Original Article

Comparison of Mean Dimensional Changes in Acrylic Resin Specimen Disinfected with Wet Versus Dry Microwave Cycles at Different Time Intervals

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Article Info

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Date Received:
26th October, 2024
Date Revised:
27th December, 2024
Date Accepted:
1st March, 2025

This article may be cited as:
Malik F, Shah SN, Chughtai MA, Khan E, Khalid M, Mian H. Comparison of mean dimensional changes in acrylic resin specimen disinfected with wet versus dry microwave cycles at different time intervals. J Postgrad Med Inst. 2025;39(1):36-43. http://doi.org/10.54079/jpmi.39.1.3518

Abstract

Objective: To determine the mean dimensional changes in acrylic resin specimens disinfected with wet and dry microwave cycles for disinfection.

Methodology: Acrylic resin specimens were fabricated using a stainless-steel mold measuring 64 x 10 x 3.3 mm in length, width, and thickness, respectively, according to ISO1567 standards. The acrylic resin specimens were measured using digital Vernier calipers and was then divided into ten groups through lottery method. After completing microwave irradiation cycles, measurements of each specimen were recorded using digital Vernier caliper and compared with the readings recorded before microwave treatment, post-irradiation dimensions of acrylic resin specimens were documented on predesigned performa.

Results: All acrylic resin specimen exhibited approximately no dimensional changes in all recorded measurements after microwave irradiation cycles. The results were statistically non-significant with all t-tests having values of $p>0.05$ for each measured distance between the points. No deformations were seen in all groups' specimen except, greatest deformation which was found were in the specimens of group F; that also showed a little change in length.

Conclusion: It may be concluded that these tested acrylic resin specimens demonstrated no deformation under experimental conditions at 850 W of dry and wet microwave irradiations for 3, 6, 9, 12 and 15 minutes and can be considered a suitable method for acrylic denture disinfection.

Keywords: Acrylic resins, Chemical disinfection, Disinfection, Microwave disinfection

Introduction

Removable dentures having acrylic components can be an origin for oral infections because of the capability of pathogenic microorganisms to adhere and survive on denture acrylic resin surfaces.[1,2] Oral infections due to poor denture hygiene demand disinfection protocols that are clinically effective, safe, and inexpensive.[3] Chemical disinfectants have largely been recommended, but most people do not clean their dentures appropriately and may misuse chemical denture cleansers, causing deterioration of acrylic dentures along with color alterations in acrylic resins.[4] Also, once the biofilm is formed, cells within the biofilm undergo profound phenotypic changes, most notably increased resistance to antifungal agents.[5]

W. H. White in 1937 introduced first acrylic resin material in dentistry, which is widely used and is extremely popular in denture base fabrication.[6] The major advantage of the acrylic resin material is its superior esthetics and physical properties compared to previously used denture base materials.[7,8] Despite its superior properties, a major disadvantage of acrylic resin is its porous nature, which absorbs water when exposed to a wet oral environment. As a result of their porous nature, acrylic dentures can be difficult to clean, and it has the affinity to absorb infectious microorganisms, which provides a suitable environment for denture-induced stomatitis.[6]

Microwave disinfection of complete dentures, which are non-autoclavable, was first introduced by Rohrer and Bulard in 1985.[9]

Microwaves are radio frequency waves that are near to the frequency of aircraft radar and television broadcasts. Microwaves are absorbed by absorbent materials such as water when exposed to a microwave field. In comparison to conventional oven where only heat is produced, in microwave the important concept is that heat is converted to energy.[10]

In dentistry, microwave energy can be utilized as a substitute for chemical disinfection. The advantage of microwave disinfection is its easy access, reduced cost and easy to perform.[9] Weekly microwave disinfection of complete dentures is as effective as nystatin antifungal agents in treating the clinical and microbiological signs of denture induced stomatitis. Microwave disinfection does not induce resistance to fungi or other microorganisms, and it also does not produce any color alterations in acrylic resin.[11] Microwave irradiation of complete dentures, however, may affect the dimensional stability of complete dentures because of heating of denture acrylic resin during irradiation, which may result in distortions that could affect the clinical fit of complete dentures.[10] The heating of acrylic resin during microwave irradiation may result in the release of residual monomers, which could further enhance the polymerization reaction. Furthermore, heating of acrylic resin may also result in release of inherent stresses incorporated during processing, which could further cause dimensional changes in complete dentures.[12]

Different research studies have been conducted to demonstrate the effect of microwave irradiation on the dimensional changes of acrylic denture bases, and conflicting results have been shown. According to a study by Rohrer and Bulard9, there were no dimensional changes after 16 minutes of microwave disinfection of both wet and dry dentures, while another study conducted by Polyzois et al. concluded that dimensional changes occur in the denture when exposed to high power in the microwave for 10 minutes.[13] According to a systematic review, microwave disinfection causes changes in the dimensional accuracy of denture base acrylic resins and should be used with caution[14]

Few studies have been conducted internationally to compare mean dimensional changes in complete dentures after microwave disinfection (650watt,700watt) in both wet and dry cycles with mixed results. Therefore, there is a need to study this further to reach a definitive conclusion. The aim of this study is to compare the mean dimensional changes in acrylic resin specimens after microwave disinfection in both wet and dry cycles at 850 watts at different time intervals. It is to find a better disinfection technique for routine use that causes no dimensional changes, which would otherwise cause loss of clinical fit and occlusal discrepancy in complete dentures.

Methodology

MATERIALS AND METHOD:

This experimental in vitro study was conducted at the Department of Prosthodontics, Sardar Begum Dental Hospital, after approval from the hospital's ethical and Board of advanced studies and research Gandhara University.

The sample size was calculated taking effect size of 0.4 mm and standard deviation of 0.28 15 at 95 % confidence interval and 80 percent power of study through the formula:

$$n=\frac{2(Z_{\alpha/2}+Z_{\beta})^2\sigma^2}{\Delta^2}$$

The sample size came out to be 7.68 per group, so to get a suitable figure, 10 specimens in each group were taken, so a total of 100 specimens were fabricated for 10 groups.

A stainless-steel mold was fabricated according to ISO standard no ISO1567, the die of the mold was measuring 64x10x3.3 mm in length, width and thickness, respectively. The die was cleaned with cotton cloth before preparing each wax pattern. The specimens were then invested in the drag of the flask using die stone (Dent America) as an investment material. After setting of the die stone plaster, dewaxing was done for 20 minutes. After opening and cooling of the molds, cold mold seal was applied. Acrylic resin was prepared in accordance with the manufacturer's instructions, packed into the mold during the dough stage, and cured using a short curing cycle, i.e., by placing in water at room temperature and setting curing temperature at 74°C for 1.5 hours followed by heating to 100 °C for one hour. The mold was then opened after bench cooling. Excess materials were removed and the specimen were then polished and kept in distilled water at 37 °C for 72 hours before they are subjected to microwave. Acrylic specimens with porosities were excluded and Hundred acrylic resin specimens were selected having dimensions measuring 64x10x3.3 mm in length, width and thickness respectively using digital vernier caliper.

The acrylic resin specimens were divided into ten groups. Microwave Oven 850 watts (LG MS3042G) was used. The acrylic resin specimen allotted to group A were subjected to microwave disinfection regimen of 03 minutes at 850W immersed in distilled water while acrylic resin specimen in group B were subjected to dry microwave disinfection regimen of 03 minutes at 850W. The acrylic resin specimen allotted to group C were subjected to microwave disinfection regimen of 06 minutes at 850W immersed in distilled water while acrylic resin specimen in group D were subjected to dry microwave disinfection regimen of 06 minutes at 850W. The acrylic resin specimen allotted to group E were subjected to microwave disinfection regimen of 09 minutes at 850W immersed in distilled water while acrylic resin specimen in group F were subjected to dry microwave disinfection regimen of 09 minutes at 850W. The acrylic resin specimen allotted to group G were subjected to microwave disinfection regimen of 12 minutes at 850W immersed in distilled water while acrylic resin specimen in group H were subjected to dry microwave disinfection regimen of 12 minutes at 850W. The acrylic resin specimen allotted to group I were subjected to microwave disinfection regimen of 15 minutes at 850W immersed in distilled water while acrylic resin specimen in group J were subjected to dry microwave disinfection regimen of 15 minutes at 850W.In order to lessen the heat concentration in the specimens, acrylic resin specimens that had not been submerged in distilled water were put directly on the microwave's rotating plate along with a glass that held eight ounces of water.

After completing cycles, the specimens were measured and compared with the readings recorded before microwave treatment, to see if there were any changes in the dimension of acrylic resin specimen. All the data was noted on predesigned Performa. All the data collected was entered and analyzed in SPSS (version 25). Mean + SD was calculated by paired sample T test. ANOVA test was applied to compare the length A width B and depth C in all the groups. All the data was than presented as tables/histograms.

Results

All acrylic resin specimens exhibited approximately no dimensional changes in all recorded measurements after microwave irradiation cycles. The results were statistically non-significant, with all t-tests having values of $p>0.05$ for each measured distance between the points. No deformations were seen in all groups' specimen except, greatest deformation which was found were in the specimens of group F; that also showed a little change in length after microwave irradiation as per research methodology of the present study.

Table 1. showing means standard deviation and significance level of Group A & B specimens

Paired statistics		Mean	Std. Deviation	Std. Error mean	Significance
Pair 1	Group A1 Length 1	64.0000	.00000	.00000	0.343
	Group A2 Length 2	64.0000	.00000	.00000	
Pair 2	Group A1 Width 1	10.0000	.00000	.00000	0.343
	Group A2 Width 2	9.9900	.03162	.01000	
Pair 3	Group A1 Thickness 1	3.3000	.00000	.00000	0.168
	Group A2 Thickness 2	3.2800	.04216	.01333	
Pair 1	Group B1 Length 1	64.0000	.00000	.00000	.343
	Group B2 Length 2	64.0000	.00000	.00000	
Pair 2	Group B1 Width 1	10.0000	.00000	.00000	.343
	Group B2 Width 2	10.0200	.06325	.02000	
Pair 3	Group B1 Thickness 1	3.3000	.00000	.00000	0.343
	Group B2 Thickness 2	3.3000	.00000	.00000	

J Postgrad Med Inst 2025;39(1):36-43.
http://doi.org/10.54079/jpmi.39.1.3518

Table 2. showing means standard deviation and significance level of Group C & D specimens

Paired statistics		Mean	Std. Deviation	Std. Error mean	Significance
Pair 1	Group C1 Length 1	64.0000	.00000	.00000	
	Group C2 Length 2	64.0000	.00000	.00000	
Pair 2	Group C1 Width 1	10.0000	.00000	.00000	
	Group C2 Width 2	10.0000	.00000	.00000	
Pair 3	Group C1 Thickness 1	3.3000	.00000	.00000	
	Group C2 Thickness 2	3.3000	.00000	.00000	
Pair 1	Group D1 Length 1	64.0000	.00000	.00000	
	Group D2 Length 2	64.0000	.00000	.00000	
Pair 2	Group D1 Width 1	10.0000	.00000	.00000	
	Group D2 Width 2	10.0000	.00000	.00000	
Pair 3	Group D1 Thickness 1	3.3000	.00000	.00000	
	Group D2 Thickness 2	3.3000	.00000	.00000	

Table 3. showing means standard deviation and significance level of Group E & F specimens

Paired statistics		Mean	Std. Deviation	Std. Error mean	Significance
Pair 1	Group E1 Length 1	64.0000	.00000	.00000	.343
	Group E2 Length 2	63.9900	.03162	.01000	
Pair 2	Group E1 Width 1	10.0000	.00000	.00000	
	Group E2 Width 2	10.0000	.00000	.00000	
Pair 3	Group E1 Thickness 1	3.3000	.00000	.00000	
	Group E2 Thickness 2	3.3000	.00000	.00000	
Pair 1	Group F1 Length 1	64.0000	.00000	.00000	.169
	Group F2 Length 2	63.9390	.12914	.04084	
Pair 2	Group F1 Width 1	10.0000	.00000	.00000	
	Group F2 Width 2	10.0000	.00000	.00000	
Pair 3	Group F1 Thickness 1	3.3000	.00000	.00000	
	Group F2 Thickness 2	3.3000	.00000	.00000	

Discussion

This study aimed to determine whether denture bases made of acrylic resin would show signs of dimensional instability after being exposed to microwave radiation cycles.

The 2-way ANOVA revealed difference in thickness of group A, width of B, length of group E, length of group F, length of group G, thickness of group H, thickness of group I and thickness of group J, although these differences were not significant. Independently of the microwave disinfection cycle duration, dry and wet microwave disinfection demonstrated no statistically significant difference.

While microwaving the specimens the dry microwaving caused the specimens to heat up while the specimens which were wet microwaved had no temperature elevation, the reason of which may be the increased molecular movement in the specimens because of the resonance produced by microwave radiation.

Prior research concluded that using 650W and 700W microwave irradiations did not affect the dimensional stability of irradiated acrylic resin specimens. The type of acrylic resin examined, the test material's shape, and its dimensions whether they are acrylic resin discs, rectangular sticks, standardized denture bases, or

Table 4. showing means standard deviation and significance level of Group G & H specimens

Paired statistics		Mean	Std. Deviation	Std. Error mean	Significance
Pair 1	Group G1 Length 1	64.0000	.00000	.00000	.343
	Group G2 Length 2	64.0000	.03162	.01000	
Pair 2	Group G1 Width 1	10.0000	.00000	.00000	
	Group G2 Width 2	10.0000	.00000	.00000	
Pair 3	Group G1 Thickness 1	3.3000	.00000	.00000	
	Group G2 Thickness 2	3.2540	.00000	.00000	
Pair 1	Group H1 Length 1	64.0000	.00000	.00000	
	Group H2 Length 2	63.9390	.00000	.00000	
Pair 2	Group H1 Width 1	10.0000	.00000	.00000	
	Group H2 Width 2	10.0000	.00000	.00000	
Pair 3	Group H1 Thickness 1	3.3000	.00000	.00000	.343
	Group H2 Thickness 2	3.3000	.07545	.02386	

Table 4. showing means standard deviation and significance level of Group I & J specimens

Paired statistics		Mean	Std. Deviation	Std. Error mean	Significance
Pair 1	Group I 1 Length 1	64.0000	.00000	.00000	
	Group I 2Length 2	64.0000	.00000	.00000	
Pair 2	Group I 1 Width 1	10.0000	.00000	.00000	
	Group I 2 Width 2	10.0000	.00000	.00000	
Pair 3	Group I 1 Thickness 1	3.3000	.00000	.00000	.533
	Group I 2 Thickness 2	3.2790	.10246	.03240	
Pair 1	Group J1 Length 1	64.0000	.00000	.00000	
	Group J2 Length 2	64.0000	.00000	.00000	
Pair 2	Group J1 Width 1	10.0000	.00000	.00000	
	Group J2 Width 2	10.0000	.00000	.00000	
Pair 3	Group J1 Thickness 1	3.3000	.00000	.00000	.187
	Group J2 Thickness 2	3.2690	.06871	.02173	

complete dentures vary widely throughout previous investigations. These investigations found that three minutes of microwave irradiation is safe and does not harm the acrylic resin samples.[16]

The fundamental idea behind microwave disinfection is that the typical experienced individual should find it straightforward and easy to perform. 650-watt microwaves are rare, and it is difficult to find a higher-wattage microwave that can be precisely lowered to 650 watts. According to studies, the procedures required to sanitize dentures using microwave radiation are more complex than what the typical individual would utilize. That's why a conventional microwave with 850 W was used in this study for delivery of disinfection cycles to acrylic resin specimens.[17]

The main reason for selecting microwave irradiation cycles for the disinfection of acrylic resin specimens is to benefit the community by minimizing the expense of disinfection solutions, chemicals, and tablets. Moreover, to make it convenient for seasoned denture wearer as their motor functions are already impaired and quantifying disinfection solutions and chemicals is not easy and they can easily deliver a microwave irradiation cycle to disinfect their dentures.

Every material was weighed and processed according to the manufacturer's specifications. In order to lessen

J Postgrad Med Inst 2025;39(1):36-43.
http://doi.org/10.54079/jpmi.39.1.3518

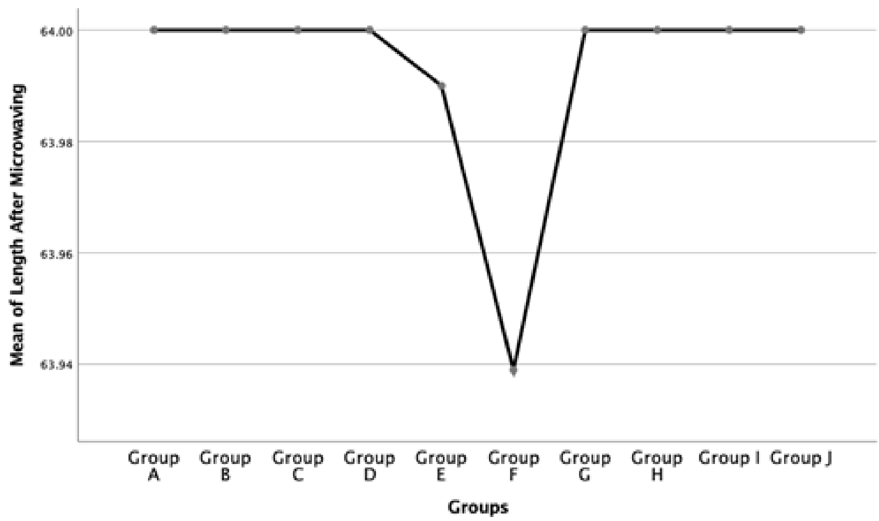

Figure 1: Graph showing mean changes amongst various groups

the impact of three-dimensional deformation, specimens were leveled before being exposed to microwave radiation. This was done since asymmetric distortions might not be picked up by merely observing linear changes. As a result, the measurement's repeatability and reliability increased.[18]

The results of the present study showed that microwave disinfection cycles did not significantly alter the dimensional stability. All measurements and experimental groups were found to be highly consistent in the experimental results. After being subjected to microwave radiation, the acrylic resin specimens experienced consistent deformation, and the results showed no increases in results. This fact is most likely explained by the acrylic resin specimens being heated uniformly while submerged in a beaker of water. This could account for Basso et al.'s findings that irradiating specimens while submerged in water improves disinfection.[18]

Effects of microwaving on the dimensional stability of acrylic resin specimens are similar to the effects in the studies of Gonçalves et al, (2009)[9] and Senna and Da Silva (2011)[19], although in their studies, the irradiation protocol was 650 W for 6 minutes and 900 W for 3 minutes per cycle. In this study, the dimensional stability was unchanged and the specimens showed repeated results as in the present study, only one cycle was delivered to each specimen, which is in perfect contrast with Basso et al, (2010) reported no significant effect on dimensional stability.[12] Conversely, a prior work by Polychronakis, Yannikakis, and Zissis[20] discovered that after seven 6-minute cycles of disinfection in a microwave oven set to 650W, acrylic resin specimens exhibited linear shrinkage of up to -1.16%. Alkhodary[21], in contrast to our investigation, found that expansion occurred in rectangular acrylic resin specimens following seven or twenty-eight cycles of microwave disinfection at 600 W or 700 W for three minutes. Different microwave disinfection procedures and test specimen measurements may be the cause of the dispute around our findings. Additionally, after two exposures at 420 W microwave energy for three minutes, Wagner and Pipko[15] found an expansion of acrylic resin; however, the test specimens were denture bases rather than rectangles.

The materials and polymerisation cycle utilized to fabricate the specimens, as well as the techniques employed to measure dimensional changes, could also be factors in the difference between their and our results.[15]

The current study's findings can be compared to the study by Consani et al. According to their research, heat is produced inside the acrylic resin specimens by microwave radiation, which increases the degree of conversion of acrylic resins by lowering the amount of residual monomer. Therefore, it is possible that the acrylic resin exposed to microwave radiation became more rigid, which reduced the cohesive strength and, consequently, the size of the irradiated specimens.[22]

Unlike the results from the present study, in which there were minimal dimensional changes because each specimen received one irradiation cycle, these results were in accordance with the conclusions of a review done by Brondani et al., in which they reviewed studies on microwave disinfection and concluded that the mechanical characteristics of the denture base and resin teeth appear to be unaffected by microwave ovens. Additionally, they discovered that denture bases are susceptible to detrimental dimensional alterations, especially following repeated, prolonged contact. However, this is a limitation of the present study that the effect of repeated microwave disinfection cycles was not evaluated.

This review also revealed that microwave irradiation provides good disinfection to the denture bases, and the mechanical properties of a denture depend on the time of exposure, power of the microwave oven, solution of immersion, and frequency of use.[23]

Conclusion

It may be concluded that these tested acrylic resin specimens demonstrated no deformation under experimental conditions at 850 W of dry and wet microwave irradiations for 03, 06, 09, 12 and 15 minutes and can be considered a safe method of disinfection for acrylic dentures. Thus, on the basis of these findings, Microwave irradiation method with the mentioned specifications can be recommended to denture wearers for disinfection of their complete dentures.

Recommendations:

The present study evaluated the effect of microwave disinfection on dimensional changes however, the effect of microwave disinfection on mechanical properties like transverse strength, modulus of elasticity, toughness and impact strength of dentures have not been studied. Further studies are recommended to evaluate them so that recommendation of this method for disinfection can be made more safe.

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Authors' Contribution Statement

FM contributed to the conception, design, acquisition, analysis, interpretation of data, and drafting of the manuscript. SNS contributed to the conception, design, acquisition, interpretation of data, drafting of the manuscript, and final approval of the version to be published. MAC contributed to the analysis, interpretation of data, drafting of the manuscript, and critical review of the manuscript. EK contributed to the acquisition, analysis, drafting of the manuscript, and critical review of the manuscript. MK contributed to the conception, design, acquisition, interpretation of data, drafting of the manuscript, and final approval of the version to be published. HM contributed to the acquisition and analysis of data. All authors are accountable for their work and ensure the accuracy and integrity of the study.

Confilct of Interest

Authors declared no conflict on interest

Grant Suppport and Financial Disclosure

None

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.