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Dental application of glass cloth to denture: dimensional accuracy in reinforced resins

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Duplicate dentures were made from heat-cured (HC) and microwave-cured (MC) bases, and with these bases reinforced with glass cloth. The clearance as a dimensional change in the resins was measured in relation to duplicate gypsum models from a master denture model. The clearance value in resins stored in distilled water at 37 °C demonstrated better dimensional accuracy as compared with base resin replicas stored in air at 37 °C. When measured at 1 kg load, MC and HC base resins showed a decrease in the clearance value. MC and HC resins reinforced with glass cloth had no significant difference between the values of dimensional accuracy at each site. The MC base and reinforced resins could be useful, comparable with HC acrylic base resin, for dental applications.

1. Introduction

Various kinds of inorganic and organic fibre have been added as reinforcing materials to acrylic resins in order to improve their mechanical properties [1–6]. In order to add the fibres to denture base resins, coating with heat-cure monomer or other multifunctional co-monomer was tried by the present authors after a silane coupling treatment of the fibres [3, 4]. These coating treatments gave the desired effect on the inclusion of fibres in the base resin, showing increased values of bending strength. In the case of glass cloth as a reinforcing material, we coated its base monomer to the cloth to inclusion into the base resin [4]. Therefore, the present study was to clarify the difference of dimensional accuracy between microwave-cured (MC) fibred resin and heat-cured (HC) fibred resin. The effect of storage conditions, such as 37 °C in air and distilled water, on the dimensional accuracy value was also examined for the MC and HC bases and their reinforced resins.

2. Experimental procedure

The base resins used were heat-cured (HC) and microwave-cured (MC) resins, which were commercially available as Natural resin (Nissin Co., Kyoto) and Acron MC (G-C Dental Ind., Tokyo). These bases were mainly composed of acrylics [4]. Samples were prepared according to the manufacturer's instructions and the study described by the present authors [4]. In HC base resin the liquid/powder (L/P) ratio was selected to be 4.0 ml/10 g and the L/P ratio and irradiation time were respectively 4.3 ml/10 g and 3 min in MC base resin. The inclusion of twill woven glass cloth (WLB, NITTOBO Co., Tokyo) into the base was carried out according to the following method: a piece of glass cloth was immersed into each base resin monomer within a shielded pack (Packman, Fujimaru Co., Tokyo) for 30 min as reported previously [3, 4], and the glass cloth (20 mm × 72 mm × 1.5 mm) was added to each base resin at the centre of the gypsum model specimen [3]. On half of a specimen one piece of glass cloth was set and each resin added to the upper half of the specimen.

The dimensional accuracy value was examined for four kinds of resin including two base resins and two fibred resins. As shown in Fig. 1, the clearance between each resin and its gypsum model was measured under two different conditions, namely unloaded and 1 kg loading. The storage of specimens was done in air and distilled water at 37 °C, and the storage times after curing were 7, 15 and 30 days. The clearance values at each site on the gypsum model were measured with a travelling microscope (Seiki-sha, Tokyo).

3. Results

Tables I to VIII indicate dimensional accuracies as the clearance in the base and reinforced resins tested. The values of clearance were measured unloaded and under 1 kg load for the resins stored in air and distilled water for 7, 15 and 30 days at 37 °C after curing. The results show that the effect of load on measured clearance was very large compared with the unloaded condition in the two MC and HC base resins. The reinforced MC and HC resins did not show a large difference of clearance value between the loading

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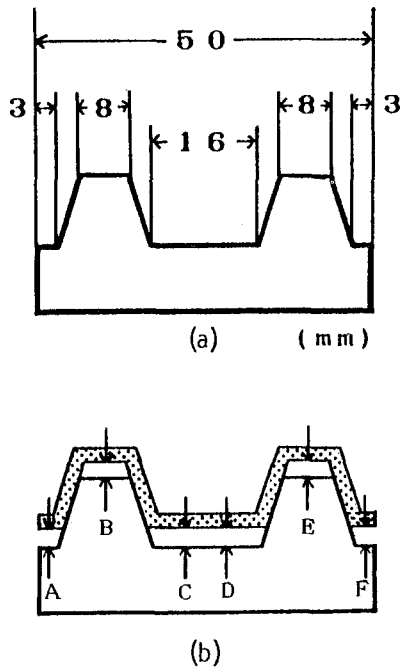

Figure 1 (a) Dental gypsum model, (b) measuring sites A to F.

TABLE I Clearance values (mm) of heat-cured (HC) base resin at the positions A to F when measured in the unloaded condition after curing and immersion for different times in air at 37 °C

Position	Clearance (mm)			
	As cured	7 days	15 days	30 days
A	0.44 ± 0.08	0.65 ± 0.18	0.85 ± 0.09	0.82 ± 0.10
B	0.34 ± 0.07	0.65 ± 0.19	0.82 ± 0.09	0.78 ± 0.11
C	0.31 ± 0.04	0.71 ± 0.14	0.83 ± 0.10	0.85 ± 0.11
D	0.33 ± 0.03	0.70 ± 0.15	0.81 ± 0.09	0.81 ± 0.12
E	0.39 ± 0.07	0.64 ± 0.15	0.69 ± 0.06	0.72 ± 0.10
F	0.49 ± 0.07	0.64 ± 0.15	0.63 ± 0.05	0.68 ± 0.10

TABLE II Clearance values of microwave-cured (MC) base resin in the unloaded condition after curing and immersion for different times in air at 37 °C

Position	Clearance (mm)			
	As cured	7 days	15 days	30 days
A	0.33 ± 0.09	0.70 ± 0.11	0.63 ± 0.01	0.51 ± 0.10
B	0.34 ± 0.03	0.77 ± 0.15	0.65 ± 0.08	0.56 ± 0.04
C	0.35 ± 0.03	0.86 ± 0.13	0.66 ± 0.14	0.62 ± 0.03
D	0.33 ± 0.04	0.87 ± 0.09	0.66 ± 0.16	0.61 ± 0.05
E	0.33 ± 0.07	0.80 ± 0.09	0.60 ± 0.18	0.59 ± 0.06
F	0.35 ± 0.13	0.78 ± 0.08	0.59 ± 0.20	0.55 ± 0.07

TABLE III Clearance values of HC base resin at 1 kg loading after curing and immersion for different times in air at 37 °C

Position	Clearance (mm)			
	As cured	7 days	15 days	30 days
A	0.26 ± 0.08	0.37 ± 0.06	0.41 ± 0.05	0.42 ± 0.05
B	0.20 ± 0.08	0.35 ± 0.08	0.36 ± 0.06	0.38 ± 0.05
C	0.22 ± 0.04	0.43 ± 0.05	0.48 ± 0.04	0.47 ± 0.06
D	0.23 ± 0.03	0.42 ± 0.05	0.47 ± 0.01	0.46 ± 0.06
E	0.22 ± 0.06	0.37 ± 0.07	0.42 ± 0.03	0.41 ± 0.04
F	0.28 ± 0.06	0.42 ± 0.08	0.44 ± 0.05	0.43 ± 0.01

TABLE IV Clearance values of MC base resin at 1 kg loading after curing and immersion for different times in air at 37 °C

Position	Clearance (mm)			
	As cured	7 days	15 days	30 days
A	0.10 ± 0.04	0.20 ± 0.05	0.23 ± 0.05	0.18 ± 0.09
B	0.10 ± 0.03	0.19 ± 0.04	0.26 ± 0.09	0.20 ± 0.06
C	0.16 ± 0.04	0.29 ± 0.05	0.33 ± 0.10	0.29 ± 0.06
D	0.16 ± 0.04	0.30 ± 0.04	0.32 ± 0.09	0.29 ± 0.03
E	0.11 ± 0.04	0.22 ± 0.05	0.29 ± 0.09	0.26 ± 0.02
F	0.15 ± 0.05	0.28 ± 0.06	0.34 ± 0.12	0.30 ± 0.06

TABLE V Clearance values of HC base resin in the unloaded condition after curing and immersion for different times at 37 °C in distilled water

Position	Clearance (mm)			
	As cured	7 days	15 days	30 days
A	0.43 ± 0.06	0.36 ± 0.06	0.38 ± 0.10	0.34 ± 0.03
B	0.34 ± 0.08	0.34 ± 0.07	0.40 ± 0.10	0.39 ± 0.04
C	0.37 ± 0.10	0.36 ± 0.05	0.40 ± 0.09	0.44 ± 0.07
D	0.38 ± 0.08	0.36 ± 0.05	0.40 ± 0.07	0.44 ± 0.07
E	0.39 ± 0.09	0.35 ± 0.05	0.33 ± 0.07	0.38 ± 0.09
F	0.51 ± 0.08	0.37 ± 0.06	0.33 ± 0.06	0.43 ± 0.15

TABLE VI Clearance values of MC base resin in the unloaded condition after curing and immersion for different times at 37 °C in distilled water

Position	Clearance (mm)			
	As cured	7 days	15 days	30 days
A	0.33 ± 0.03	0.34 ± 0.07	0.35 ± 0.07	0.35 ± 0.06
B	0.33 ± 0.05	0.40 ± 0.10	0.42 ± 0.05	0.44 ± 0.08
C	0.36 ± 0.03	0.42 ± 0.12	0.40 ± 0.07	0.46 ± 0.12
D	0.37 ± 0.03	0.42 ± 0.11	0.40 ± 0.06	0.47 ± 0.12
E	0.37 ± 0.04	0.39 ± 0.09	0.35 ± 0.04	0.42 ± 0.11
F	0.33 ± 0.02	0.35 ± 0.08	0.28 ± 0.04	0.34 ± 0.12

TABLE VII Clearance values of HC base resin at 1 kg loading after curing and immersion for different times at 37 °C in distilled water

Position	Clearance (mm)			
	As cured	7 days	15 days	30 days
A	0.22 ± 0.06	0.19 ± 0.05	0.16 ± 0.07	0.12 ± 0.03
B	0.17 ± 0.06	0.18 ± 0.06	0.16 ± 0.07	0.15 ± 0.05
C	0.24 ± 0.05	0.21 ± 0.05	0.21 ± 0.04	0.20 ± 0.06
D	0.25 ± 0.05	0.24 ± 0.07	0.21 ± 0.05	0.21 ± 0.07
E	0.21 ± 0.07	0.21 ± 0.07	0.17 ± 0.08	0.17 ± 0.07
F	0.29 ± 0.08	0.23 ± 0.08	0.21 ± 0.10	0.17 ± 0.07

conditions. The storage conditions affected the clearance values at each portion in the gypsum model, ranging from approximately 0.1 to 0.5 mm (distilled water) and 0.1 to 0.9 mm (air) in base resins. In the case of reinforced resins the clearance values ranged from approximately 0.1 to 0.6 mm (distilled water) and 0.2 to 0.5 mm (air). Figs 2 to 5 show the values of

TABLE VIII Clearance values of MC base resin at 1 kg loading after curing and immersion for different times at 37 °C in distilled water

Position	Clearance (mm)			
	As cured	7 days	15 days	30 days
A	0.14 ± 0.03	0.09 ± 0.03	0.08 ± 0.03	0.07 ± 0.02
B	0.13 ± 0.01	0.11 ± 0.02	0.11 ± 0.03	0.11 ± 0.03
C	0.18 ± 0.01	0.12 ± 0.02	0.14 ± 0.03	0.13 ± 0.03
D	0.20 ± 0.02	0.12 ± 0.02	0.13 ± 0.02	0.14 ± 0.02
E	0.13 ± 0.02	0.10 ± 0.03	0.11 ± 0.02	0.11 ± 0.04
F	0.14 ± 0.02	0.11 ± 0.05	0.08 ± 0.02	0.09 ± 0.03

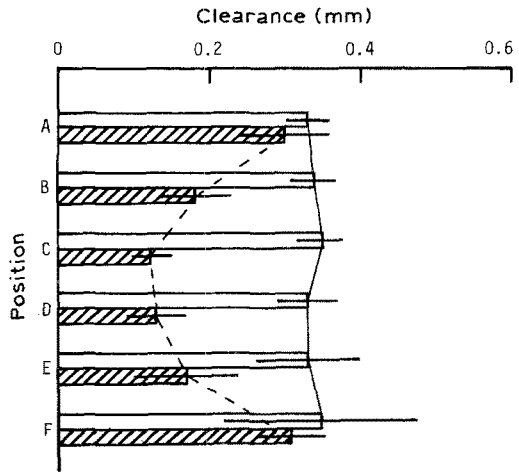

Figure 2 Clearance values of MC base and fibred resins after curing at the positions A to F (unloaded measuring condition; storage at 37 °C in air; ▭ MC base resin, ▨ MC fibred resin).

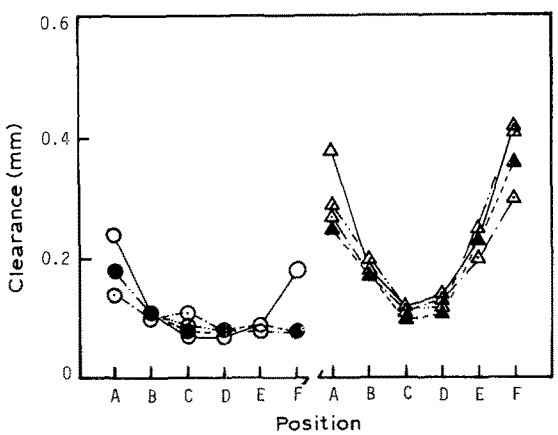

Figure 3 Clearance values of MC (left side) and HC (right side) reinforced resins at 1 kg loading: (○, △) as cured, and after immersion in distilled water at 37 °C for (⊙, ◬) 7 days, (Ø, ⩓) 15 days and (●, ▲) 30 days.

clearance for two base resins and two fibred resins at the sites A to F, where the resins were conserved in air and distilled water. In the MC reinforced specimen the clearance values at positions B, C, D and E were smaller than that in MC base resin (Fig. 2). The clearance value became smaller at the loading condition, when comparing base and fibred resins (Figs 3 to 5).

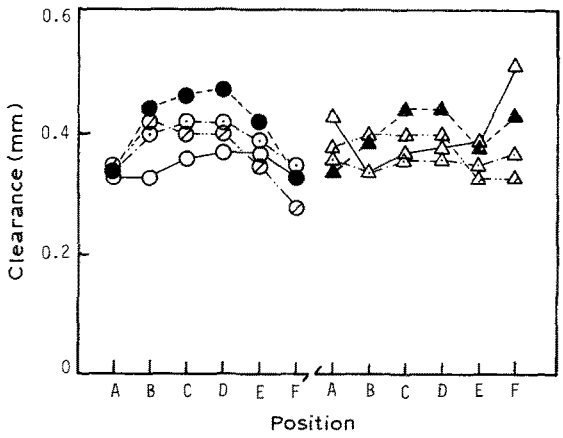

Figure 4 Clearance values of MC (left side) and HC (right side) base resins (in the unloaded measuring condition after storage at 37 °C in distilled water (symbols as for Fig. 3).

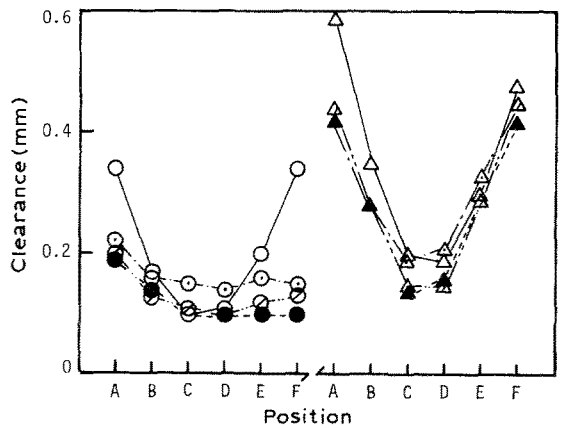

Figure 5 Clearance values of MC (left side) and HC (right side) reinforced resins measured under the same conditions as Fig. 4 (symbols as for Fig. 3).

4. Discussion

It is known that dimensional changes occurs during the processing of acrylic denture base resin [7, 8], and variables such as the investment material and L/P ratio of base resin influence the dimensional changes of acrylic resin. In this study on the measured differences, various loading conditions (unloaded and 1 kg loading) and storage conditions were selected to evaluate the values of dimensional change (Tables I to VIII and Figs 2 to 5). The results show differences between the values consequent on the storage conditions for each resin. The measurement sites A to F had a significant difference of changes in dimension for every variable tested ($p < 0.05$). Using a plastic denture model with a U-shape, the measured value of the clearance between the gypsum model and the plastic model and the resin after curing ranged from 0.30 to 0.40 mm (MC base resin), and 0.31 to 0.46 mm (HC base resin), as reported by Andou *et al.* [9]. No statistically significant changes in dimension were found between the base resins. The difference of clearance between MC and HC base resins tested here was also not significant for storage in distilled water under each loading condition (Tables V to VIII), ranging approximately from 0.3 to 0.5 mm (unloaded) and 0.1

to 0.3 mm (1 kg load). Each value in each base resin was, however, found to be significant between loading conditions ($p < 0.01$). An effect of reinforcement due to glass cloth was found for the value of clearance at the centre portion of the gypsum model (Figs 4 and 5). The clearance value was about 0.1 mm for MC and HC fibred resins, indicating that the base resins had about 0.3 mm. At the edges of model the values in fibred resins were almost the same as for base resins.

The results showed that the dimensional accuracy reflected by the clearance between the resin material and the gypsum model ranged from approximately 0.1 to 0.5 mm for MC and HC base resins after storing them in distilled water, and 0.1 to 0.9 mm after storage in air. The changes in dimension were different for different measuring sites, but this value was not significantly large between MC and HC base resins, or MC and HC fibred resins. The reinforcement of base resins increased the flexure properties and impact energy as reported previously [4], and the processing method was not complicated, because the reinforcement does not need special equipment. To summarize, the MC fibred resin had almost the same trend of dimensional accuracy as the HC base resin when processed conventionally.

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