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ORIGINAL RESEARCH

A Comparative Study on the Effect of Two Different Investing Mediums on the Movement of Artificial Teeth during the Fabrication of Complete Denture: An *in vitro* Study

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ABSTRACT

Purpose: Acrylic processing of waxed-up dentures is considered to be a crucial and technique-sensitive procedure. Even after investing a lot of time and clinical skill a definitive movement of teeth during and after processing has long been observed which lead to occlusal discrepancies and disturb the harmonious occlusal scheme achieved earlier. Shifting of the teeth can occur as a result of the investing procedures and investing materials. The objective of this study was to evaluate and compare the movement of artificial teeth in two-dimensions of space (anteroposterior and mediolateral) during processing of the waxed-up dentures using two different gypsum materials for investing.

Methods: Two groups of 15 waxed-up maxillary dentures were processed using two different investing mediums (a) dental plaster and (b) combination of dental stone core and plaster mold. The artificial teeth movement was measured in the mediolateral and the anteroposterior directions between predetermined reference points before and after processing with the aid of a traveling microscope. The findings were statistically analyzed using parametric t-tests and ANOVA F-test.

Results: Artificial teeth movement in both the anteroposterior and mediolateral direction was less with the use of investment combination of dental stone core and plaster mold when compared to the conventional method of investing with dental plaster.

Conclusion: The dental stone core method is superior in view of the fact that it produces significantly less artificial teeth movement than the conventional method. However, neither of the investing methods is successful in completely preventing artificial teeth movement.

Keywords: Complete denture, Coring, Movement of teeth.

INTRODUCTION

Acrylic processing of waxed-up dentures is considered to be a crucial and technique-sensitive procedure. Polymethyl-methacrylate (PMMA) has become the most commonly used material for denture bases since its introduction in 1937. The advantages of PMMA include excellent esthetic properties, adequate strength, low water sorption, low solubility, lack of toxicity, facility of repair, and construction by a simple molding and processing technique.[1] Since, their introduction in dentistry, a certain lack of dimensional accuracy has been accepted as one of the disadvantages of complete denture construction, resulting from the unavoidable denture base shrinkage during acrylic resin polymerization.[1,2]

Polymerization shrinkage affects the position of the teeth on maxillary and mandibular dentures, and thus the final occlusion of the dentures. Even after investing a lot of time and clinical skill a definitive movement of teeth during and after processing has long been observed which lead to occlusal discrepancies and disturb the harmonious occlusal scheme achieved earlier. Shifting of teeth results in an opening of vertical dimension[3] and this is indicated by lifting of the incisal guide pin,[4] when the casts are remounted on an articulator. Compensation is made for opening of vertical dimension by selective spot grinding of teeth until the original occlusion is restored. The greater the occlusal errors, the more the time consumed in their correction.

The aim of this study was to investigate the influence and relationship of investing medium on the movements of teeth taking place in two-dimensions of space in compression molding technique.

MATERIALS AND METHODS

Two groups of 15 waxed-up maxillary dentures were processed using two different investing mediums (a) dental plaster and (b) combination of dental stone core and plaster mold. The artificial teeth movement was measured in the mediolateral and the anteroposterior directions between predetermined reference points before and after processing with the aid of a traveling microscope. The findings were statistically analyzed using parametric t-tests and ANOVA F-test.

Preparation of the Samples

For the fabrication of the test specimens, a model gypsum cast simulating a maxillary edentulous ridge was used. A silicone mold (Wirosil®; BEGO, Bremen, Germany) of the model gypsum cast was fabricated. This mold was used to make 30 duplicate master casts in type III dental stone (Castone™ Dental Stone, Dentsply Intl, Can) on which the complete maxillary dentures could be waxed and processed.[5]

The casts were assigned to the two test groups containing 15 casts each and the casts were scored numerically from 1 to 30. This was to aid in comparing the measurements taken before flasking with those taken after curing of the same denture, thus preventing errors of comparing measurements of one denture with those of other. To fabricate the initial denture, two layers of modeling wax (Modeling wax No.2, Hindustan Dental Products, Hyd, India) were adapted on a gypsum master cast. Semi-anatomic cross-linked acrylic teeth (Lactodent™; Pyrax Polymars, India) were arranged according to basic guidelines and the denture was completely waxed-up. This maxillary denture was duplicated with RTV silicon duplicating material (Wirosil®; BEGO, Bremen, Germany) to obtain a mold.

Using this silicone mold, 30 maxillary wax dentures with semi-anatomic cross-linked acrylic teeth (Lactodent™, Pyrax Polymars; India) were fabricated on the previously poured casts.[5-7] Small aluminum foil squares were stuck on the occlusal surface of the 1st premolars and 2nd molars using industrial cyanoacrylate adhesive (Feviquick™, Pidilite industries LTD, India).[8] Each square was scored with a cross using a No.23 Bard Parker blade[8,9] (Fig. 1). The center point of these crosses served as reference points which were measured with the aid of a traveling microscope[8-10] (Figs 2 and 3).

Measurements were made from:

1. Maxillary right 1st premolar (PM) to maxillary left 1st premolar (PM)
2. Maxillary right 2nd molar (SM) to maxillary left 2nd molar (SM)
3. Maxillary right 1st premolar (rt PM) to maxillary right 2nd molar (rt SM)
4. Maxillary left 1st premolar (lt PM) to maxillary left 2nd molar (lt SM).

Fig. 1: Waxed-up maxillary denture with small aluminum foil squares stuck on the occlusal surface of the reference teeth and scored with a cross

Fig. 2: Measurements being made with the aid of a traveling microscope

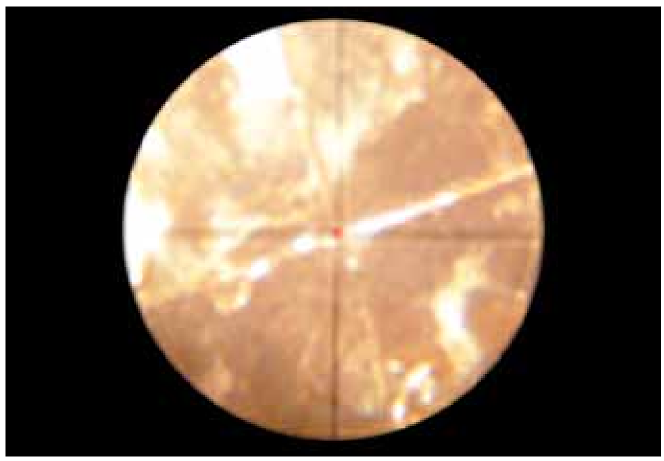

Fig. 3: Reference cross in alignment with the cross hair of traveling microscope

Using a traveling microscope before the investing of the specimens (waxed-up dentures) and afterward the specimens (waxed-up dentures) in groups 1 and 2 were invested.

Following investing mediums were used:

Group 1: Investing medium used – dental plaster. As mentioned above this group contained 15 waxed-up dentures all of which were invested in dental plaster in the conventional manner. Dental plaster was mixed according to the manufacturer's direction.

Group 2: First a coring of dental stone around the teeth followed by investing in dental plaster.[11,12] First a thick core of type III dental stone was applied all around the artificial cross-linked acrylic teeth in the shape of a horseshoe (Fig. 4). After the initial set of the stone core, a pour of dental plaster was done to completely fill the cope portion of the flask as in the conventional method of flasking using dental plaster.

Fig. 4: A thick core of type III dental stone applied all around the artificial cross-linked acrylic teeth in the shape of a horseshoe

The rest of the denture processing steps were common to both the groups (groups 1 and 2). The flasks were placed in boiling water for 5 minutes[12] to perform wax boil out. The casts and the denture molds were allowed to cool till room temperature. Separating medium was applied while the dewaxed molds were warm to get a thin layer of separating medium. Later the molds were allowed to cool for 1 hour.[12] Packing was done with heat cure polymethyl-methacrylate (DPI Heat Cure®, Dental Products of India) following standardized procedure with a polymer: Monomer ratio of 3:1 by volume[13] (approximately 25 ml of polymer and 9 ml of monomer).[12] Trial closure was done to ensure complete closure of the flasks.[12,14,15] The flasks were bench cured for 2 hours before placing in the water bath unit and a short curing cycle of acrylic resin was followed for processing.[14] The flasks were allowed to bench cool for 2 hours[16,17] and the dentures were divested carefully taking care that the dentures along with the cast were retrieved as a single unit.

Measurements were once again made as aforementioned after the processing of the specimens in groups 1 and 2. The measurements at the wax stage were used as the baseline readings, and all values were calculated with these measurements as the starting point. The results were subjected to statistical analysis using parametric tests—paired and unpaired t-test and ANOVA F-test.

STATISTICAL ANALYSIS

The results for anterior-posterior and mediolateral dimensions were subjected to a paired t-test when comparing within the same specimen group and to an unpaired t-test with parametric inference, when comparing between the two specimen groups. In order to allow for multiple pair-wise comparisons within a specimen group a Bonferroni adjustment was employed, and statistical significance was accepted at $p < 0.05$.

RESULTS

Mean values of all the four measurements using paired t-test for the 15 samples tested in group 1 were analyzed (Table 1). Of the two mediolateral measurements—the mean value of second molar to second molar (SM-SM) measurement before and after processing were statistically significant ($p = 0.020$). In the anteroposterior direction—the mean values of the measurement from right premolar to right second molar (rt PM-rt SM) before and after processing were found to be highly significant ($p = 0.004$). Mean values of all the four measurements using paired t-test for the 15 samples tested in group 2 were analyzed (Table 2). The mean values of the mediolateral measurement for teeth movement—second molar to second molar (SM-SM) were highly significant ($p = 0.001$). And mean values for both the anteroposterior measurements for teeth movement—left premolar to left second molar (lt PM-lt SM) and right premolar to right second molar (rt PM-rt SM) were highly significant ($p < 0.001$).

Table 1: Mean values of the four measurements before and after processing of dentures in group 1

Conventional flasking using dental plaster							
Type	*N*	*Minimum*	*Maximum*	*Median*	*Mean*	*Std. deviation*	*Paired t-test*
Premolar to premolar (PM-PM)							
Before	15	32.27	33.39	32.98	32.9193	0.36112	t (14) = 0.811,
After	15	32.0	34.6	32.760	32.794	0.6922	p = 0.431, NS
Second molar to second molar (SM-SM)							
Before	15	46.87	48.66	47.980	48.023	0.45577	t (14) = 2.636,
After	15	46.8	49.1	47.480	47.727	0.6466	p = 0.020, S
Rt premolar to rt second molar (rt PM-rt SM)							
Before	15	21.43	23.42	22.310	22.3040	0.41983	t (14) = 3.486,
After	15	21.0	22.9	21.940	21.972	0.5783	p = 0.004, HS
Lt premolar to lt second molar (lt PM-lt SM)							
Before	15	20.89	22.81	21.6900	21.77	0.51605	t (14) = 1.681,
After	15	20.70	23.3	21.600	21.607	0.6354	p = 0.115, NS

S: Significant; NS: Not significant; HS: Highly significant

Table 2: Mean values of the four measurements before and after processing of dentures in group 2

Flasking with dental stone core around the teeth							
Type	*N*	*Minimum*	*Maximum*	*Median*	*Mean*	*Std. deviation*	*Paired t-test*
Premolar to premolar (PM-PM)							
Before	15	32.00	34.81	33.3200	33.2107	0.6858	t (14) = 2.574,
After	15	31.7	34.7	32.960	32.960	0.7518	p = 0.022, S
Second molar to second molar (SM-SM)							
Before	15	47.12	48.30	47.530	47.6827	0.44682	t (14) = 3.959,
After	15	46.5	48.5	47.440	47.426	0.5256	p = 0.001, HS
Rt premolar to rt second molar (rt PM-rt SM)							
Before	15	21.41	22.662	22.3000	22.2247	0.3479	t (14) = 5.093,
After	15	21.6	22.5	22.140	22.063	0.2916	p = 0.000, HS
Lt premolar to lt second molar (lt PM-lt SM)							
Before	15	20.95	22.30	21.870	21.8040	0.42812	t (14) = 4.444,
After	15	20.7	22.1	21.710	21.633	0.3778	p = 0.001, HS

S: Significant; HS: Highly significant

Table 3: Comparison of the mean of difference for four measurements between groups 1 and 2

Type		*Groups*	*N*	*Mean of difference*	*Std. deviation of difference*	*t-test*
Premolar to premolar	Difference	Group 1: Dental plaster	15	0.5107	0.30911	t (28) = 1.217
(PM-PM)		Group 2: Dental stone	15	0.3933	0.20924	p = 0.234, NS
Second molar to second molar	Difference	Group 1: Dental plaster	15	0.4787	0.19364	t (28) = 2.467,
(SM-SM)		Group 2: Dental stone	15	0.3367	0.11043	p = 0.020, S
Rt premolar to rt second molar	Difference	Group 1: Dental plaster	15	0.4187	0.25754	t (28) = 3.318,
(rt PM-rt SM)		Group 2: Dental stone	15	0.1913	0.06379	p = 0.003, HS
Lt premolar to lt second molar	Difference	Group 1: Dental plaster	15	0.3640	0.17233	t (28) = 3.153,
(lt PM-lt SM)		Group 2: Dental stone	15	0.2107	0.07601	p = 0.004, HS

S: Significant; NS: Not significant; HS: Highly significant

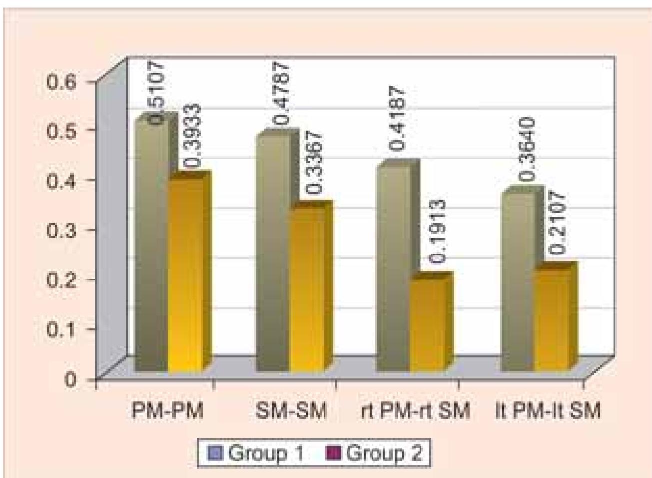

Fig. 5: Comparison of the mean of difference for four measurements between groups 1 and 2

Analysis of the data from the comparison of mean difference for all the four measurements between the groups 1 and 2 was done using unpaired t-test (Table 3 and Fig. 5). The results are indicative of an appreciable difference ($p < 0.005$) in artificial teeth movement in the anteroposterior direction between groups 1 and 2. In group 2, artificial teeth movement in the anteroposterior direction is statistically less than group 1. Analysis of the data for group 1 using ANOVA F-test shows that the comparison of mean difference for the four measurements (two mediolateral and two anteroposterior) was not statistically significant (Table 4).

This result is indicative that artificial teeth movement was uniform in both the dimensions (mediolateral and antero-posterior). However, analysis of data for group 2 shows a statistically significant difference between the two mediolateral and two anteroposterior mean difference values ($p = 0.000$). Thus, artificial teeth movement in the anteroposterior dimension was significantly less than in the mediolateral dimension for group 2.

DISCUSSION

This study evaluated and compared the movement of artificial teeth in two dimensions of space (anteroposterior and medio-lateral) during processing of the waxed-up dentures using two different gypsum materials for investing. The tooth may change in its position as a result of the investing procedures. The setting expansion will result in the movement of the tooth along with

Table 4: Comparison of the mean of difference for the four measurements within each group (to test the effect across the types)

Dependent variable: Difference				
Group	*Type*	*Mean*	*Std. deviation*	*ANOVA F-test*
Group 1: Dental plaster	Premolar to premolar (PM-PM)	0.5107	0.30911	F (3.56) = 1.107,
	Second molar to second molar (SM-SM)	0.4787	0.19364	p = 0.354, NS
	Rt premolar to rt second molar (rt PM-rt SM)	0.4187	0.25754	
	Lt premolar to lt second molar (Lt PM-lt SM)	0.3640	0.17233	
Group 2: Dental stone	Premolar to premolar (PM-PM)	0.3933	0.20924	F (3.56) = 8.717,
	Second molar to molar (SM-SM)	0.3367	0.11043	p = 0.000, HS
	Rt premolar to rt second molar (rt PM-rt SM)	0.1913	0.06379	
	Lt premolar to lt second molar (lt PM-lt SM)	0.2107	0.07601	

NS: Not significant; HS: Highly significant

the setting dental plaster. Analysis of the data from the comparison of mean difference for all the four measurement between the groups 1 and 2 using unpaired t-test showed that artificial teeth movement in the mediolateral direction, between right premolar to left premolar (PM-PM) was nearly the same for both groups 1 and 2. Whereas there was an appreciable difference in artificial teeth movement in the antero-posterior direction between groups 1 and 2. In group 2 artificial teeth movement in the anteroposterior direction is statistically less than group 1. Therefore the combination of dental stone core and dental plaster in the mold appears to be more effective in reducing artificial teeth movement. These findings are in agreement with the findings of earlier studies by Zakhari NK[11] and Turakhia et al.[12] The investment combination of Plaster of Paris in the mold and an artificial stone cap was superior to other media investigated.[18] However, an earlier study by Vieira[19] concluded that the magnitude of the setting expansion of the investing stone had no significant influence on the changes which occurred in the relative positions of teeth.

Comparison of the mean of difference for the four measurements within group 1 by ANOVA F-test shows nearly uniform teeth movement in both mediolateral and antero-posterior dimensions. This may be because the artificial teeth are surrounded by fairly uniform volume of dental plaster on all the sides. Whereas artificial teeth movement is least in the anteroposterior dimension (p = 0.000) in the dental stone core investing procedure (group 2) and more in the mediolateral direction as teeth are supported in these regions by relatively weaker materials namely dental plaster. Artificial stone core with a low water: Powder ratio has been suggested as an investing medium to resist the pressure of the expanding acrylic resin. A disadvantage of using stone is that it takes more caution and time to deflask and recover cured dentures.[11]

It appears that pressure induced within a plastic mass of acrylic dough in an enclosed flask is difficult to contain. Solution of this problem does not appear to lie in stronger materials to resist this force but it probably lies in restricting and minimizing the forces created or induced within the flask. In other words what we need is a denture base material, which would give adequate physical properties without needing heavy pressure during closure of flask. Newer methods of polymerizing acrylic resin have come into existence in order to decrease the amount of distortion that occurs during the processing of the denture.

Alexander,[20] Becker et al,[21] Jakson et al,[22] Baemert et al,[23] Dirckx[24] had conducted studies on injection molding systems and they concluded that there was no significant change in the dimension of cured dentures using this technique in comparison with the compression molding technique. Strohaver[25] reported that the injection molding system was more superior in terms of dimensional accuracy. Shlosberg et al,[26] Wakkace,[27] Sanders et al[28] and Negreiros et al[29] conducted tests to compare microwave energy and conventional hot water bath polymerization techniques. The two methods of polymerization produced similar dimensional accuracy in complete denture bases.

This study focused on the effect of two gypsum investing medium on the movement of artificial teeth in two dimensions of space, i.e. mediolateral and anteroposterior by comparing measurements at two intervals, i.e. before and after acrylization. There is a need for further studies to evaluate artificial teeth movement in three dimensions of space serially, step by step from the wax-up to completion of processing, cooling, deflasking and after deflasking.

CONCLUSION

Within the limits of the present study and on the basis of results obtained, it may be concluded that: (1) The dental stone core method is superior in view of the fact that it produces significantly less artificial teeth movement than the conventional method. (2) Artificial teeth movement in the horizontal plane is minimized by the use of the investment combination of dental stone core and plaster mold. (3) The ability of the investing medium to restrict artificial teeth movement might depend on its capacity to resist the pressure induced within the acrylic, when the flask is closed under pressure. (4) Neither of the investing methods is successful in completely preventing artificial teeth movement.

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