

## Effect of Repeated Microwave Disinfection on the Surface Hardness of a Heat-Cured Denture Base Resin: An *In vitro* Study

### Abstract

**Statement of the Problem:** Disinfection of complete dentures is very crucial to prevent cross-contamination and infection. Microwave disinfection is a quick, easy, and effective means to disinfect dentures. However, the effect of repeated microwave cycles on the surface hardness property of heat-cured polymethyl methacrylate (PMMA) resin is not known. **Materials and Methods:** A total of 60 samples of heat-cured PMMA resin were fabricated for surface hardness. Each group was divided into four groups, according to the number of microwave cycles (MWC) applied for disinfection: control group (no disinfection) 0MWC, 1MWC group, 3MWC group, and 5MWC group. **Results:** No significant change on the surface hardness of a heat-cured denture base resin on repeated microwave disinfection. **Conclusion:** The repeated microwave disinfection showed statistically nonsignificant change on the surface hardness of the PMMA resin. Microwave disinfection can be safely used in regular practice to avoid cross-contamination and can also be suggested to patients for the regular denture hygiene.

**Keywords:** Denture base resin, microwave disinfection, surface hardness

### Introduction

The ultimate purpose of dentistry is to heal and give relief to the patients from their dental problems. During the procedures, the dentist has a legal and ethical obligation to prevent infections among patients, dental personnels, and technicians due to cross-contamination. Control of cross-infection has been a subject of interest to the area of dentistry over the last few decades. Therefore concern about the transmission of infectious contagious diseases like AIDS, hepatitis, tuberculosis, pneumonia, and herpes between the dental patients and dental personnel is of prime importance.<sup>[1]</sup>

Dentures can be cleaned or disinfected mechanically, chemically, or through a combination of both mechanical and chemical procedures. The disadvantages of mechanical procedures are ineffective in removing an unacceptably large proportion of adherent microorganisms.<sup>[2]</sup> It causes scratches and irregularities on the surface of the dentures. Chemical methods for disinfecting dentures include soaking or immersion in solutions such as vinegar, sodium hypochlorite, glutaraldehydes,

iodoforms, chlorine dioxide, or alcohol solutions. However, the chemical disinfection may present disadvantages such as denture staining, bleaching, denture corrosion, odor, and patient's oral tissue reactions.<sup>[3]</sup> To overcome the disadvantages of chemical disinfection, the use of microwave energy has been suggested in dentistry as a simple alternative to prostheses disinfection.<sup>[3-6]</sup>

The surface hardness of a denture is based on its ability to resist scratching. Hardness is defined as the "resistance to indentation." Measurements of surface hardness of a denture base resin indicate to what extent the forces applied during mastication can be resisted.<sup>[7]</sup> Hence, if the hardness decreases considerably with subsequent microwave disinfection cycles, then wear of the denture base material increases, leading to fracture of the denture.

Hence, the purpose of this study was to investigate the effect of repeated microwave disinfection on the surface hardness of a heat-cured denture base resin and to test the hypothesis that repeated microwave disinfection will have a negative effect on the property of surface hardness of denture base resins.

**Priti Jaiswal,  
Neelam Pande,  
Rajlakshmi  
Banerjee,  
Usha Radke**

*Department of Prosthodontics,  
VSPM DCRC, Nagpur,  
Maharashtra, India*

### Address for correspondence:

Dr. Priti Jaiswal,  
"Shree Ganesh," Plot No. 8,  
South Ambazari Road, Laxmi  
Nagar, Nagpur - 440 022,  
Maharashtra, India.  
E-mail: dr.priti.jaiswal@  
gmail.com

### Access this article online

#### Website:

www.contempclindent.org

DOI: 10.4103/ccd.ccd\_271\_18

#### Quick Response Code:



**How to cite this article:** Jaiswal P, Pande N, Banerjee R, Radke U. Effect of repeated microwave disinfection on the surface hardness of a heat-cured denture base resin: An *In vitro* study. *Contemp Clin Dent* 2018;9:446-51.

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

## Aim and objectives

### Aim

The aim of this study is to evaluate and to compare the effect of repeated microwave disinfection on the surface hardness of a heat-cured denture base resin.

### Objectives

The objective of this study is to evaluate the effect of repeated microwave disinfection on the surface hardness of a heat-cured denture base resin. Moreover, to compare the effect of different cycles of microwave disinfection on surface hardness of a heat-cured denture base resin.

## Materials and Methods

Heat-cured polymethyl methacrylate (PMMA) resin (DPI Heat Cure PINKTM, Dental Product of India Ltd., India 2135) was used to fabricate the test samples which were tested using the Microhardness Tester (Company Reichert, Austria SR. No. 363798).

The steps involved in the fabrication of the test samples are as follows:

### Fabrication of metal dyes

A set of six brass metal dies of disk shape was fabricated, each having dimensions of 15 mm diameter and 5 mm depth [Figure 1]. These metal dies also have a threaded hole at the center; to facilitate easy removal of dies from the stone mold, with screws engaged in these threaded holes. The diameter of threaded hole was 5 mm, and depth was 3 mm, leaving the other surface untouched for the measurement of surface hardness.<sup>[8]</sup>

### Fabrication of gypsum mold

In a single mold, for surface hardness test, six metal dies (15 mm × 5 mm depth) were invested in the flask [Figure 2]. The stone was allowed to set for 1 h.<sup>[9]</sup> After that flask was opened with the help of screws, the dies were gently separated from the investing material, leaving behind the mold cavities.

### Preparation of polymethyl methacrylate resin samples

Conventional heat polymerizing denture base material (DPI Heat Cure) was used in the study. A total of 60 samples for the tests were fabricated, 3 ml of monomer and 7.5 g of polymer powder was mixed. Packing was done. Short-curing cycle was carried out, and then, finishing and polishing of the samples were done and then stored in distilled water. In the group (SH), there were total 60 samples divided into four groups of 15 samples each [Figure 3].

- Group SH-0 Samples without undergoing microwave disinfection cycle
- Group SH-One microwave cycle (1MWC) – Samples with 1 cycle of microwave disinfection

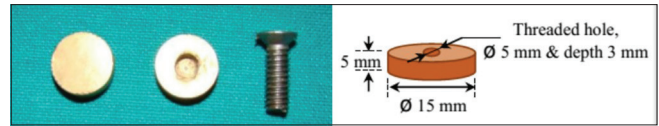


Figure 1: Metal dies (brass) with screw



Figure 2: Metal dies invested in die stone for preparation of the mold

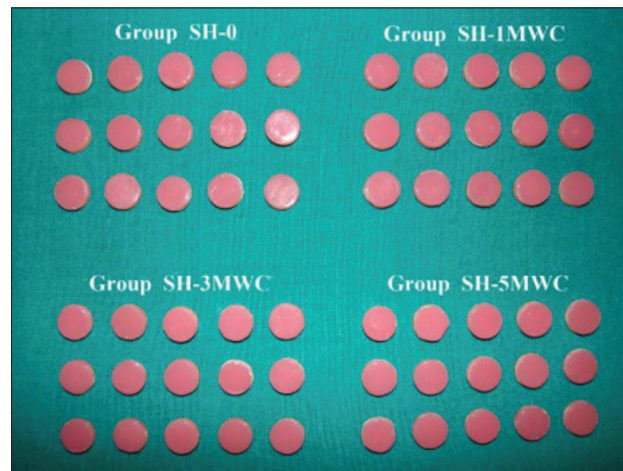


Figure 3: Groups of surface hardness test samples

- Group SH-3MWC – Samples with three cycles of microwave disinfection
- Group SH-5MWC– Samples with five cycles of microwave disinfection.

### Microwave disinfection of the samples

Each sample was immersed in 150 ml of distilled water<sup>[8]</sup> inside a Borosil beaker and then inserted inside a microwave oven, which was set at 650 W for 3 min.<sup>[10]</sup> This was referred as “one disinfection cycle of microwave irradiation.” Thus, the above-described procedure for 1MWC was repeated three times for the group with 3MWCs and five times for 5MWCs one cycle/day. After completion of MWCs, all the samples were again stored in the distilled water, till the tests were performed [Figure 4].

## Testing of samples

All the samples were initially conditioned in incubator, immersed in distilled water at 37°C for 48 h, before they were tested on machines, to simulate oral conditions.<sup>[8]</sup>

## Surface hardness test

The samples were tested using the Vickers hardness (HV) test method, which consists of indenting the test material with a diamond indenter, in the form of a right pyramid with a square base and an angle of 136° between opposite faces subjected to a load of 0.05 kgf [Figure 5]. The load was applied for 10–15 s. The two diagonals of the indentation left on the surface of the sample, after removal of the load, were measured using a microscope and their average was calculated. The area of the sloping surface of the indentation was calculated. The HV was the quotient obtained by dividing the kgf load by the square millimeter area of indentation.

The HV number was calculated in (HV) using the formula:

$$HV = (1.854 \times F)/d^2$$

Where F = Load (kgf), d = Arithmetic mean of the two diagonals, d1 and d2, (mm)

## Results

The datasets for each test were evaluated for normal or nonnormal distribution. The mean and median values for each group were also evaluated. The Shapiro–Wilk normality test was used to check the normal distribution of data.  $P < 0.05$  indicates that the sample deviates from normality. For the normally distributed data, the mean of the four subgroups was suggested for the comparison using one-way analysis of variance (ANOVA) and Student's *t*-test for pair-wise comparison.  $P \leq 0.05$  was considered to be statistically significant. The computer software, such as NCSS, EPI INFO software, and WinSTAT (MS Excel), was used to perform statistical calculations.

The arithmetic mean of the two diagonals for the surface hardness of each sample under the load of 50 g (0.05 kgf) was recorded as shown in Master Chart 1.



Figure 4: Microwave oven

The HV number for each sample was calculated using the formula described above. The highest, lowest, and mean surface hardness value with standard deviation for Control Group SH-0MWC, SH-1MWC, SH-3MWC, and SH-5MWC were recorded as shown in Table 1. The mean surface hardness for groups control group SH-0 MWC, SH-1MWC, SH-3MWC, and SH-5MWC is shown in Graph 1. One-way ANOVA was applied on the test results of the four groups, and comparison was done. The results of ANOVA for the surface hardness of all the four groups were shown in Table 2. The  $P < 0.05$  was taken as significant change among the groups. This analysis revealed statistically nonsignificant ( $P = 0.380$ ) change in the surface hardness of the four groups. Student's *t*-test was applied to compare two groups in a pair, and pairwise significance of surface hardness is shown in Table 3.  $P < 0.05$  was taken as significant change between the two compared groups. On comparison, it was found that there was no significant change in groups from each other.

## Discussion

Surface hardness of a denture base resin indicates to what extent the forces applied during mastication can be resisted.<sup>[7]</sup> The result for surface hardness, from Tables 1 and 3, indicates that there is an increase in mean HV number of the denture base resin up to 3MWCs and decreased for 5MWCs. The increase in surface hardness was observed because of reduction in residual monomer levels either due to leaching out of monomer with increases in temperature or due to further conversion of monomer into acrylic because of microwave polymerization. However, there was decrease in surface hardness of the last disinfection group, which could be due to water sorption at the surface, accelerated by increase in temperature during microwave disinfection, thus producing a plasticizing effect and causing the reduction in the surface hardness of the denture base material. The statistical analysis (ANOVA) of current study, Table 3 indicates that the change in the surface hardness of denture resin due to repeated



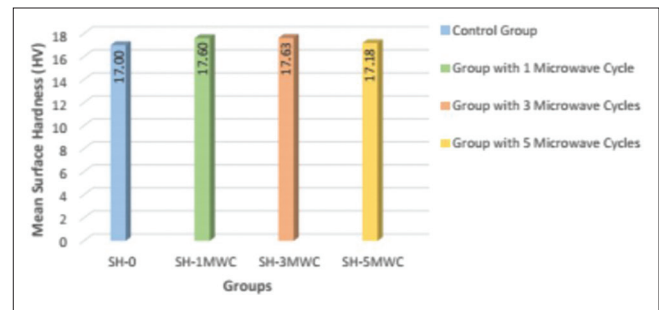
Figure 5: Microhardness tester

microwave disinfection is nonsignificant,  $P = 0.380$  (at the 95% confidence level,  $P$  value is significant, if  $P \leq 0.05$ ). This can be explained by the use of higher polymerization temperature for the denture material at the time of polymerization, which eventually, resulted in less residual monomer to cause any effect on the surface hardness of the resin. In addition, the rise in temperature, which was for very short interval of time, did not influence the water sorption at the surface, significantly. Hence, the repeated microwave disinfection contributed nonsignificant change in the surface hardness of the denture resin. In a previous study, Ribeiro *et al.*<sup>[11]</sup> found no significant changes in the mean hardness values between the control specimens and those submitted to microwave disinfection at different exposure times (up to 5 min). Consani *et al.*<sup>[12]</sup> also evaluated and compared the effect of repeated simulated microwave disinfections on the adaptation of the maxillary complete denture achieved when bases were prepared using the traditional cramp flask closure and Restriction System flask closure methods. Repeated simulated disinfections by microwave energy did not cause deleterious effect on the base adaptation when the

traditional cramp and RS system flask closure methods were compared. Silva *et al.*<sup>[13]</sup> also stated that the hardness of heat-cured resin was not significantly influenced by either of the disinfection methods, immersion in sodium perborate (50°C/10 min) or microwave irradiation (650 watts/6 min), or the number of MWCs. Hence, there was no significant increase in hardness of heat-cured resin by microwave disinfection. Senna *et al.*<sup>[14]</sup> evaluated the cumulative effects of different microwave power levels on the physical properties of two PMMA denture base resins. PMMA specimens (two polymerized in a water bath and two using microwave energy) were submitted to microwave irradiation for 3 min at a power level of 450,630, or 900 W. The surface roughness, surface hardness, linear stability, flexural strength, elastic modulus, impact strength, and fractographic properties were evaluated after either 6 or 36 simulated disinfection cycles. The results showed that the polymerization method did not influence any property except linear stability. They also concluded that microwave disinfection at 450 W to 630 W for 3 min is safe for PMMA. Konchada *et al.*<sup>[15]</sup> evaluated and compared the effect of simulated microwave disinfection at a recommended power setting on the mechanical properties of three denture base heat-polymerized acrylic resins. The mechanical properties of the three denture base resins were not altered after simulated microwave disinfection, as compared to those of the controls. They concluded that Microwave irradiation at 650 W for 5 min did not affect the mechanical properties of the three denture base resins. Domestic microwave oven, at the prescribed setting, can be used as an alternative method of disinfection for complete dentures without affecting their properties. Thus, the results of the present study are in accordance with the findings of the previous studies<sup>[11-15]</sup> stating that there is no significant effect on the surface hardness of the denture material due

Sample No.	RESULTS							
	Group SH-0 - Control Group (Acrylic resin without Microwave Cycle.)		Group SH-1MWC - Acrylic resin with one Microwave Cycle.		Group SH-3MWC - Acrylic resin with three Microwave Cycles.		Group SH-5MWC - Acrylic resin with five Microwave Cycles.	
	Reading (µm)	Hardness, 50g Load, (HV)	Reading (µm)	Hardness, 50g Load, (HV)	Reading (µm)	Hardness, 50g Load, (HV)	Reading (µm)	Hardness, 50g Load, (HV)
1	68.43	19.80	74.25	16.81	73.01	17.39	69.66	19.10
2	70.72	18.54	70.37	18.72	71.95	17.91	71.20	18.29
3	73.19	17.31	75.48	16.27	71.67	18.05	70.72	18.54
4	71.02	18.38	71.42	18.17	74.95	16.50	75.83	16.12
5	75.82	16.13	75.48	16.27	71.88	17.94	76.89	15.68
6	77.60	15.39	72.66	17.56	72.02	17.87	74.42	16.74
7	74.42	16.74	71.42	18.17	74.95	16.50	76.62	15.79
8	69.66	19.10	75.13	16.42	68.43	19.80	74.80	16.57
9	76.72	15.75	72.83	17.48	71.42	18.17	76.01	16.04
10	74.42	16.74	71.07	18.35	74.13	16.87	73.01	17.39
11	73.19	17.31	74.07	16.90	72.66	17.56	71.80	17.98
12	78.48	15.05	71.04	18.37	75.41	16.30	73.36	17.23
13	82.89	13.49	72.55	17.61	73.01	17.39	75.66	16.19
14	71.42	18.17	70.13	18.85	71.95	17.91	72.31	17.73
15	73.54	17.14	71.60	18.08	71.30	18.23	71.20	18.29
AVG.	74.10	17.00	72.63	17.60	72.58	17.63	73.57	17.18

Master Chart 1: Surface hardness test data



Graph 1: Mean surface hardness for different groups

Table 1: Descriptive statistics of Surface Hardness test data

Group	Count	Min.	Max.	Median	Mean	Standard deviation	Standard error
SH-0	15	13.49	19.80	17.14	17.00	1.67	0.43
SH-1MWC	15	16.27	18.85	17.61	17.60	0.88	0.23
SH-3MWC	15	16.30	18.23	17.87	17.63	0.88	0.23
SH-5MWC	15	15.68	19.10	17.23	17.18	1.11	0.29

\* $P \leq 0.05$ =Data non-normally distributed, \*\* $P > 0.05$ =Data normally distributed

to microwave disinfection. Vasconcelos *et al.*<sup>[16]</sup> evaluated the effect of simulated disinfections (2% glutaraldehyde, 1% sodium hypochlorite, and microwave energy) on the surface hardness of Trilux, Biocler, Biotone, New Ace, and Magister commercial artificial teeth. They concluded that different disinfection methods promoted different effects on the microhardness of different types of artificial teeth. Surface microhardness of the teeth was less affected by the simulated chemical disinfections when compared to microwaved specimens. Although in this study, some effect is seen on the artificial teeth with the use of microwaves, the present study was done to check the effect of microwave disinfection on the surface hardness of denture base and effect on denture teeth was not considered in the ambit of this study. Senna *et al.*<sup>[17]</sup> evaluated whether the addition of an enzymatic cleanser to microwave disinfection regimen would disinfect dentures with shorter irradiation time. The group of specimens colonized with *Candida albicans* biofilm was submitted to microwave irradiation at 450 W for 1, 2, or 3 min. Another group of specimens colonized with *Candida albicans* biofilm was immersed in denture cleanser for 3 min with microwave irradiation at 450 W for 1, 2, or 3 min. The results showed that no viable cells were found after immersion in denture cleanser with microwave irradiation at 450 W for 2 or 3 min and microwave irradiation alone at 450 W for 3 min. The lowest temperature was achieved when disinfected through microwave irradiation at 450 W for 2 min along with immersion in denture cleanser. They concluded that the association of a denture cleanser and microwave energy

is efficient to disinfect dentures in lower irradiation time and temperature. Klironomos *et al.*<sup>[18]</sup> evaluated the effect of microwave disinfection on denture base polymers, liners, and teeth. The results showed that microwave disinfection could be a safe alternative for the disinfection microwave disinfection (650 W/3 min/3 cycles) is a safe alternative for the disinfection of denture bases and liners compared to the chemical one when the procedure is carried out in dry conditions, but could possibly cause dimensional changes of clinical significance when the irradiation takes place in wet environment. More than three cycles of microwave disinfection in these settings could adversely affect the physical–mechanical properties of denture base resins, liners, or teeth. Microwave irradiation (650 W/3 min) seems to have no detrimental effects of clinical importance on the flexural properties, impact strength and hardness of denture resins and the bond, flexural strength, porosity, and hardness of denture liners. The effects of microwave disinfection on the hardness of denture teeth and teeth/denture bond strength are still controversial and no safe conclusions can be drawn. However, in the present study, it was found that no significant difference was seen on the surface hardness with (650 W/5 cycles) in wet conditions on the denture base resins.

The findings fulfilled the aim and objectives of this study, which clinically implies that microwave irradiation, can be used for denture disinfection to avoid cross-contamination. It can be performed repeatedly as there is no adverse effect of microwave irradiation on the surface hardness of the denture base acrylic resin. This method of disinfection for complete dentures and treatment partial dentures can be performed in domestic microwave oven, with the same parameters and setting used in this study. In this study, samples were prepared in accordance with the American Dental Association specification number 12. Although the study was designed and carried out with highest possible accuracy, still, the present study has certain limitations as in practice; dentures would be exposed to large number of MWCs

**Table 2: ANOVA of Surface Hardness test data**

Source of variation	Sum of squares	df	Mean square	F	P	Status
Between groups	4.365	3	1.455	1.043	0.380***	Not significant
Within groups	78.096	56	1.395			
Total	82.461	59				

\* $P < 0.01$ =Highly significant. \*\* $P < 0.05$ =Significant. \*\*\* $P > 0.05$ =Not significant

**Table 3: Pairwise significance of Surface Hardness test data (t-test)**

t-test	Group	Count	Mean	Std. deviation	t	P	Status
1.	SH-0	15	17.00	1.67	-1.230	0.229***	Not significant
	SH-1MWC	15	17.60	0.88			
2.	SH-0	15	17.00	1.67	-1.279	0.211***	Not significant
	SH-3MWC	15	17.63	0.88			
3.	SH-0	15	17.00	1.67	-0.341	0.736***	Not significant
	SH-5MWC	15	17.18	1.11			
4.	SH-1MWC	15	17.60	0.88	-0.073	0.943***	Not significant
	SH-3MWC	15	17.63	0.88			
5.	SH-1MWC	15	17.60	0.88	1.163	0.255***	Not significant
	SH-5MWC	15	17.18	1.11			
6.	SH-3MWC	15	17.63	0.88	1.228	0.230***	Not significant
	SH-5MWC	15	17.18	1.11			

\* $P < 0.01$ =Highly significant. \*\* $P < 0.05$ =Significant. \*\*\* $P > 0.05$ =Not significant

within its service life. Therefore, a long-term study can be carried out to investigate the effect of microwave irradiations throughout the service life of the dentures. In the oral cavity, dentures are subjected to forces of varying magnitudes acting in different directions, all at the same time. The same situation could not be simulated, in this *in vitro* study. Furthermore, the curvature of the denture follows the contours of the anatomic tissues. Rectangular acrylic strips were used for the test; the same curvature could not be simulated in this study.

## Summary and Conclusion

Within the limitations of this study, following conclusions were drawn. The domestic microwave oven can be used to disinfect the dentures. The microwave disinfection method can be used repeatedly for disinfecting the dentures up to 650 W for 3 min. The repeated microwave disinfection showed statistically nonsignificant change in the surface hardness of the PMMA resin. It is safe, as it does not require chemicals, which may cause irritation to patients soft tissue or do not need to compromise on esthetics, due to discoloration.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

## References

- Guidelines for infection control in the dental office and the commercial dental laboratory. Council on Dental Therapeutics. Council on Prosthetic Services and Dental Laboratory Relations. J Am Dent Assoc 1985;110:969-72.
- Shay K. Denture hygiene: A review and update. J Contemp Dent Pract 2000;1:28-41.
- Baysan A, Whiley R, Wright PS. Use of microwave energy to disinfect a long-term soft lining material contaminated with *Candida albicans* or *Staphylococcus aureus*. J Prosthet Dent 1998;79:454-8.
- Banting DW, Hill SA. Microwave disinfection of dentures for the treatment of oral candidiasis. Spec Care Dentist 2001;21:4-8.
- Dixon DL, Breeding LC, Faler TA. Microwave disinfection of denture base materials colonized with *Candida albicans*. J Prosthet Dent 1999;81:207-14.
- Mima EG, Pavarina AC, Neppelenbroek KH, Vergani CE, Spolidorio DM, Machado AL, et al. Effect of different exposure times on microwave irradiation on the disinfection of a hard chairside reline resin. J Prosthodont 2008;17:312-7.
- Asad T, Watkinson AC, Huggett R. The effects of various disinfectant solutions on the surface hardness of an acrylic resin denture base material. Int J Prosthodont 1993;6:9-12.
- Ali AM, Raghdaa KJ. Evaluation and comparison of the effect of repeated microwave irradiations on some mechanical and physical properties of heat cure acrylic resin and valplast (nylon) denturebase materials. J Bagh Coll Dent 2011;23:6-10.
- Anusavice KJ. Phillips' Science of Dental Materials. 11<sup>th</sup> ed., Philadelphia: Saunders; p. 255-81.
- Ribeiro DG, Pavarina AC, Dovigo LN, Palomari Spolidorio DM, Giampaolo ET, Vergani CE, et al. Denture disinfection by microwave irradiation: A randomized clinical study. J Dent 2009;37:666-72.
- Ribeiro DG, Pavarina AC, Machado AL, Giampaolo ET, Vergani CE. Flexural strength and hardness of reline and denture base acrylic resins after different exposure times of microwave disinfection. Quintessence Int 2008;39:833-40.
- Consani RL, Iwasaki RY, Mesquita MF, Mendes WB, Consani S. Effect of repeated simulated disinfections by microwave energy on the complete denture base adaptation. Open Dent J 2008;2:61-6.
- Silva MM, Vergani CE, Giampaolo ET, Neppelenbroek KH, Spolidorio DM, Machado AL, et al. Effectiveness of microwave irradiation on the disinfection of complete dentures. Int J Prosthodont 2006;19:288-93.
- Senna PM, Da Silva WJ, Faot F, Del Bel Cury AA. Microwave disinfection: Cumulative effect of different power levels on physical properties of denture base resins. J Prosthodont 2011;20:606-12.
- Konchada J, Karthigeyan S, Ali SA, Venkateshwaran R, Amirisetty R, Dani A, et al. Effect of simulated microwave disinfection on the mechanical properties of three different types of denture base resins. J Clin Diagn Res 2013;7:3051-3.
- Vasconcelos LR, Consani RL, Mesquita MF, Sinhoreti MA. Effect of chemical and microwave disinfection on the surface microhardness of acrylic resin denture teeth. J Prosthodont 2013;22:298-303.
- Senna PM, Sotto-Maior BS, Silva WJ, Del Bel Cury AA. Adding denture cleanser to microwave disinfection regimen to reduce the irradiation time and the exposure of dentures to high temperatures. Gerodontology 2013;30:26-31.
- Klironomos T, Katsimpali A, Polyzois G. The effect of microwave disinfection on denture base polymers, liners and teeth: A Basic overview. Acta Stomatol Croat 2015;49:242-53.