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## Evaluation of Occlusal Pressure Pattern and Dimensional Changes of the Lined Dentures Subjected to Microwave Disinfection Protocol

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## Evaluation of Occlusal Pressure Pattern and Dimensional Changes of the Lined Dentures Subjected to Microwave Disinfection Protocol

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### ABSTRACT

**Purpose:** This study aimed to evaluate the effect of microwave disinfection protocol on dimensional changes and the pattern of occlusal pressure over lined complete dentures.

**Material and methods:** ten completely edentulous patients were selected to receive conventional complete dentures. A layer of soft liner was added to the lower dentures and occlusal pressure contacts were recorded using T-scan device. The lower dentures were subjected to microwave radiation 700 Watt for three minutes once a week for four successive weeks in a dry condition. Twenty maxillary denture bases were constructed and lined with soft liner, the gap between the lined denture base and the stone cast was measured at the posterior palatal seal area at three different points, as well as the occlusal pattern before and after exposure to microwave radiation. **Results:** there were no significant effect for using microwave radiation on the lined denture regarding occlusal force distribution and dimensional changes. **Conclusion:** lined denture disinfection by microwave energy at 700watt for three minutes has no statistically significant effect over the dimensional changes and occlusal force distribution.

### INTRODUCTION

Complete dentures have been used for many years as a successful line of treatment for edentulous patients. Denture disinfection became more important as the number of edentulous patients increases<sup>(1-3)</sup>. Soft denture liners are soft polymers that added to the conventional denture with patients who cannot tolerate conventional acrylic dentures. The soft liners offer comfort, enhance the masticatory performance and allow better occlusal forces distribution over the supporting mucosa<sup>(4-6)</sup>.

It was revealed that soft liners had higher levels of microbial adhe-

### KEYWORDS

Microwave disinfection, soft  
liner, dimension changes.

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sion and produce denture stomatitis than conventional acrylic resin base materials <sup>(7-9)</sup>.

The direct and indirect techniques for denture relining generated similar results, and therefore can both be applied. Results showed that, the direct denture relining procedure is simple, time saving and gives better denture fitness to underlying tissues<sup>(10,11)</sup>.

The dentures represent a good environment for the microorganisms to colonize, the denture hygiene is essential to maintain the serviceability of the prosthesis. The ideal cleanser used for dentures should be easily manipulated, can erase both organic and non-organic debris effectively from the fitting surface, has both anti-bacterial and anti-fungal effects and should minimally affect the denture base <sup>(12,13)</sup>.

Denture disinfection using chemical solutions and microwave irradiation had documented. However, the effect of these protocols on the denture base surface and relining materials properties have not been fully evaluated <sup>(12,14)</sup>.

Chemical disinfection such as sodium hypochlorite, chlorine dioxide, glutaraldehyde and chlorhexidine were used for prosthesis disinfection, daily before and after denture usage <sup>(15)</sup>.

The denture disinfectant proved to significantly changes the surface roughness and hardness for denture base and should be used carefully depending on the resin type. The effect of disinfecting media is different for acrylic-based materials than its effect on silicon-based soft-liner materials. Some organic compounds were released following exposure of denture soft liners to chemical disinfectants. Low concentration of dodecyl methacrylate, dibutyl phthalate, benzene and toluene were observed. The leached compounds approved to have direct influence on the denture materials properties and have significant cancerogenic, allergic, teratogenic effect<sup>(16,17)</sup>.

The microwave irradiation is considered to be an easy, efficient and low-cost technique for denture disinfection with antifungal effect, it was used for post-polymerization denture base treatment, to decrease acrylic resins residual monomer amount<sup>(18,19)</sup>.

Also, denture wearer patients suffer from oral candidiasis would use microwave irradiation for denture disinfection <sup>(20)</sup>. It has disinfection effect against candida albicans, and other candida species that inoculated into acrylic resin dentures <sup>(18,21)</sup>.

The microwave lethal effect on various microorganisms, seems to be well established, although the exact mechanisms causing this effect is still controversial. Authors mentioned that, the direct thermal nature of microwave irradiation might be the reason for this effect on the microorganisms. Others proposed that, the death of micro-organisms may be due to the electromagnetic field interaction with the structure of micro-organism and the surrounding media <sup>(22-24)</sup>.

The disinfection by microwave proved to improve the denture base adaptation. In addition, the surface hardness, flexural and impact strength of denture resins didn't affect by the microwave disinfection energy <sup>(22,25,26)</sup>.

The occlusal interferences can affect the retention and stability of the removable denture, these factors in turn affect muscle activity, patient tolerance, and the preservation of the alveolar bone <sup>(27)</sup>.

The analysis of occlusal contact is applicable through articulating paper and base plate wax. Also, these techniques consider being inaccurate or reliable as they couldn't provide the operator with load distribution and percentage. therefore, computerized occlusal analysis has been developed to overcome the drawbacks of the previous techniques <sup>(28)</sup>.

Studies revealed that, the maxillary complete dentures exposure to microwave disinfection 650 watt for three minutes, three times a week, for four successive weeks, showed significant increase in vertical dimension of occlusion, and in case of exposure of the maxillary dentures to microwave radiation 650 watt for three minutes, every seven days, for four successive weeks, there was no significant effect <sup>(29)</sup>.

It has been recorded that; the acrylic resin exposure to microwave radiation results in approaching the water boiling temperature to the resin for 2 minutes and 10 seconds, which in turn leads to the release of processing stored stresses, leading to denture bases warpage<sup>(30-32)</sup>.

Other studies showed that there is diminish in gab dimension and enhancement of adaptation to these denture bases disinfected using microwave radiation when the traditional method used for denture base fabrication<sup>(22)</sup>.

Despite the dimensional changes that occurred with microwave disinfection, there was no significant effect at the clinical evaluation of occlusal contacts<sup>(33)</sup>.

The analysis of linear dimensional changes only, cannot consider being enough for detection of the asymmetric distortion in the denture base, as the occlusal irregularities of the denture's teeth are multifactorial in origin, and denture base warpage is just one factor<sup>(33)</sup>.

## MATERIAL AND METHODS

Ten completely edentulous patients were selected from the Out-Patient Clinic of Removable Prosthodontic Department, Faculty of Oral and Dental Medicine, Al-Azhar university. The patients were rehabilitated with conventional complete dentures. The patients' ages were ranged between 60-75 years.

They were all selected to be nonsmoking, free from any neuromuscular and/ or TMD sign and symptoms, and had class I Angle classification, all the patients had healthy mucosa free from infection, ulceration or inflammation. Patients with severely resorbed alveolar ridges or parafunctional habits were excluded from the study.

The treatment protocol was approved by the Ethics Committee of the Faculty of Oral and Dental Medicine for Girls, Al-Azhar university and given approval code; 01-P-PD-22. Each patient was

provided with written consent to share in this study. All patients received conventional maxillary and mandibular complete dentures, made from heat cured acrylic resin (Acrostone Manufacturing and Import Co, Egypt).

## Complete denture construction

For each patient, upper and lower complete dentures were constructed using heat cure acrylic as a denture base material and anatomic acrylic teeth (Acrostone Manufacturing and Import Co, Egypt) manufacture instructions were followed for packing, and curing.

The occlusal contacts of the artificial teeth were set at bilateral balanced occlusion using face bow and semi-adjustable articulator (Hanau face bow and Hanau™ 96H2 articulator, Whip Mix, USA). The dentures were checked inside the patient's mouth for retention, stability, extension pressure areas and harmonious occlusal contacts.

Dentures were delivered to the patients with the regular use and cleansings instructions, and allowed to use them for a month to allow functional muscle adaptation to occur.

## Chair side soft liner application (directly)

The lower denture fitting surface and borders were reduced for about 1.5 mm to provide adequate thickness for the lining material, the amount of reduction was checked using a caliper, the borders were trimmed into right- angled periphery as instructed by the manufacture MUCOPERN-SOFT Kettenbach GmbH and Co. Kg, Germany.

A thin film of the adhesive material was applied over the entire roughened fitting surface and beyond prepared borders, left for 30 seconds, followed by application of a second coat of adhesive and the material was allowed to dry for 90 seconds in air.

The Mucopren soft liner was loaded uniformly over the fitting surface of the lower denture with the dispensing gun following manufacturing instruc-

tions, the lower denture was inserted inside the patient mouth and all border movements active and passive were performed, the patient was guided to close in centric occlusion, the soft lining material allowed to cure under occlusal pressure. The lower denture was removed from the patient mouth, placed in warm water about 50 degree for 15 minutes.

The denture was finished and the excess material was trimmed with finishing bur supplied with the material kit. The occlusal contact was verified by clinical remounting using new records for face bow, centric, protrusive, right and left lateral mandibular movement. The articulating paper was used for occlusal adjustment. The patient allowed to use the denture for a month before occlusal contacts were recorded.

### Occlusal pressure analysis

The occlusal contacts were registered in static occlusion condition. Analysis of the occlusal contacts was carried out using the T-Scan system (T-Scan III

v9; Tekscan Inc). Recording sensor with suitable size according to the size of the arch was selected for each patient, large and small sensor sizes were available. The record was made with the patient in upright position, and the sensor was adjusted with the midline and the lower denture's occlusal plane, as represented in figure (1)

To adjust the sensor sensitivity before recording, the patient was asked to close firmly in centric occlusion several times over the recording sensor, then the patient was asked to keep constant occlusal pressure on the recording sensor for three seconds in centric occlusion. The occlusal force distribution in percentage (%) was recorded at the anterior, right and left posterior areas, as represented in figure (2)

Lower denture was exposed to microwave radiation, 700 Watt for three minutes once a week for four successive weeks in a dry condition. The entire process of occlusal pressure analysis was repeated for each patient.

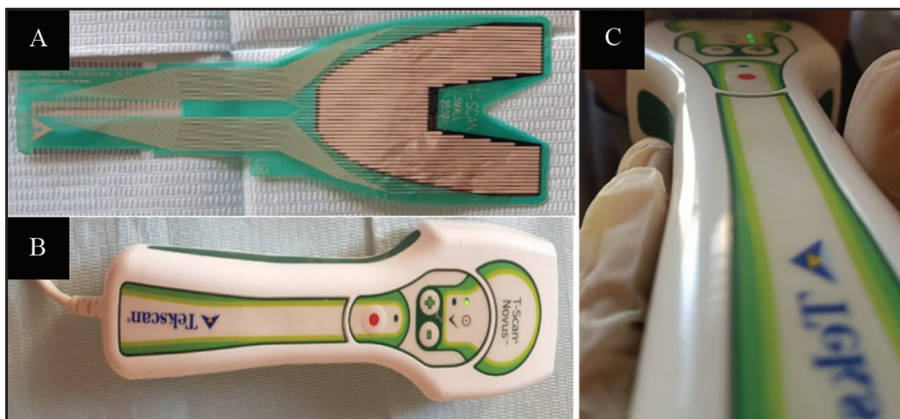


Figure (1): (A and B) -T-Scan device and the sensors (C)- T-Scan device inside the patient's mouth

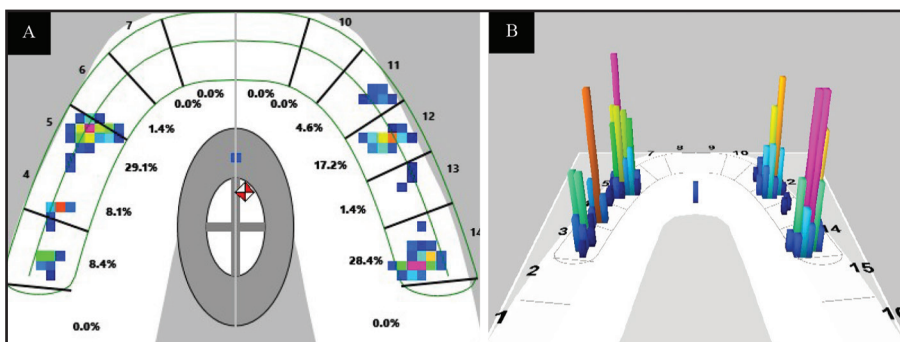


Figure (2) A,B: T-Scan record after microwave exposure for the lower lined denture, the right and the left side occlusal force distribution with percentages.



The mean values in percentage were calculated, from the pre and post radiation exposure recordings and the data were saved for statistical analysis.

### Dimensional changes measurement

Forty stone master casts were fabricated, by duplicating the standard maxillary edentulous plaster cast model, using silicon duplicating material (Dupliflex, Protechno, Spain).

To standardize the cuts position of the master cast, landmarks were cuts on both sides at the posterior palatal seal area in the silicone mold.

Twenty denture bases were fabricated; Standard tin foil spacer of 2 mm thickness was adapted to the maxillary cast, the border of the spacer was trimmed to be right angled as recommended by the manufacture MUCOPERN-SOFT Kettenbach GmbH and Co. Kg, Germany, and to be 3mm shorter than the borders of the denture base. The spacer was cut to provide stopers to maintain even thickness of the relining material.

The denture base had been waxed up to full contour on the spaced master cast, the waxed denture bases with the spacer were processed using conventionally pressure-packed processed PMMA (Acrostone, Egypt). The flask was allowed for bench cooling, the spacers were removed, denture bases were finished.

The denture bases reset over the other twenty master casts, a saw with a fixer table was used, for transverse sectioning of the set of denture bases and cast together at the previously designed landmarks

at the posterior palatal seal area while constant water cooling was applied.

The adhesive material was applied over the entire fitting surface of the denture base sections and beyond prepared borders, left for 30 seconds, followed by application of a second coat of adhesive and allowed the material to dry for 90 seconds in air.

The denture base sections were lined with soft liner Mucopren Soft, the lined denture base section was reset inside the flask that was used for curing of the denture base, directly after soft liner application and the soft lining material allowed to cure under press pressure, then the material completed setting into warm water 50 degree for 15 minutes.

The excess material was trimmed. The lined sections were kept in worm water for 6 hours at 37 °C. The temperature was insured using thermal stainless-steel bottle. The gap between the lined sections of the denture base and the stone casts was recorded at the three reference points, representing the right and left crests of the ridge and the center of the palate at the posterior palatal seal area, these points were marked over the cast and the lined denture base.

The measurements were done, using zoom stereomicroscopes (Prior Company, United Kingdom) with 5.1megapixel camera (Olympus Company, Japan) at  $\times 40$  magnification and the OMAX calibration slide, stage micrometer (OMAX microscope, Korea) was used to measure the maximum gap in 10 micrometer resolution at the three reference points, as represented in figure (3).

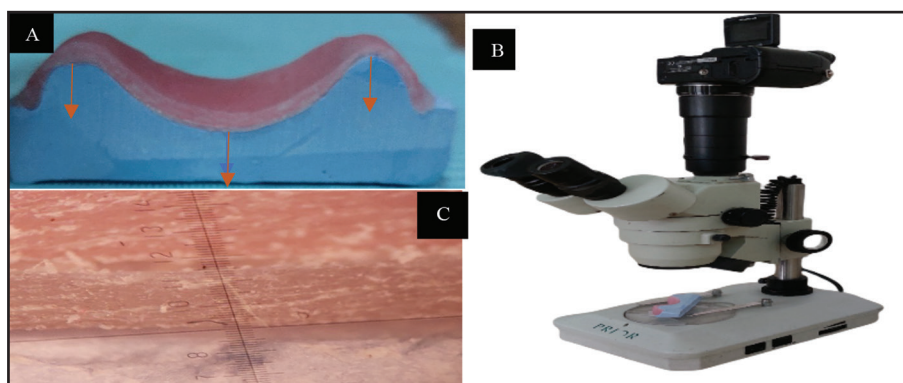


Figure (3): (A) Transvers view of the posterior palatal seal area showing the reference points for gap measurement. (B): stereomicroscope. (C): calibrated image to measure the gab by stereomicroscope.

The lined denture base sections were subjected to microwave radiation, 700 Watt for three minutes in a dry condition and the cycle repeated for four successive times with at least 6 hours interval while the sections were kept in water at 37 degrees. The gap measurements were recorded again at the same three points after microwave exposure.

The numerical data were collected, tabulated and presented as mean and standard deviation values. The Paired t test was used to compare between the records of occlusion force distribution in the posterior right and left sides before and after the lined lower denture subjected to microwave radiation. Statistical analysis was performed with SPSS statistic program and the significant level was set at  $P < 0.05$ .

SPSS statistic program also was used for statistical analysis of dimensional changes and the significant level was set at  $P < 0.05$ . Paired t-test was used to compare the reading before and after exposure to microwave radiation at the right, center and left reference point of the denture base at posterior palatal seal area, theses reference points representing the crest of the right side of the ridge, mid palate and crest of the left side ridge respectively.

## RESULTS

### Comparison of occlusal force distribution patterns before and after exposure to microwave radiation

The mean value for occlusal force percentage before the denture subjected to microwave radiation at the posterior right was  $49.81 \pm 3.445$  and at the posterior left side was  $51.26 \pm 3.416$  %

The mean value for occlusal force percentage after the denture subjected to microwave radiation at the posterior right was  $47.82 \pm 4.06$  and at the posterior left side was  $50.03 \pm 4.25$ %, as shown in table (1), and figure (4).

Comparing the reading of occlusal forces distribution for the right and left sides pre and post

exposure of the lower dentures to microwave radiation, it was found that; there were no significant difference at both sides with p value 0.11 for the right side and 0.41 for the left side, ( $P > 0.05$ ) as indicated by t-test.

**Table (1)** Means and standard deviations and pairwise comparisons of occlusal scan of right and left sides.

	Right side		Left side	
	Before	After	Before	After
<b>Means</b>	49.81	47.82	51.26	50.03
<b>STDs</b>	$\pm 3.445$	$\pm 4.06$	$\pm 3.416$	$\pm 4.25$
<b>P value</b>	0.11 <sup>ns*</sup>		0.41 <sup>ns*</sup>	

\*ns= non-significant

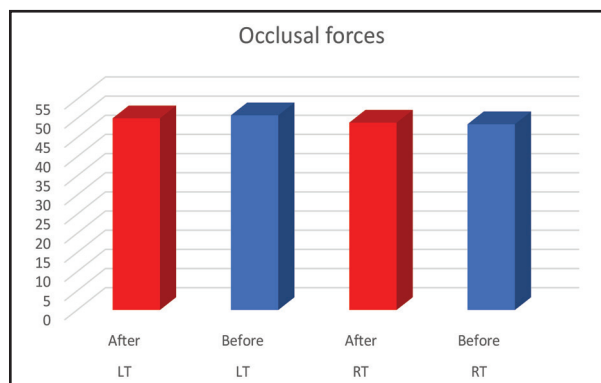


Figure. (4) Column chart comparing occlusal forces mean values for both right and left sides before and after exposure to microwave radiation.

### Dimensional changes analysis

The mean values and standard deviations for gap measures at the right side before and after radiation exposure were 0.193,  $\pm 0.071$  and 0.198  $\pm 0.076/10\mu\text{m}$  respectively, while at the center before and after were 0.343,  $\pm 0.084$  and 0.351,  $\pm 0.079/10\mu\text{m}$  respectively, and at the left side before and after were 0.202,  $\pm 0.061$  and 0.215,  $\pm 0.092/10\mu\text{m}$  respectively, as shown in table (2), and figure (5).

Comparing the reading at the right, center and left sides pre and post exposure to microwave radiation, it was found that; there were no significant difference at the right, center or the left sides with p value 0.64 for the right side, 0.068 at the center and 0.52 at the left side, ( $P>0.05$ ) as indicated by t-test.

**Table (2)** Means and standard deviations and pairwise comparisons of dimensional changes of right, center and left sides.

	Right		Center		Left	
	Before	After	Before	After	Before	After
<b>Mean value</b>	0.193	0.198	0.343	0.351	0.202	0.215
<b>STDV</b>	±0.071	±0.076	±0.084	±0.079	±0.061	±0.092
<b>P value</b>	0.64 <sup>ns*</sup>		0.068 <sup>ns*</sup>		0.52 <sup>ns*</sup>	

\*ns= non-significant

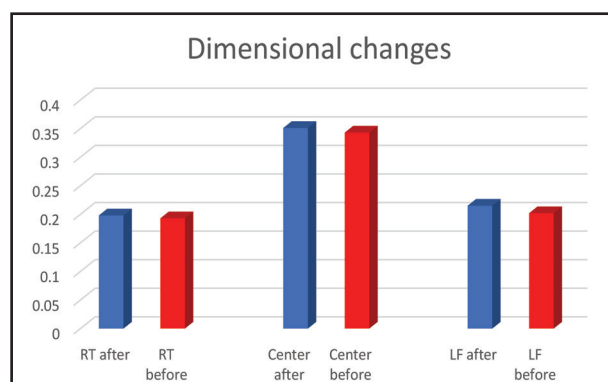


Figure (5) Column chart comparing dimensional changes mean values in for right, center and left sides before and after radiation exposure

## DISCUSSION

According to the current study using microwave radiation 700 watt for three minutes for four successive times over the lined denture base sections showed no significant changes at the posterior palatal seal area.

The previous studies had showed that, the exact microwave disinfection protocol that ensures denture sterilization, without causing hazard effect

on physical and/ or mechanical properties of the denture is still controversial. Apparently, a broad range of power and exposure time is available ranging from 350 to 1400 watt and from one to 20 minutes<sup>(34)</sup>.

In the study of Mima et al, the relined denture resin was exposed to different microwave exposure times and the study suggested 650 watt for three minutes can be used safely for lined acrylic resin disinfection<sup>(35)</sup>.

According to Klironomos T et al. microwave irradiation 650 watt for three minutes showed no harmful effects of clinical significance on the hardness, impact, and bond strength of both denture resins and denture liners<sup>(34)</sup>.

The outcome of the present study could be in agreement with Klironomos T et al. who suggested that microwave radiation is a safe disinfection technique for the lined denture if the microwave disinfection technique is to be carried out in dry conditions<sup>(34)</sup>.

Basso MF et al revealed that, the lined denture exposure for 650 watt for 3 minutes once a week for 4 successive weeks showed dimensional changes beneath 1%. According to their study there were shrinkage at the denture liners but without denture base warpage or significant clinical effect<sup>(33)</sup>.

Wagner and Pipko study showed dimensional changes about 3% when denture base was exposed two times to either 420 or 700 watt for three minutes in wet conditions. The result of these dimensional changes may be due to the wet condition of disinfection, as the microwave radiation may cause dimensional changes with clinical significance when the microwave exposure condition is wet<sup>(36)</sup>.

Different microwave disinfection protocols are available with different power, time and exposure condition, this may explain the conflicting results after different microwave cycles. The different results probably due to difference in microwave exposure protocol<sup>(37,38)</sup>.



Urban discussed the changes in dimensional changes of the denture liners. The microwave radiation exposes the lined denture to a great thermal temperature beyond the glass transition of the resin, leading to resin deformation. In addition to that, the high temperature affects the residual monomer leading to extra polymerization which in turn causes additional dimensional changes <sup>(39)</sup>.

Complete dentures occlusion is important factor for maintaining health of TMJ structure, hard and soft tissue as well. Obtaining bilateral balanced occlusion is an important target for removable prosthodontists. Using mechanical equipment such as face-bow and adjustable articulator is time-consuming and requires professional skills. Modern technology provided clinicians with computerized occlusal analysis which is a digital answer for clinical force balance <sup>(40,41)</sup>.

The T-scan device can provide the operator with digital occlusal analysis to evaluate different occlusal force distribution patterns for complete denture wearers. T-scan is applicable device to analyze the percentage of occlusal forces for removable dentures <sup>(42)</sup>.

T-Scan III has been considered as reliable and precise device for analysis of occlusal contact in centric occlusion. The device was proven to be accurate and no conflict was raised from repeated recording. The premature occlusal contacts and interferences during articulation can be detected <sup>(43)</sup>.

The results of the current study had recorded that, the balanced occlusion was maintained at the right and left sides of the lined dentures even after the denture has exposed to microwave radiation.

According to Basso, microwave disinfection for the maxillary denture with 650 watt for three minutes once a week, for four successive weeks, had no influence on occlusion of the complete dentures which may agree with the result of the current study <sup>(38)</sup>.

Seo et al, revealed that, disinfection with microwave radiation for six minutes at 650watt causes shrinkage of the denture bases and the relined denture bases <sup>(44)</sup>. Shrinkage of the denture base could possibly lead to artificial teeth movement, inducing occlusal contact irregularities

However, the denture base structure is complex which may lead to asymmetric deformation in different areas of the denture base, that may not be clear, but could provide pressure occlusal contact to the denture artificial teeth <sup>(38)</sup>.

The exact irradiation power and time for periodical microwave disinfection that affects the dentures and denture liners are still unclear. The effect of microwave radiation requires more studies to reveal a reliable disinfection protocol and declare the physical and mechanical properties of denture base and denture relating material exposed to microwave radiation <sup>(34,45)</sup>.

## CONCLUSION

Within the limitations of this study, it could be concluded that, lined denture disinfection by microwave energy at 700watt for three minutes has no statistically significant effect over the dimensional changes and occlusal force distribution.

## RECOMMENDATIONS

More studies are required to study the effect of microwave disinfection protocols in long term and also its effect on the bond between the denture base and soft-liner material.

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This research received no external funding.

## Conflict of Interest

The authors report no conflict of interest, that could influence the work reported in this paper.

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