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ORIGINAL ARTICLE

Effect of three investing materials on tooth movement during flasking procedure for complete denture construction

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KEYWORDS

Maxillary complete denture;
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Tooth movement

Abstract *Problem statement:* Tooth movement has been shown to occur during and after the processing of complete dentures. An understanding of this phenomenon may permit one to construct functional complete dentures that require less occlusal adjustment in the articulator and in the patient's mouth.

Purpose: The purpose of this study was to examine the effects of three different investing methods on tooth movement occurring during the processing of simulated maxillary complete dentures.

Material and methods: Forty-five similar maxillary dentures were made using heat-polymerized acrylic resin, and assigned randomly to three experimental groups ($n = 15$ each) according to investing method: plaster–plaster–plaster (P–P–P), plaster–stone–stone (P-S-S), and plaster–mix (P–M). Specimens in all experimental groups were compression molded with denture base resin. Transverse interincisor (I–I) and intermolar (M–M) distances, and anteroposterior incisor–molar (LI–LM and RI–RM) distances, were measured with digital calipers at the wax denture stage (pre-polymerization) and after denture decasting (post-polymerization). Analysis of variance and Tukey's test were used to compare the results.

Results: M–M, LI–LM, and RI–RM movement was significantly greater in the P–P–P group than in the P–S–S and P–M groups; no significant difference in I–I movement was observed among groups. Transverse movement along M–M and I–I was significantly greater than anteroposterior movement in the P–P–P group; no significant difference among measurements was observed in the other two groups.

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Conclusion: The study results indicate that the use of dental stone or a 50:50 mixture of plaster and stone for investing of dentures is an important factor in efforts to control the magnitude of tooth movement.

1. Introduction

Acrylic resin remains the most commonly used material for denture base construction (Zarb et al., 2004). It has good physical, mechanical, and esthetic properties, and it is easy to use with low-cost equipment (Arora et al., 2011a). However, this material does not fulfill all requirements for an ideal denture base material (Arora et al., 2011b; Zarb et al., 2004). Many researchers have shown that acrylic resin can undergo deformation when processed dentures are removed from the cast; this processing deformation is considered to be a major disadvantage (Becker et al., 1977a; Chen et al., 1988).

The quality of a complete denture is affected by several processing variables that may cause base distortion and consequent alteration of tooth position (Kimoto et al., 2005; Skinner and Cooper, 1943; Teraoka and Takahashi, 2000; Wong et al., 1999). These factors include acrylic and investing medium types, method of resin introduction, and temperature used to activate polymerization (Skinner and Cooper, 1943). In efforts to overcome these undesirable processing effects, various flasking and polymerization techniques and materials have been studied (Shibayama et al., 2009). Rudd (1969) indicated that the use of artificial stone as an investing medium can significantly reduce tooth movement. Another study showed that the use of a silicone investment layer when flasking complete dentures resulted in the smallest changes in artificial tooth position, regardless of polymerization technique (Shibayama et al., 2009).

Differences in denture base thickness have also been found to lead to variation in tooth movement (Jamani and Moligoda Abuza, 1998). Flask closure method and post-pressing time were reported to be important factors affecting tooth displacement (Negreiros et al., 2009). However, reported data on investing materials and methods are very inconsistent (Baydas et al., 2003; Wong et al., 1999; Zakhari, 1976). The objective of this in vitro study was to compare movement of teeth during the processing of simulated complete maxillary dentures using three different investing methods and the compression molding technique. The study hypothesis was that tooth displacement would not be affected by investing method.

2. Material and methods

After performing a power analysis using G*Power version 3.1.5 to determine the required sample size, 45 identical maxillary stone casts were prepared using a silicone mold (Vertex Castil 21; Vertex Dental, Zeist, The Netherlands) of a master edentulous maxillary cast with no irregularity on the alveolar ridge surfaces. The casts were made of artificial stone (Durguix hard natural stone; Protechno, Gerona, Spain) and the water: powder ratio was 28 ml:100 g. A record base (thickness = 2 mm) was made of auto-polymerizing acrylic resin (Vertex Dental) on the master cast, according to a previously described method (Reeson and Jepson, 1999; Winkler et al., 1971). An occlusal wax rim (height = 20 mm) was created in the buccal sulcus of the cast, and the height was reduced gradually to 10 mm in the second molar area.

Acrylic resin denture teeth (MAJOR-DENT; Major Prodotti Dentari S.P.A., Moncalieri, Italy) were arranged on the cast. The arrangement of the left anterior teeth began with the carved wax rim serving as a guide for the positioning of the central and lateral incisors and canine. The same procedure was applied on the right side. The posterior teeth were arranged starting with the first premolar and continuing through the second molar. The same procedure was applied in the right arch. A wax-up was used to form the polished surfaces of the upper dentures. Replicate dentures were made using a silicone matrix (Fig. 1). Two sprue holes were prepared in the resulting mold.

After the placement of artificial teeth and prepared stone casts in the matrix, molten pink base-plate wax (modeling wax; Vertex Dental) was poured into the matrix and allowed to cool before removal. All sets of teeth were from the same mold. Simulated metallic reference pins were placed in the artificial teeth at the mesial aspects of the central grooves of the first molars, and upright on cingula of both central incisors (Molligoda Abuzar et al., 1995) (Fig. 2). Intermolar (M–M) and interincisor (I–I) transverse distances, and anteroposterior distances from the incisors to the molars (LI–LM and RI–RM), were measured with digital calipers (Mitutoyo Corporation, Kanagawa, Japan), which can record changes as small as 0.01 mm (Barbosa et al., 2002) (Fig. 3). The measurements were made at the wax denture stage (pre-polymerization) and after denture decasting (post-polymerization). Differences between the final and initial measurements indicated tooth movement.

Figure 1 The silicone matrix.

Figure 2 Simulated metallic reference pins placed in the artificial teeth.

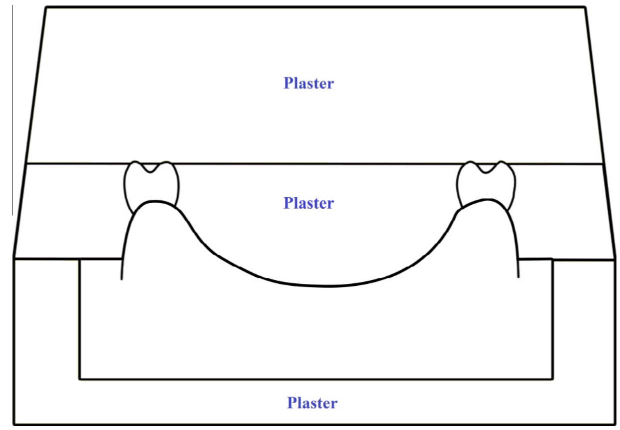

Figure 4 The plaster-plaster-plaster group.

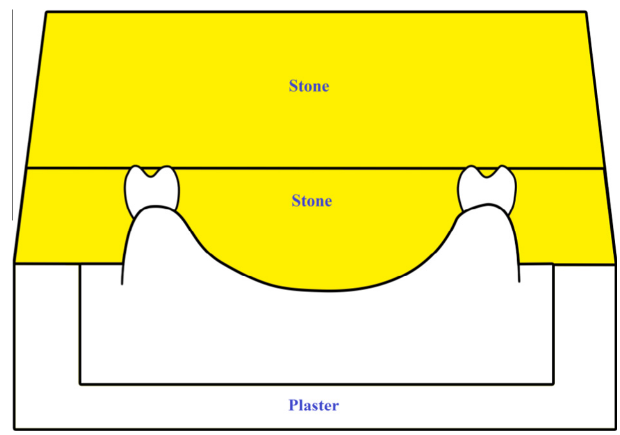

Figure 5 The plaster-stone-stone group.

The sample was divided randomly into three groups (n = 15 each) according to investing method. In the plaster–plaster–plaster (P–P–P) group, the lower part of flask (the drag) was filled with dental plaster (Pars Dandan, Tehran, Iran). After separating medium was applied to the exposed surface, plaster was poured up to the level of the incisal edges of the anterior teeth and the cusp tips of the posterior teeth (the middle portion of the mold, or the cope), and the remaining portion of the flask (the cap) was also filled with plaster (Fig. 4). The same procedure was applied to the plaster–stone–stone (P–S–S) group, except the middle and upper portions of the mold were filled with artificial stone (Fig. 5). In the plaster–mix (P–M) group, the lower part of the flask was filled with plaster and the upper portion was filled with a single layer of a 50:50 mixture of plaster and artificial stone (Fig. 6).

The compression molding technique was used to preparing all dentures. The heat-polymerized acrylic resin (Vertex Regular; Vertex Dental) was mixed with polymer and monomer at a ratio of 3:1 by volume. When the mixture reached a doughy consistency, it was placed in the mold over the teeth. A sheet of separating plastic was applied between the gypsum and the acrylic resin. The flask was closed and submitted to a trial packing procedure. Final closure was performed at 3500 psi and maintained for 30 min. The acrylic resin was polymerized in water with a long polymerization cycle. The polymerizing unit (Hanau Engineering Company, Buffalo, NY, USA) was programmed to increase the temperature to 74 °C at 1 h, which was maintained for 8 h. After polymerizing and cooling to room temperature in a water bath, deflasking and decasting were carefully completed. The dentures were stored in water

Figure 3 Measuring intermolar (M–M) transverse distance with digital calipers.

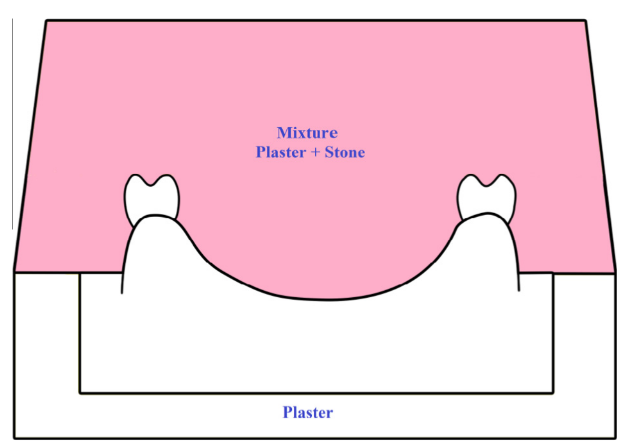

Figure 6 The plaster-mix group.

at 37 °C for 24 h. Then, the transverse and anteroposterior distances were measured again.

The ethics committee of the Dental Faculty of Damascus University approved the research protocol (374/D). Collected data were analyzed by using SPSS version 20. They were submitted to one-way ANOVA at a significant level of 5%. ANOVA was followed by Tukey's Post-hoc tests to determine significant differences in pairwise comparisons.

3. Results

Tooth movement occurred in two directions in all three groups (Tables 1 and 2). M–M, LI–LM, and RI–RM movement was significantly greater in specimens prepared with dental plaster alone (0.1573 mm, 0.1193 mm, and 0.1133 mm, respectively) than in the other groups; no significant difference in I–I movement was observed among groups (Table 1). Transverse movement along M–M and I–I was significantly greater than anteroposterior movement in specimens prepared with dental plaster alone; no significant difference among measurements was observed in the other two groups (Table 2).

4. Discussion

Results revealed that using dental stone or 50–50 mixture of plaster and stone during investing procedure resulted in smaller denture teeth displacement. Various studies have proven that tooth movement occurs during and after the processing of complete dentures (Atkinson and Grant, 1962; Consani et al., 2003, 2006). An understanding of this phenomenon may permit one to construct functional complete dentures that require less occlusal adjustment in the articulator and in the patient's mouth (Mainieri et al., 1980; Molligoda Abuzar et al., 1995).

Despite the use of 2 mm thick-bases, a long polymerization cycle and slow cooling in a water bath, which has been associated with reduced dimensional change in the denture base (Ristic and Carr, 1987; Yau et al., 2002; Negreiros et al., 2008); tooth movement was detected in all three groups after processing in this study. The authors of previous studies have reported that the greatest magnitude of tooth movement occurred in the posterior teeth (Consani et al., 2006; Wesley et al., 1973); however, the present study showed that maximum M–M tooth movement occurred only in group P–P–P. As dimensional changes caused by water sorption cause expansion, apparently due to the entrance of water between polymethyl methacrylate molecules (Campbell, 1956), final measurements were taken after the dentures were immersed in water for 24 h in this study.

Many factors influence tooth movement during the processing of complete dentures. The effects of base thickness (Jamani and Moligoda Abuza, 1998), geometric palatal form (Molligoda Abuzar et al., 1995), and closure flask pressure (Negreiros et al., 2008, 2009) have been investigated. The current study examined the effects of three different investing methods on tooth movement. Investment method obviously affected tooth movement, with less transverse (M–M) and anteroposterior (RI–RM and LI–LM) displacement of teeth in groups P–S–S and P–M than in group P–P–P.

Grant (1962) stated that tooth movement resulted from the setting expansion of a gypsum mold; the disparity observed among the three groups in this study may be attributed to differences in setting expansion. Plaster has a setting expansion of 0.2–0.3%, whereas type III dental stone has a setting expansion of 0.15–0.25% (Sakaguchi and Powers, 2012). Moreover, setting expansion of gypsum increases with reduced water: powder ratio (Noort, 2007); thus, the increased setting expansion of dental stone relative to that of plaster may contribute by compensating the polymerization shrinkage of an acrylic resin denture base, ultimately reducing tooth movement during processing. Grant (1962) also showed that the effect of gypsum's setting expansion can be reduced by confining it within a flask. Harder investing materials increase the difficulty of deflasking, which generates additional stress within the resin that is released after decasting, as well as water storage; together, these factors result in tooth displacement (Skinner

Table 1 Means and standard deviations (mm) of tooth movement in relation to the investing materials tested.

Investing materials tested	Tooth displacement			
	Intermolar distance (M–M)	RM–RI	LM–LI	I–I
P–P–P	0.1573 ± 0.02987a	0.1133 ± 0.02160a	0.1193 ± 0.02658a	0.0820 ± 0.02210a
P–S–S	0.0793 ± 0.01438b	0.0860 ± 0.02230b	0.0813 ± 0.02031b	0.0833 ± 0.02093a
P-MIX	0.0720 ± 0.02678b	0.0813 ± 0.01846b	0.0740 ± 0.02414b	0.0900 ± 0.02449a

P = plaster, S = stone, Mix = plaster + stone.
RM to RI right molar to right central incisor.
LM to LI left molar to left central incisor.
Means followed by identical letters in each column do not differ statistically at $p < .05$.

Table 2 Means and standard deviations (mm) of tooth movement for investing methods in relation to distance factor.

Tooth displacement	Investing method		
	P–P–P	P–S–S	P-MIX
M–M	0.1573 ± 0.02987a	0.0793 ± 0.01438a	0.0720 ± 0.02678a
RM–RI	0.1133 ± 0.02160b	0.0860 ± 0.02230a	0.0813 ± 0.01846a
LM–LI	0.1193 ± 0.02658b	0.0813 ± 0.02031a	0.0740 ± 0.02414a
I–I	0.0820 ± 0.02210c	0.0833 ± 0.02093a	0.0900 ± 0.02449a

Means followed by identical letters in each column do not differ statistically at $p < .05$.

and Cooper, 1943). As dental stone is harder than plaster (Sakaguchi and Powers, 2012), investment with dental stone may lead to more tooth movement relative to the use of plaster. However, artificial tooth undercuts support the restrictive effect of the investing material. Taken together, these factors may explain the observation of less tooth movement in group P–S–S than in group P–P–P in the present study.

The recommended amounts of water for mixing with 100 g plaster and 100 g stone are 45–50 ml and 28–30 ml, respectively (Anusavice, 2004). However, only 18.6 g water reacts with the plaster or stone; the excess is distributed as free water in the set mass. When the gypsum is dried, the excess water evaporates and leaves pores in the composition, weakening it (Sakaguchi and Powers, 2012). Thus, set plaster is weaker than dental stone because it contains more free water. Thus, the restrictive effect of investing plaster on tooth position may be less than that of dental stone throughout the resin polymerization and cooling processes.

Transverse (M–M) tooth displacement did not differ significantly between dentures flasked in dental stone alone and those flasked in a 50:50 mixture of plaster and stone in the current study. These results may be attributed to the rigidity of stone, which contributes to the binding of teeth together and prevents them from moving (Turakhia and Ram, 2005).

The results of this study are not consistent with the concept that teeth always tend to move toward the midline section of the palate (Becker et al., 1977b). They are also inconsistent with the findings of Carr et al. (1985), who showed that more tooth movement occurred when stone was used as an investing material in comparison with plaster. The present findings are in agreement with those of Turakhia and Ram (2005) and Negreiros et al. (2008), who showed that the use of dental stone contributes to the reduction of tooth movement.

The limitations of the present in vitro study include the focus on the effects of three investing methods, as tooth displacement during denture construction is affected by various factors. Moreover, the study was performed using only maxillary dentures.

Further research is required to evaluate the effects of different investing methods on the retention and stability of complete dentures during use. The effect of water storage on tooth movement when different investing methods are used with the compression molding technique also requires further examination.

5. Conclusion

Within the limitations of this in vitro study results suggest that the investing method appears to be an important factor in efforts to control the magnitude of tooth movement. Using dental stone or 50–50 mixture of plaster and stone during investing procedure led to smaller teeth displacement.

Conflict of interest

The current research is free of conflict of interest.

Acknowledgments

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