The effect of microwave on dimensional accuracies of maxillary denture bases

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Abstract

Objective: This study was carried out to investigate the effect of different microwave powers on dimensional accuracies of sampled maxillary acrylic resin bases.
Method: Maxillary acrylic resin bases were constructed on stone casts previously made from a prefabricated rubber mould. Dimensions of the cast-acrylic resin assemblies were taken at designated points with digital caliper. The acrylic bases were then subjected to simulated disinfection under different microwave powers and time periods, after which they were returned to their casts and post microwave measurements taken at the same designated points.
Result: The highest mean (±SD) of dimensional discrepancies (0.082±0.03) was observed in the mid-palatal region of the maxillary bases at 690W/6minutes regimen while the lowest was at the right crest (0.012±0.02).The dimensional distortion at the mid-palatal region was statistically significant compared to other measurement points.
Conclusion: The mid-palatal region of the maxillary bases which shows the greatest tendency to undergo significant distortion is unfortunately the area that makes one of the greatest contribution to the retention of upper dentures by way of close adaptation to the palatal tissue.

Key words: Microwave, maxillary, denture bases, dimensional accuracy

Introduction

Removable complete dentures (RCD) are usually fabricated to restore aesthetics, mastication, speech, comfort, systemic health of the wearer and to counter the psychological effects of tooth loss[1-5]. For RCD to effectively perform these functions particularly in the upper arch where the effect of gravity and weight of the prosthesis is counterproductive[6], the denture base (which is the part of a denture that rests on the foundation tissues and to which teeth are attached[7] must be well extended, stabilized, supported, light, and biocompatible. Also, it must be closely adapted to denture bearing area and possess good thermal conductivity, enough strength, resilience and abrasion resistance. Apart from these, the denture base must be easy to fabricate and repair, aesthetically pleasing, opaque, insoluble and impermeable to oral fluids and it should be dimensionally stable[8]. Acrylic resin and dental alloy have been described as the material of choice for fabricating denture bases[9], but acrylic resin is more commonly employed on account of its relative advantages[9]. The popularity of acrylic denture bases notwithstanding, the display of polymerization shrinkages, water sorption and dimensional changes during casting, storage and microwave sterilization remained a challenge[9,10]

In-vitro studies have shown that linear dimensional accuracies are important to successful complete denture fabrication[11,12]. Dimensional inaccuracies of acrylic resin had been attributed to combined effect of polymerization shrinkage, differential thermal contraction, water sorption, stress relaxation[13,14], and flask cooling[14].

For successful rehabilitation with complete denture, patients and their dentists have significant roles to play[15]. Denture fabrication and its maintenance (relining and rebasing) are carried out by the dentists and any discrepancy or distortion that occurred during these procedures is routinely evaluated and corrected at delivery stage. Routine cleaning and disinfection on the other hand, by either chemical or microwave disinfection is the responsibility of the patients. Microwave disinfection is currently being recommended by clinicians because it does not cause tooth staining[16] and irritation[17] unlike chemical disinfection. Furthermore, it has been reported to reduce cross infection between dental personnel and the patients[18]. It is however a known fact that the procedure may cause distortion. If, therefore, a patient's denture becomes unstable as a result of microwave disinfection at a time the patient is to meet an important appointment, it becomes a prosthodontic emergency. If access to the dentist is not possible at that time, the patient could miss the important appointment, or develop functional and/or psychological impairments. Conflicting reports have been given on the effects of microwave treatments on dimensional accuracies of maxillary bases[19]. In addition, various recommendations of microwave regimens have been given[20-24], and there appears to be no consensus on any particular regimen. This study investigated the effect of microwave treatment on dimensional accuracies of maxillary denture bases by employing three different microwave powers and three different time periods.

Materials and method

This was an experimental study in which forty five (45) upper edentulous models were poured in type IV dental stone (vel-mix, SDS/kerr, Orange, CA, USA) using a prefabricated upper edentulous rubber mould (ZL-KQ334 Shangai) according to manufacturer's instructions. A 1.6mm thick modeling wax (Shanghai New Century Dental Material Co., Ltd., China Mainland) was softened in warm water of about 65 degree centigrade and adapted on the stone casts to make wax bases. Excess wax was cut off using wax knife and the periphery adjusted as appropriate. The adapted wax bases and stone casts were then invested in denture flasks (Safrany; J. Safrany metallurgy, Sao Paulo, SP, Brazil) using plaster of Paris(Neelkanth Filtraids And Mineral Products, Jodhpur Rajasthan -342008, India.) following standard laboratory procedure. After one hour, the flasks were placed in boiling water (100 degree centigrade) for five minutes to soften the wax. Subsequently, the denture flasks were opened and the residual wax flushed out with hot water and liquid detergent. After the investment (Plaster of Paris) had cooled down from hot state to warm state, its surfaces were then coated with separating medium- sodium alginate (s.s white dental product, Rio de Janeiro, RJ, Brazil) after which the acrylic resin polymer and monomer were mixed in a ratio of 35.5g powder to 15mls liquid. At the dough stage, the homogenized resin bulk was packed into the denture flasks under 1250kg final packing pressure, the flasks were then placed in strain clamps and submitted to the curing cycle of initially 65 degree centigrade for 90 minutes, then 100 degree centigrade for one hour. The acrylic bases were then cooled at room temperature, deflasked and excess resin trimmed and polished. The bases were subsequently stored in distilled water for 30 days to release stresses associated with polymerization and deflasking.

At the end of thirty days, the acrylic resin bases were removed from water and seated on their respective casts. The initial measurements of the cast-acrylic base plates were taken with the use of a digital calliper (Shandong Sound Metal and Machinery Inc China). The measurements were taken at the right marginal limit, right crest, mid-palatal region, left crest, and left marginal limit already marked with indelible pencil.

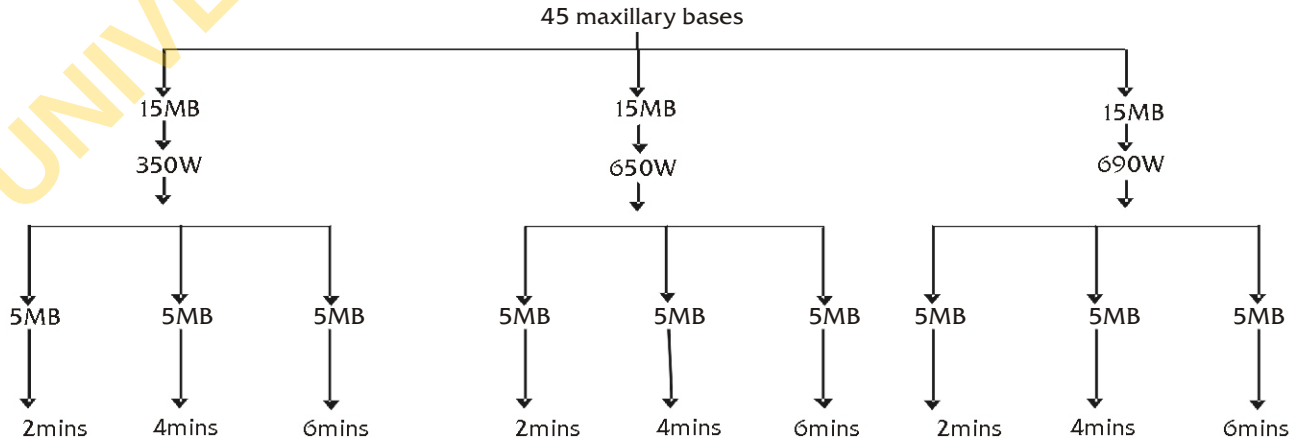
Each acrylic base plate was then transferred to a separate 600ml beaker containing 200ml of distilled water. The top of the beakers were covered with paper foil, following which they were placed on the rotational plate in a domestic microwave oven (Thermal Technologies pty Ltd, Moorebank NSW 1985, Australia) ready for irradiation. The forty five bases were divided into three groups of fifteen and those in each group were further divided into three subgroup of five. Denture bases in each of the three group were microwaved at 350W, 650W and 690W respectively and denture bases in each sub-group were microwaved for two, four and six minutes respectively **(Figure 1)**. After irradiation and cooling, each acrylic base plate was removed from the distilled water and fitted on its cast. The measurements were taken again at the same measurement points using the same digital calliper (Shandong Sound Metals and Machinery Inc China).

The differences (dimensional discrepancies) in these pre and post microwave exposures were collected on a data form. These were then analyzed using the statistical package for social sciences (SPSS) version 20. Data were presented using mean and standard deviation. 2-way ANOVA and Turkeys honestly significant difference (HSD) were used to test associations among categories of variables at 95% level of confidence (i.e. p = 0.05) e.g. Dimensional distortion at 350W, 650W, and 690W at 2, 4 and 6mins.

Results

Means (±SD) of dimensional discrepancies at each measurement points are shown in table 1. The highest mean of dimensional discrepancies (0.082±0.03) was observed in the mid-palatal region of group of maxillary bases subjected to 690W/ 6 minutes regimen, followed by the right marginal limits in the same 690W/6mins regimen denture base sub-group.

Figure 1. Stages of microwave treatments of maxillary acrylic resin denture bases.



Where MB= maxillary denture bases; W= watts and mins= minutes.

Table 1: Mean of discrepancies between the maxillary acrylic bases and the stone cast.

Microwave Treatment (W)	Time (mins)	Left marginal limits mm(±SD)	Left Crest mm(±SD)	Mid-palatal region mm(±SD)	Right crest mm(±SD)	Right marginal limits mm(±SD)
	2	0.016 (0.015)	0.016(0.011)	0.020(0.012)	0.014 (0.009)	0.022 (0.022)
350	4	0.018 (0.013)	0.018(0.015)	0.022 (0.018)	0.014 (0.013)	0.022 (0.013)
	6	0.016 (0.011)	0.024 (0.005)	0.024 (0.015)	0.022 (0.016)	0.016 (0.018)
	2	0.020 (0.019)	0.014 (0.011)	0.022 (0.016)	0.018 (0.008)	0.028 (0.019)
650	4	0.022 (0.016)	0.016 (0.011)	0.022 (0.015)	0.016 (0.009)	0.028 (0.022)
	6	0.026 (0.017)	0.018 (0.016)	0.028 (0.015)	0.018 (0.019)	0.036 (0.013)
	2	0.026 (0.019)	0.014 (0.015)	0.028 (0.015)	0.012 (0.022)	0.028 (0.015)
690	4	0.028 (0.033)	0.018 (0.022)	0.042 (0.036)	0.022 (0.016)	0.028 (0.028)
	6	0.062 (0.041)	0.032 (0.023)	0.082 (0.030)	0.026 (0.027)	0.068 (0.051)

Table 2: Comparison of the means of dimensional changes in the maxillary denture bases at each measurement points.

Variation cause	df	Left marginal limits		Left crest		Mid-palatal region		Right crest		Right marginal limits	
		F value	p value	F value	p value	F value	p value	F value	p value	F value	p value
Power	2	2.306	0.114	0.372	0.692	9.052	0.001	0.460	0.6351	3.837	0.031
Time	2	2.098	0.137	0.372	0.692	4.356	0.020	1.700	0.197	1.701	0.197
Power X Time	2	1.224	0.318	0.291	0.882	2.542	0.056	0.319	0.863	1.226	0.317

A 2 way ANOVA analysis comparing the means of dimensional changes at the measurement points on the maxillary bases and considering the two influencing factors: power of microwave in Watts and time in minutes, showed statistical significance in mid-palatal region for influence of power of microwave (F=9.052, df=2, p=0.001) and time (F=4.356, df=2, p=0.020) **(Table 2)**, while the influence of interaction between power and time on dimensional discrepancies of maxillary bases was not significant (F=2.542, df=4, p=0.056) at the level of p=0.05. There was statistical significance in dimensional distortion in mid-palatal region between groups of maxillary bases subjected to microwave treatment at 350W and 690W (P = 0.001), between 2 and 6 minutes (P = 0.020), and between 650W and 690W (P = 0.003). However, there was no statistical significant different in distortion between the groups of maxillary denture bases microwaved at 4 minutes and those microwaved at 2 minutes. Similarly, there was no statistical significant difference in distortion between those treated by microwave for 4 minutes and those for 6 minutes. Table three shows that the dimensional distortion exhibited by the group of maxillary bases at 350W and 2 minutes and those at 690W and 6 minutes showed the greatest distortion differences (p=0.001).

Discussion

The traditional way of disinfecting the denture is by soaking it in solution disinfectants such as glutaraldehyde[17] and sodium hypochlorites[25]. The resulting side effects such as cytotoxicity[26] and staining of plastic components of denture[27] had led to discovery of microwave which unfortunately had come with possible

Table 3. Tukey's HSD statistic of the mid-palatal region for multiple comparisons of dimensional changes at various power and times.

Power	(W)	P-value	Time	(Mins)	p-value
350	650	0.962	2	4	0.760
690		0.001		6	0.020
650	350	0.962	4	2	0.760
		0.003		6	0.099
690	350	0.001	6	2	0.020
	650	0.003		4	0.099

side effects such as increase deformation at fracture sites[28], decreased shear bond strength at tooth-resin base interface and dimensional distortion[19].

There was no significant distortion in the dimension of maxillary resin bases along all measurement points microwaved at 350W with all the time regimen of 2, 4 and 6 minutes. This is similar to the results of some studies[27,29], where 350W power was employed for sterilization of acrylic resin infected with Candida albicans at 10 and 6 minutes respectively. Using 350W/10 minutes, Webb and his colleagues[29] found no significant distortion in the dimensions of the acrylic base despite placing it dry and direct in the microwave. The insignificant distortion observed in this study, and in other similar studies mentioned above, may be because 350W as a power regimen is too low irrespective of time the denture bases spent in the microwave and whether it is placed in water or not. Consequently, this appears to be a very useful power regimen for preservation of acrylic denture base dimension provided it can eliminate all infective agents from the denture.

Also, those acrylic denture bases microwaved at 650W produced no significant distortion in all measurement points irrespective of the time periods (2, 4 and 6 minutes) **(Table 3)** they were subjected to the microwave treatment. This is in contrast to a previous study[30] which showed that microwave regimen of 650W/6 minutes produced shrinkage of denture bases. This difference could be as a result of the difference in significant level selected by the two studies. We used P□0.05 while Nirale and his colleagues[30] selected P□0.001 which has 50 times more capacity for detecting smaller changes.

However, using two-way ANOVA and considering the two factors of power and time **(Table 2)**, statistical significance in dimensional distortion in the mid-palatal region (p=0.001 for power in Watts and p=0.020 for time in minutes) was noted. This was further located to those microwaved at 690W/6 minutes by Tukey's HSD test because three groups of samples were investigated (Table 3), and this showed the differential distortion was highest between those microwaved at 350W/2 minutes and 690W/6minutes, revealing the significant distortion in mid-palatal region was mainly produced by the 690W/6 minutes regimen (Table 3). This is in agreement with some previous studies[31,32,33] and may have been caused by prolong exposure to the microwave regimen, in addition to other aggravated factor such as the palatal geometry[19] . That 6 minutes produced the greatest discrepancies was supported by a study[34] which showed that the use of microwave disinfection cycle with greater energy intensity and larger application time produced great discrepancies in the base adaptation to the stone cast.

Although a statistical significance was observed in the mid-palatal region, the value (0.082±0.03), fell within a normal clinically acceptable range of less or equal to 0.04-0.15mm set by another study[35] which reported that discrepancies within the range will not produce any noticeable loss of retention of denture. This is especially important in situation where the other two power regimens (350W and 650W) are not able to totally eliminate microorganism from the denture, the 690W/6minutes can be employed knowing that though it may produce slight distortion, this will be inconsequential and of no clinical significance.

When comparing the dimensional distortion by measurement points, the least distortion in this study was recorded at the right and left upper palatal crest **(Table 1)** especially when considering the influence of the interaction of the microwave power and time on the dimensional discrepancies of acrylic resin (p=0.882 at the left crest and 0.863 at the right crest).In addition, each of the independent factors, that is, for the left crest (power; p=0.692, time; p=0.692) and the right crest (power; p=0.635, time; p=0.197) has no significant effect on the acrylic base in causing distortion. This is consistent with a finding by another study[19] and may have been due to the fact that the ridge shape morphology of the crest (geometry) on which the acrylic sat discouraged much discrepancies.

Conclusion

This study showed that distortion of acrylic resin denture base tends to increase with increasing microwave power and time. The mid-palatal region tends to display the greatest distortion. It is however not clear at the moment whether all microorganisms and their products can be eliminated at 350W microwave regimen where least distortion was recorded in this study, and it is also not clear whether the distortion that occurred at 690W regimen is sufficient enough to jeopardize the clinical performance of the denture bases. Combined clinical and microbiologic studies are suggested to address these issues.

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