Effects of time delay and tension system application after final flask closure on the vertical displacement of acrylic and porcelain teeth in maxillary complete dentures

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ABSTRACT

Background: The displacement of artificial teeth during complete denture construction presents major processing errors in the occlusal vertical dimension which were verified at the previous trial denture stage. The aim of this study was to assess the effect of delay in processing after final flask closure and tension application on the vertical acrylic and porcelain teeth displacement of complete dentures constructed from heat cured acrylic and the results were compared with the conventional processing method.

Materials and methods: forty samples of identical maxillary complete dentures were constructed from heat polymerized acrylic resin. These samples were subdivided into the following experimental subgroups in which each subgroup contains 5 samples for both acrylic and porcelain teeth and as follows: 1. Conventional flasking technique and immediate processing. 2. Conventional flasking technique and 6 hours delay in processing. 3. flasking technique with tension system and immediate processing. 4. flasking technique with tension system and 6 hours delay in processing. Reference metal pins were attached to the middle of the buccal surface of the upper right canine and center of the buccal groove of the left first molar. And according to these reference points on the teeth another metallic Reference pins were fixed on the denture vestibules and at a distance of 7.5mm by straight lines and 6.5mm where placed between the metal pins and the vestibules in order to standardize the measurement. The distance between the right and left metal pins on the canine and molars and the corresponding metal pins on the buccal vestibules were measured during the wax up stage and after processing by using an optical travelling microscope with an accuracy of 0.0005 mm. Means in (mm) were analyzed statistically by analysis of variance and the comparative T-test and least significance test (LSD).

Results: Significant reduction in vertical displacement of the teeth occurred in groups when 6 hours delay in processing were applied, but a significant improvement was also observed in groups with tension system application when compared with control group. On the other hand, there were a high significant reduction in the vertical displacement in groups with tension system and 6 hours delay in processing combination. While for the type of artificial teeth data showed significant difference in the amount of vertical displacement of the teeth in groups with acrylic teeth when compared with porcelain teeth.

Conclusions: The findings of this study showed that 6 hours delay in processing and tension system application were effective in reducing the vertical displacement of the artificial teeth during flasking. The maximum reduction in the displacement was observed in dentures constructed from acrylic teeth. On the other hand, significant decrease in vertical displacement of the teeth was detected in dentures constructed from porcelain teeth.

Key words: Complete denture, flasking, tension system, vertical displacement, porcelain teeth, and optical travelling microscope. (J Bagh Coll Dentistry 2013; 25(2):1-7).

INTRODUCTION

Accurate occlusal vertical dimension and stable occlusal scheme are very important criteria in order to obtain normal function. The artificial teeth displacement during complete denture flasking creates inharmonious occlusal configuration which were obtained during the previous trial denture stage.[(1)] Its important from the clinical point of view to study the teeth movements during denture processing in order to obtain an accurate occlusal contact, retention, esthetics, health and functional quality of complete dentures.[(2)]

The undesirable dimensional changes during processing are considered a major disadvantages of acrylic resin because these changes can modify tooth position.[(3)]

The teeth displacement results in difficulties in occlusal adjustment procedure and leads to modifications in the planned vertical dimension and results in trauma and damages to the oral mucosa and loss of the alveolar bone.[(4)]

The time delay after final flask closure whether 6,12 or 24 hours before placing in the water bath was an effective method for decreasing the teeth displacement.[(5)] but this procedure did not influence the dimensional change values of the denture bases.[(6)]

Methods of flask closure should be considered when the denture base stability and comfort of the patient are being assessed during clinical use of the dentures.[(7)] Dimensional changes in the denture bases were reduced when these dentures were processed by using tension system to avoid flask opening during its transference from the hydraulic press. [(8)]

Accurate measurements of teeth displacement by using optical microscope is necessary in order to detect minor denture processing inaccuracies,

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which resulted in displacement of artificial teeth and responsible for poor retention and stability of the complete dentures and the increase in the vertical tooth displacement which results in difficulty in the occlusal adjustment procedures. [2]

This study was conducted to evaluate and compare the effect of time delay in processing after final flask closure and tension system application on the vertical displacement of the artificial teeth (acrylic and porcelain) in maxillary complete dentures constructed from heat cured acrylic and comparing the results obtained with the conventional flasking technique and evaluate whether the type of artificial teeth influence the amount of that displacement.

MATERIAL AND METHODS

An edentulous silicone mold (Columbia dentoform Corp., New York, USA) was made from a metallic master die simulating an edentulous maxillary arch without irregularities in the alveolar ridge walls as shown in figure (1,A). Forty similar stone casts were poured in type III dental stone (Elite model, Zhermack technical, Italy) in a W/P ratio of 30mL water to 100g powder. Pouring was accomplished by using a vibrator (Quayle Dental, England) and the cast was left undisturbed for 45 min. then removed from the mold as illustrated in figure (1,B).

(A) (B)

Figure 1: A. an edentulous silicone mold. B. stone cast used in the study.

A standardized record bases were formed by the same technique for each stone cast with a 2mm-thick thermoplastic acrylic cakes (Biocryl"C", SCHEU-Dental, Iserlohn Germany) by using Biostar machine (SCHU-DENTAL, Germany) manipulated according to the manufacturer recommendations, an even thickness of 2mm for each record base was obtained and measured with a digital caliper (Shanghai Shenhanme assuring tools Co., LTD, China), for standardization purposes, as shown in figure 2.

Figure 2: The stone cast with the thermoplastic record base attached to the biostar machine.

After completion of record bases, a horse shoe shaped block of extra-hard wax (Shanghai New Century Dental material, China) was attached to the record base to form the occlusion rim. The wax was contoured with a measurement of 22 mm length from the highest area of the labial flange to the occlusion edge and 18 mm in the posterior area. The width of the rim was about 3-4 mm anteriorly and (7-8) mm posteriorly [9] as illustrated in figure 3.

Figure 3: Occlusion rim with record base and attached horse shoe wax.

The maxillary stone casts were mounted on a semi adjustable articulator (Model H2, HANAU Eng. Co. Buffalo, New York, USA) with an universal mounting technique. The condylar track was fixed at an average angle of 30 degree and the Bennett angle was set at 10 degree. The incisal pin was secured to zero. The midline of the occlusal rim was oriented according to the incisal pin. To get the cast correctly seated in an anterio-posterior direction, the midline of the record base in the incisal region was placed at the tip of the triangle of Bonwill. [10]

In order to mount the maxillary cast with the wax rim. The interoclusal relation were set by using a standardized glass slab which had been mounted to the lower member of the articulator with plaster of Paris half away between the upper and lower members of the articulator after the incisal pin was tightly secured at zero degree. This glass slab acted as an occlusal table upon

which the maxillary cast with the occlusion rim was mounted. (11)

The occlusal plane of the maxillary occlusal rim was oriented in the articulator with the aid of the marks on the condylar posts and the incisal pin, respectively.

A dentate silicone mold (Columbia dent form Corp., New York, USA) was used as a standard guide for the arrangement of the artificial teeth in all dentures. The arrangement of the acrylic (Floridient, cross linked, shade No.3, china) and porcelain teeth (Ivoclar vivadent, shade No.3, Germany) started with the carved wax rim serving as a guide to the positions of the teeth inside the silicon mould as shown in figure 4.

Figure 4: The stone cast with the record base and artificial teeth were fixed to the semi adjustable articulator.

Metallic referential pins (Unimetric 0.8 mm, Dentsply-Maillefer, Swiss) of 8mm in length were fixed with instantaneous adhesive (Cyanoacrylate adhesive material, Japan) on the middle of the buccal surface of the upper right canine and buccal groove of the left first molar after drilling 3mm by using acrylic round bur for acrylic teeth and diamond bur for porcelain teeth. And according to these reference pins on the teeth another metallic reference pins were fixed on the denture vestibules by straight lines, keeping a 6.5mm distance between each screw and the upper border of the record base and 7.5mm between the reference pins on the teeth and that of the vestibules in order to have a standardized position for the right and left screws as shown in figure 5.

The preprocessing vertical distances between the reference pins were measured with an STM microscope (Leitz/WETZLAR, Germany) with an accuracy of 0.0005mm as shown in figure 6.
The stone casts samples were subdivided into the following subgroups were each subgroup contains 5 samples for both acrylic and porcelain teeth and as follows: **1.** Conventional flasking technique and immediate processing (Group1, control). **2.** Conventional flasking technique and 6 hours delay in processing (Group2). **3.** flasking technique with tension system and immediate processing (Group3). **4.** flasking technique with tension system and 6 hours delay in processing (Group4).

(A) (B)

Figure 5: A: the anterior reference point on the right canine. B: the posterior reference point on the left first molar.

Figure 6: the optical travelling microscope which was used for measuring the vertical distances.

The stone cast and wax pattern with teeth sets were flasked in the lower part of conventional brass flasks (BRODEN, Sweden) with type II dental stone (Elite model, Zhermack technical, Italy). Petroleum jelly (Vaseline petroleum jelly, Germany) was used as a separating medium. After 1 hour, the flasks were placed in boiling water to soften the wax base plate. The stone was cleaned with liquid detergent (alamadia, Iraq) and boiling water solution, and two coats of sodium alginate (Kamadent,Swindon, England) were used as a mold separator.

The proportion for mixing acrylic resin (Regular TM, Vertex-Dental, Netherlands) was used with a monomer: polymer ratio of 1:3 by volume. The resin was prepared in accordance with the manufacturer's instructions and was carried out at once, in a clean and dry mixing

vessel and mixed by a clean wax knife for 30 second. The mixture was then covered and left to stand until a dough stage was reached and then each sample was packed in accordance with the group assignments. A plastic sheet (Amalgamated dental Trade Distributors LTD, London, England) was used as a separating medium during the initial flask closure under a pressure of 20 bars.

After this procedure, the plastic sheet was removed and the acrylic resin excess trimmed away. In the conventional flask closure (Groups 1 and 2), the flasks were placed in traditional clamps (Ash Co., England) after final pressing in a hydraulic press (BREMER GOLDSCHLAGEREI WILH, HERBST West Germany) for 5 minutes. The flasks of group 1 were immediately immersed in water bath (EWL 55 01, West Germany) at 73C° for 90 minutes, raising the temperature to 100ºC and maintaining the boiling for 30 minute, while the flasks of group 2 were submitted to the same procedures, however, the polymerization took place after 6 hours.[12] In the flask closure with tension system (Groups 3 and 4), the same trial pack at final closure was accomplished; however, the flask was positioned between the 2 plates of the tension system[1]. During the definitive flask closure, the screws of the lower plate were fitted into the holes of the upper plate and after hydraulic pressure; the screw-nuts were strongly tightened on the screws until just one stop as shown in figure 7.

Figure 7: The flasks were placed under the two plates of the tension system while they were still placed under the hydraulic press.

Flasks of the Group 3 were immediately immersed in water bath at 73C° for 90 minutes, raising the temperature to 100ºC and maintaining the boiling for 30 minute, while the polymerization of the group 4 took place after 6 hours.[12] Once the polymerization cycle was completed, the flasks were allowed to slow cooling in a water bath at room temperature before deflasking. The specimens were trimmed with a tungsten bur to remove acrylic flashes and finishes by using silicon carbide abrasive papers. Pumice was used for final polishing. The specimens were immersed in water at 50ºC for 3 hours for excess residual monomer removal [13].

The vertical distances in mm between the reference pins of the teeth and corresponding reference pins on the vestibules were measured in conditions similar to those used before denture polymerization by using optical microscope. The differences between pre and post polymerization measurements were calculated, organized and submitted to analysis of variance (ANOVA), considering 2 factors (delay after final flask closure and tension system) and their interactions. Differences between subgroups were submitted to comparative t-test and least significant testing (LSD at level of significance of 0.05).

RESULTS

The amount of the vertical displacements means of the artificial teeth in (mm) results were given in Table 1.

Table 1: means and standard deviations for the data of vertical displacement of the artificial teeth.

Descriptive Analysis	Experimental groups	Conventional flasking technique and immediate processing (control)		Conventional flasking technique and 6 hours delay in processing		Flasking technique with tension system and immediate processing		Flasking technique with tension system and 6 hours delay in processing	
Artificial Teeth	Measuring Distances	Right Canine	Left 1st molar	Right Canine	Left 1st molar	Right Canine	Left 1st molar	Right Canine	Left 1st molar
Acrylic Teeth	Mean	1.30	1.482	1.10	1.298	0.876	1.10	0.504	0.704
	SD	0.015	0.047	0.015	0.014	0.011	0.015	0.011	0.011
Porcelain teeth	Mean	3.104	3.312	2.704	2.906	2.506	2.612	1.88	2.066
	SD	0.011	0.013	0.011	0.008	0.008	0.013	0.015	0.011

The experimental groups:

1. Conventional flasking technique and 6 hours delay in processing:

The results of this study indicated that Conventional flasking technique and 6 hours delay in processing is effective in reducing the amount of vertical displacement of the artificial teeth and this was illustrated in table 2.

2. Flasking technique with tension system and immediate processing:

The results indicated that flasking technique with tension system and immediate processing is effective in reducing the amount of vertical displacement of the artificial teeth. And this was illustrated in table 3.

Table 2: t-test between control and experimental groups for Conventional flasking technique and 6 hours delay in processing for acrylic and porcelain teeth (Group2).

Groups	t-test	P-value	Sig
Control& Group2 (acrylic teeth) Right canines	14.14	0.000	HS
Control& Group2 (acrylic teeth) left 1st molars	10.191	0.000	HS
Control& Group2 (porcelain teeth) Right canine	73.03	0.000	HS
Control& Group2 (porcelain teeth) left 1st molars	79.62	0.000	HS

Table 3: t-test between control and experimental groups of flasking technique with tension system and immediate processing for acrylic and porcelain teeth (Group3).

Groups	t-test	P-value	Sig
Control& Group3(acrylic teeth) Right canine	106.6	0.000	HS
Control& Group3(acrylic teeth) left 1stmolars	14.197	0.000	HS
Control&Group3(porcelain teeth) Right canine	90.15	0.000	HS
Control& Group3(porcelain teeth) left 1st molars	110.68	0.000	HS

3. Flasking technique with tension system and 6 hours delay in processing:

The results indicated that flasking with 6 hours delay in processing and tension system is the best method in reducing the amount of vertical displacement of the artificial teeth and this were illustrated in table 4.

The vertical tooth movements occurred in all measuring points; and the data showed high significant difference. However, movements were greater in the posterior region (1st molar region) when compared with the anterior region (canine region) for the control and time delay and tension system and combination of both as shown in table 5.

The analysis of variance (ANOVA) table shows that there were significant difference between the tested groups for the different processing times (immediate and 6 hours delay) and for flasking technique (conventional flask closure and tension system) were used as shown table 6 for acrylic teeth and table 7 for porcelain teeth.

On the other hand the results indicated that significant reduction in the mount of vertical displacement for experimental groups with acrylic teeth when compared with same groups with porcelain teeth as shown in table 8; and figure 8 in the canine region and figure 9 in the first molar region.

Table 4: t-test between control and experimental groups for flasking technique with tension system and 6 hours delay in processing for acrylic and porcelain teeth (Group4).

Groups	t-test	P-value	Sig
Control& Group4 (acrylic teeth) Right canine	77.31	0.000	HS
Control& Group4 (acrylic teeth) left 1st molars	37.34	0.000	HS
Control& Group4 (porcelain teeth) Right canine	20.40	0.000	HS
Control& Group4 (porcelain teeth) left 1st molars	31.1	0.000	HS

Table 5: t test between canine region and 1st molar region for the control groups and experimental groups for acrylic and porcelain teeth.

Groups	t-test	P-value	Sig
Right canines & left 1st molars of acrylic teeth in control group	6.906	0.002	HS
Right canines & left 1st molars of acrylic teeth in Group2	99.00	0.000	HS
Right canines & left 1st molars of porcelain teeth in control group	24.18	0.000	HS
Right canines & left 1st molars of porcelain teeth in Group2	27.48	0.000	HS
Right canines & left 1st molars of acrylic teeth Group3	43.93	0.000	HS
Right canines & left 1st molars of porcelain teeth Group3	12.139	0.000	HS
Right canines & left 1st molars of acrylic teeth Group4	63.24	0.000	HS
Right canines & left 1st molars of porcelain teeth Group4	22.89	0.000	HS

Table 6: ANOVA table for comparison of control, delay in processing, tension system and combination of both for acrylic teeth in both measuring areas.

Measuring areas	F-test	P-value	Sig
Right canine	23.82	0.000	HS
left 1st molars	74.25	0.000	HS
Right canines & left 1st molars	113.9	0.001	HS

Table 7: ANOVA table for comparison of control, delay in processing, tension system and combination of both for porcelain teeth in both measuring areas.

Measuring areas	F-test	P-value	Sig
Right canine	109.2	0.000	HS
left 1st molars	189.1	0.000	HS
Right canines & left 1st molars	83.16	0.000	HS

***P<0.05 Significant **P>0.05 Non significant**
*****P<0.001 High significant**.

Table 8: LSD test for comparison of the control groups and experimental subgroups for the type of artificial teeth (acrylic and porcelain).

Groups	Right Canine			Left 1st molar		
	T test	P-Value	Sig	T test	P-Value	Sig
Group1 (Control)	194.5	0.001	HS	78.03	0.001	HS
Group2 (time delay)	40.11	0.001	HS	21.88	0.001	HS
Group3 (tension system)	124.5	0.001	HS	155.95	0.001	HS
Group4 (combination of time delay and tension system)	202.8	0.001	HS	133.5	0.001	HS

***P<0.05 Significant **P>0.05 Non significant ***P<0.001 High significant**.

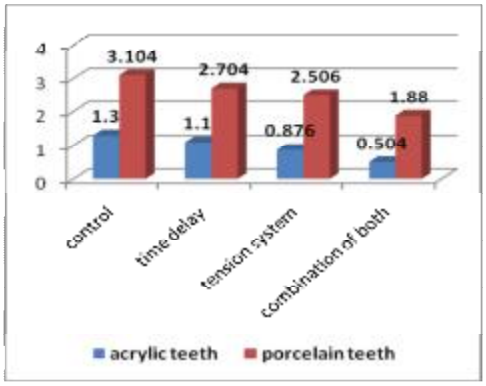

Figure 8: bar chart of the comparison of means in mm between acrylic and porcelain teeth in the canine region.

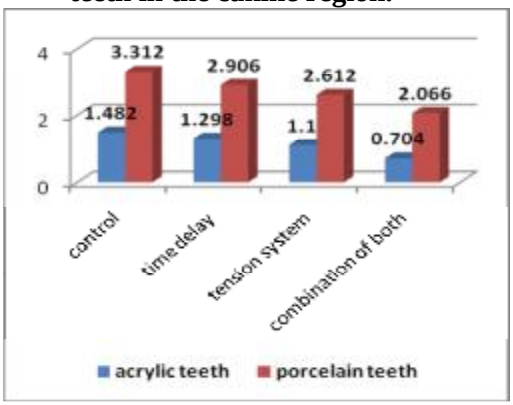

Figure 9: Bar chart of the comparison of means in mm between acrylic and porcelain teeth in the first molar region.

DISCUSSION

The delay in processing by a period of time (6-hours) found to be effective in Increasing resin dough relaxation, and probably a possible laboratory technique to be used in the laboratory steps for denture processing. The explanation for leaving the flask to stay for several hours before processing is to allow the resin dough mass to flow into all regions of the mold. In this study, 6-hours delay time produced statistically significant reduction in the vertical tooth displacement in relation to the flask closure methods used, when compared to the immediate processing time due to resin mass stay for a longer time before polymerization.[14,15]

The flask closure with tension system method positively influenced the tooth displacements independently of the post-pressing time used. This system reduced the stress release because flask closure was maintained after press releasing, promoting less distortion in the denture base. Therefore, the reduction of the base inaccuracy allowed the teeth to preserve their position in the denture.[16,17] Reduced dimensional changes in the denture bases processed with tension system suggest that this system maintained the acrylic resin dough under constant pressure conditions, because the halves of the flasks remained in contact when it was removed from the hydraulic press. This condition may impede or inhibit the premature release of the residual internal stresses from the acrylic resin dough before polymerization.[8] So the combinations of the two methods were found to be beneficial for reducing the vertical displacement of artificial teeth.

A greater magnitude of tooth movement occurs in posterior teeth, altering the occlusal relationship. A possible explanation is that the exothermic setting reaction of the investing stone in contact with the wax trial denture causes softening and expansion of the wax leading to a change in tooth - master cast relationship.[18, 19] and as the posterior teeth has a wider wax band than the anterior teeth so the amount of inaccuracies were also greater posteriorly.[20, 21]

So the anterior teeth are located in a restrictive topographic area resulting from cast anatomy which impedes resin expansion. In addition, the topographic form of the anterior arch limits the stresses released after mould separation. The posterior region is less restrictive and permits strain release, producing more evident distortion in this region.[8, 22]

Teeth displacement were found to be smaller when acrylic teeth where used compared with porcelain teeth. The possible explanation for these finding is that the coefficient of thermal expansion of the acrylic teeth and denture base was the same, while for the porcelain teeth the coefficient is different from that of acrylic denture base.[23] This mismatch between porcelain coefficient and acrylic coefficient is responsible for the higher degree of porcelain teeth displacement.[24]

The results of this study suggest that the delay in denture processing reduces the amount of teeth displacement. Also tension system application should be a factor in decreasing the magnitude of vertical teeth displacement. On the other hand, the combination effect of delay in processing and tension system was found to be the method of choice in order to improve the stability and accurate position of the artificial teeth in the complete dentures.

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