

Cast expansion was observed in a study[18] when cast was subjected to immersion disinfection in 0.5% Sodium hypochlorite for seven times. Our study also showed the same results. The reason for increased dimension may also be because of the dissolution of gypsum metal rod duplicates resulting in increased distance between reference points. According to Malaviya Neha, microwave irradiation causes loss of water as steam[35] which may be the probable reason for the shrinkage of microwave disinfected gypsum casts. In our study, shrinkage also occurred in microwave disinfection group in anteroposterior dimension. According to the results of this study, casts disinfected through immersion disinfection did not produce dimensionally accurate casts in anteroposterior dimension after third cycle (percent dimensional change greater than 0.5) and in seventh cycle of mediolateral dimension. However, result is significant only in the seventh cycle of Anteroposterior dimension (P value= 0.003) and in seventh cycle of mediolateral dimension (P value= 0.004).

In a study performed by Saleh[26], when microwave irradiated gypsum casts and casts obtained by immersing impression in sodium hypochlorite were compared, there was a statistically significant difference ($P < 0.05$) of the overall dimensional accuracy of casts between the control group, sodium hypochlorite disinfection group and microwave irradiation group. The results of this study showed that casts treated with microwave irradiation present similar or improved dimensional accuracy when compared to the casts in the control group.[26] Our study also showed the same results i.e.; microwave irradiation produced dimensionally accurate casts and there was statistically significant difference between control, chemical disinfection and microwave irradiation group in the seventh disinfecting cycle. However, in our study, casts are immersed in sodium hypochlorite instead of impression and repeated disinfection was performed.

In a study conducted by Anaraki et al.[36], there was no significant difference in dimensional accuracy of gypsum casts between case and control samples when samples were exposed to 7 consecutive rounds of 900 watts (W) microwave irradiation for five minutes each time. In our study, microwave disinfection gave dimensionally accurate casts throughout seven disinfecting cycles but a significant difference between chemical disinfected casts and control samples was observed in the seventh disinfecting cycle.

Kumar et al. studied dimensional stability of gypsum cast after repeated immersion in 0.5% sodium hypochlorite and 2%gluteraldehyde. The results of his study revealed that stone casts immersed in 0.525% sodium hypochlorite and 2% glutaraldehyde solutions showed significant linear dimensional change compared to stone casts in slurry (control group). Our study also showed the same results i.e.; casts disinfected through immersion disinfection did not produce dimensionally accurate casts after third cycle in anteroposterior dimension and in seventh cycle of mediolateral dimension. However, result is significant only in anteroposterior and mediolateral dimension in the seventh cycle. This difference may be because immersion time was 30 minutes in Kumar's study as compared to 10 minutes used in our study.[18]

Goel K et al[37] performed a study comparing microwave irradiation with chemical disinfection (using 0.07 % Sodium Hypochlorite) on the dimensional accuracy of gypsum cast. The results showed that there was no significant difference between the microwave irradiated group and chemical disinfection group. However, Goel et al did not study effect of repeated immersion and microwave disinfection. In our study, repeated disinfection was performed according to which, there was no significant difference between the three groups upto six disinfecting cycles.

CONCLUSION

Microwave disinfected casts remained more dimensionally stable as compared to casts disinfected through immersion.

LIMITATIONS

1. A similar study with larger sample size should be designed.
2. A more precise measuring instrument will give more reliable results.
3. Another study should be performed with time interval between two disinfecting cycles of 24 hours so as to simulate the clinical situation more closely.
4. Another study should be designed focusing on the effect of repeated microwave and immersion disinfection on hardness, compressive and tensile strength of gypsum casts.

CONFLICT OF INTEREST

The authors declare that there is no Conflict of interest.

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