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Effect of Microwave Disinfection on Dimensional Stability of Polymethyl Methacrylate and Polyamide Denture Base Material

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Abstract:-

Aim: The aim of this study was to test and compare the effects of microwave irradiation on the dimensional stability of two types of complete denture bases.

Methodology: A prefabricated rubber mould was used for the fabrication of maxillary stone cast with four reference points and duplicated. The duplicated casts were then used for fabrication of denture bases. The study included thirty samples, which were divided into two groups of fifteen each (Group 1-Polymethylmethacrylate PMMA and Group 2- Polyamide PA). Dentures were microwaved for three minutes at 650 Watts each day while placed in distilled water. After the specimens were made, measurements were taken at one, two, and three months. To estimate the overall dimensional changes of the simulated complete dentures being tested, the percentage difference between the baseline distances of each denture base and each test group was used. The data was analysed using a 2-way repeated measures ANOVA, followed by the post hoc Tukey test.

Results : When compared to the control, the Polymethyl methacrylate group shrank by 0.14% at one month; 0.18% at two months; and 0.34% at three months. The Polyamide group shrank by 0.068% after one month, 0.13% after two months, and 0.25% after three months. Statisticaly significant result was seen in PMMA after 3 months of irradiation.

Conclusion: The findings indicate that the linear changes observed had no clinical significance. Microwave sterilisation of dentures is an effective alternative method.

Keywords:- *Sterilization, Polymethymethacrylate, Polyamide, Irradiation.*

I. INTRODUCTION

Maintenance of the completely edentulous patient's oral health is an important factor in denture-wearing patients, including quality of life, nutrition, social interactions, and overall systemic health[1]. The number of published studies on the relationship between oral health and systemic diseases in edentulous, partially edentulous, and dentate patients is growing[2]. While not always life-threatening, the presence of oral biofilm on complete dentures has been linked to denture stomatitis as well as more serious systemic conditions, particularly in the elderly[2].

If proper hygiene is not maintained, dentures similar to natural teeth have a tendency to accumulate stains, plague & calculus and they accumulate readily on rough surfaces. Failure to clean the dentures results in increased incidence of denture stomatitis[3,4]. Several methods of cleaning dentures have been proposed in an effort to prevent such diseases to occur[2]. Denture cleaning methods include brushing of dentures using ultra soft brushes, soaking in effervescent tablets & chemical disinfectants, and ultrasonic cleaning. However, research has shown that these methods can have negative effect on the physicomechanical properties of denture base materials[5,6,7,8]. Newer methods like microwave irradiation and Light emitting diode have shown to be the most effective methods for disinfecting complete dentures[9,10]. These two methods have been recommended as safe, easy with antifungal properties.

The commonly used denture base material is polymethylmethacrylate[11]. It has numerous beneficial qualities, including a great aesthetic quality, low water sorption and solubility, appropriate strength, low toxicity, ease of repair, and a simple processing method[12,13]. Even yet, it has several drawbacks including weak flexural, weaker impact, and low fatigue resistance because of polymerization shrinkage[14,15]. These frequently cause dentures to break off when the patient is chewing or when they fall out of their hands. Several initiatives have been made to improve some PMMA qualities, including the insertion of metal wires, fibres, metal inserts, and chemical structural changes[16,17]. As a base material for dentures, nylon polymer has gained popularity recently. PMMA is an amorphous polymer, whereas nylon is a crystalline polymer[11]. This crystalline phenomenon explains nylon's great heat resistance, high strength and ductility, as well as its lack of solubility in solvents[18]. The use of heat-molding rather than chemical polymerization to control polymerization shrinkage and its associated deformation was claimed to have additional benefits for nylon materials, including higher elasticity than common heat-polymerizing resins, toxicological safety for patients with resin monomer and metal allergy[19,20,21]. The adverse effect of these materials include difficulty in polishing, surface roughness, bacterial contamination and warpage[22]. According to the published studies, Candida biofilms grew substantially more on polyamide than PMMA, suggesting that polyamide can make a good surface for microbial colonisation[23]. These variations could be attributable to PMMA's increased residual monomer content, which led to variations in resin surface-charge that could reduce adhesion and prevent Candida development.

Regardless of the type of solution utilised, after 20 days of repeated immersion, the polyamide's surface roughness increases[24]. Microwave disinfection has been proposed as an alternative technique to address this problem. According to Webb et al. microwave sterilisation of dentures may be more successful than soaking them in sodium hypochlorite[25].

Despite the effectiveness of microwave as denture disinfectant, researchers have reached contradictory findings regarding its harmful effects on some properties of denture base materials. Therefore, the purpose of the study is to evaluate the dimensional stability of polymethymethacrylate and polyamide denture bases on repeated exposure of microwave radiations.

II. METHODOLOGY

The present study was conducted in vitro to assess the dimensional accuracy of polymethymethacrylate and polyamide denture bases on repeated exposure to microwave radiations. The study design comprised of thirty simulated maxillary complete denture bases that were divided into two different groups of fifteen each. For this study, two resin denture bases that are often employed in clinical settings were chosen. Each chosen denture base has a unique processing method.

A prefabricated rubber mould (Fig. 1) was used for the fabrication of maxillary stone cast. This was followed by placing three stoppers in the land area of the reference wax model serving as indexes. Using a round carbide bur, four round indentations were made on the crest of the maxillary cast. Using silicone material, the modified stone cast was duplicated into thirty similar stone casts (Fig. 2).

A. *Fabrication of polymethylacrylate denture bases:*

A total of fifteen polymethylmethacrylate denture bases were made. Wax pattern of maxillary denture base was fabricated on one of the duplicated stone cast. For fabrication of fifteen identical wax patterns, cast along with wax pattern was again duplicated in silicone material. Molten wax was poured into the silicone mould for wax pattern replication, and a duplicate cast was entirely seated into the mould in alignment with the three included indentations that served as indexes. Wax patterns were then acrylized after that. Following the manufacturer's instructions, acrylic resin was mixed, packed in the appropriate mould during the dough stage, processed in an acrylizer at 74°C for eight hours, and then terminally boiled for an hour[26]. Before being deflasked, specimens were bench chilled for the whole night. The samples of polymerized resin were removed from the mould, and all specimens had the extra resin cut off with a bur. With stone and sandpaper, each specimen was polished and trimmed. Pumice slurry with a white bristle brush and a cloth buff used for polishing.

B. *Fabrication of polyamide denture bases :*

Wax patterns for Polyamide base were created in the same manner as PMMA and invested in flasks with dental stone (type III). The wax patterns were then attached to wax sprues. The flasks were dewaxed before being placed in the hydraulic injector for flexible denture base resin. For 3 minutes, molten polyamide was forced into the flask using a polyamide injection system at a pressure of 5 bars[10]. Before de flasking, the flasks were bench cooled. After deflasking, finishing was done with 600 and 800 grit silicon carbide paper, followed by polishing with a white cotton yam wheel polishing brush. A total of fifteen maxillary polyamide denture bases were fabricated and stored in distilled water for two days at room temperature.

C. *Disinfection of dentures using microwave radiations*

Before disinfection, each denture base was measured five times by a single operator, and the mean was calculated for each denture base which served as a control for that specific denture base. Following that, all specimens were microwave-irradiated at 650 W for three minutes while placed in distilled water using a conventional household microwave, as previously described by Sanita[27] et al and Silva[28] et al for three months (Fig. 4).

D. *Measurement Protocol*

Using Tool makers microscope, all denture bases were measured for linear dimensional accuracy. The centre of round markings which were reproduced on the intaglio surface of denture bases were used as reference points. For simplification, four round markings were named as A'B'C'D' respectively from left to right. Six measurement were made for each denture base corresponding to six distances (Fig. 3). At one, two, and three months, each irradiated denture was measured three times. Each specimen's initial measurements (control) were compared to measurements taken one, two, and three months later. These measurements were made by same operator to avoid errors.

E. *Statistical Analysis*

For each distance, the mean and standard deviation were calculated. The collected data was compiled and entered into excel before being exported to the SPSS Version 20.0 data editor. The two factors tested using a 2-way ANOVA were: (1) one between factor (groups) and (2) one within factor (time), followed by the Tukey HSD test to determine significant differences between the means.

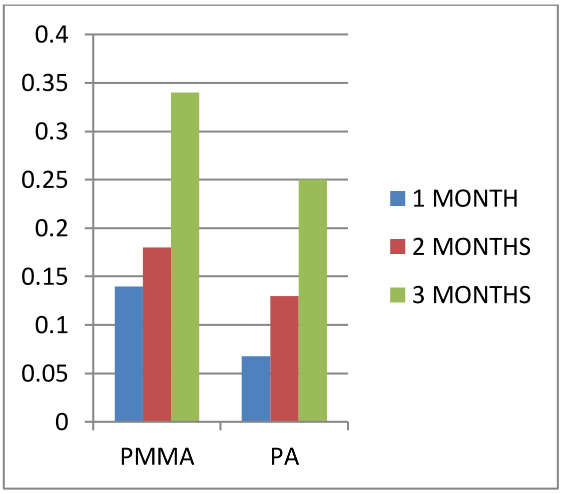
III. RESULTS

Fifteen dentures in each group were evaluated for percent shrinkage after one, two, and three months of microwave disinfection, with the initial measurements serving as the baseline. When compared to the baseline, the Polymethymethacrylate group shrank by 0.14% at one month with a standard error of 0.017; 0.18% (0.021) at two months; and 0.34% (0.022) at three months. The Polyamide group shrank by 0.068% (0.013) after one month, 0.13% (0.019) after two months, and 0.25% (0.025) after three months. Student's t-test was performed on each group at each time point to evaluate if the data sets were normally distributed. While comparing control values to one and two months for the PMMA group, it was found that the data was normally distributed with a significance of 0.200. However, at three months, values of 0.028 were observed, indicating that the data was not normally distributed. For all time points in the

PA group, a significance of 0.200 was found, indicating that the data was normally distributed. Both the PMMA and PA groups had the same p-value of 0.001 on Two-Way ANOVA test. (Table & Graph)

Group (Month)	Mean (%)	Standard Error	P-value	Level Of Sig
PMMA 1month	0.14	0.017	0.200	Non-Sig
PMMA 2months	0.18	0.021	0.200	Non-Sig
PMMA 3months	0.34	0.022	0.028	Sig
PA 1month	0.068	0.013	0.200	Non-Sig
PA 2months	0.13	0.019	0.200	Non-Sig
PA 3months	0.25	0.025	0.200	Non-Sig

Table 1 percentage shrinkage over 3 months of PMMA & PA denture bases.



Graph 1 showing percentage shrinkage over 3 months of PMMA & PA denture bases.

IV. DISCUSSION

Denture base dimensional stability is crucial during service because it plays vital role in denture retention and cuspal interdigitation[29]. As a result, any effects of the disinfection techniques used on denture base dimensions may cause problems. Among various disinfection methods, microwave disinfection has proven to be effective method.

Rohrer and Bulard pioneered microwave oven irradiation for sterilisation of non-autoclavable dental instruments and dentures, but its mechanism of action is still unknown[9]. There are two possible explanations: the thermal effect and the non-thermal effect. Companha et al. discussed the thermal effect on Candida albicans by demonstrating changes in cell structure, changes in cell membrane permeability, and cell death[30,31]. These changes are thought to be caused by the heat generated by microwaves on organic matter. The non-thermal effect is explained by the interaction between the electromagnetic field produced by microwaves and the cell molecules. Microwave irradiation is an easy, quick, and low-cost method of disinfecting and sterilising dentures[32,33]. It does not require any special storage device nor does it has an expiry date. It does not appear to cause fungi or other microorganism resistance, nor does it appear to change the colour or smell of dentures, but it cannot be used if the appliances contain metal components[34]. Candida species and other microorganisms can quickly grow on denture appliances because many denture wearers do not remove their dentures at night[35]. Microwaving the dentures at any time during the day is another option for these people[35].

Dentures are microwave-irradiated using either the wet (in a water bath) or dry disinfection methods[36]. The microwave energy ranges from 450 to 650 W for 2 to 10 minutes. However, the temperature that develops during microwave disinfection may have an adverse effect on polymer structure. The fact that water begins to boil after 90 seconds of irradiation and the appliance remains at this temperature until the end of the disinfection cycle may enhance an acrylic resin polymerization reaction, resulting in denture distortion[37]. Furthermore, temperature levels above 77°C have been shown to distort the base of the denture due to the release of internal stresses trapped within the material during the polymerization procedure[37].

The findings of various research studies were mixed and contradictory. As a result, an attempt was made to compare dimensional changes in Polymethylmethacrylate and Polyamide denture bases disinfected with microwave radiation.

In the present study, shrinkage was observed in both groups after three months of daily microwave irradiation exposure. After three months, it was found that there were statistically significant differences in denture dimensional stability on the Polymethylmethacrylate (p-value of 0.028). The differences were determined to be clinically insignificant when compared to denture processing shrinkage of 0.5%. The current study supports the findings of Burns et al, who tested three acrylic resin materials and discovered that these materials tested had shrinkage values ranging from 0.02% to 0.03%. They concluded that microwave irradiation shrinkage is clinically insignificant when compared to polymerization shrinkage. Basso et al reported on dimensional stability as well, but because the shrinkage was less than 1%, they determined it was not clinically significant. This study also supports the findings of Polyzois et al. They came to the conclusion that all specimens showed linear changes during disinfection procedures. Although statistically significant, these changes were not clinically significant (0.03%).

V. CONCLUSION

Based on the findings of this study, it was established that microwave irradiation of dentures is an effective technique that can be used to disinfect denture. Microwave ovens are available in most homes, providing patients with an easy and quick method of maintaining their prostheses.

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Fig. 1, Edentulous Mould.

Fig. 2, Stone cast modified with four round holes & indentations on land area of cast.

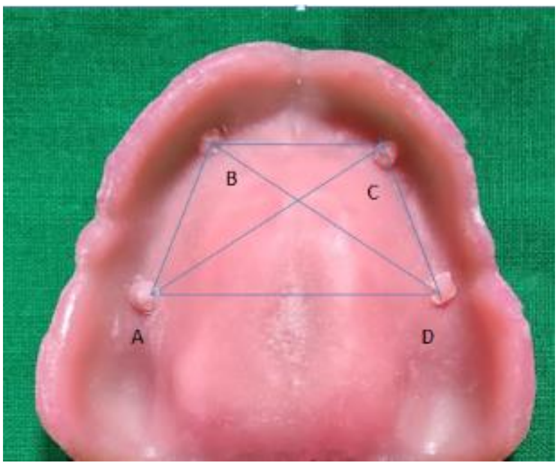

Fig. 3, Denture base with four marks on intaglio surface which were used for measurements.

Fig. 4, Household Microwave for disinfection of denture bases.