

ORIGINAL ARTICLE

Effect of the inclusion procedure on the alteration of teeth position in maxillary complete dentures

Efeito dos procedimentos de inclusão na alteração da posição dos dentes em dentaduras completas maxilares

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ABSTRACT

The dimensional alterations of denture base jeopardize adaptation and retention associated to altered occlusion, which are considered relevant factors for fabrication of complete dentures. **Objective:** The aim of this study was to evaluate linear tooth displacement during processing of maxillary complete dentures submitted to two inclusion methods and conventional polymerization. **Material and Methods:** Twenty maxillary complete dentures were fabricated: G1 – inclusion with silicone barrier, and G2 – inclusion with dental stone type IV barrier. Points were marked on incisal surface of right central incisor and cusp of second molars to allow linear measurement of the replicas through the software AutoCAD. The evaluation of artificial teeth displacement for both groups was carried out in different moments: a) waxed denture; b) waxed denture partially invested with stone or silicone barrier; c) after complete flasking; d) denture into flask after polymerization; e) denture attached to the cast after deflasking; f) denture separated from the cast; g) denture after finishing and polishing; h) denture after storage in water at 36° during 7 days. **Results:** Linear alterations occurred on artificial teeth positioning for both groups and in all periods of inclusion, with higher alterations for group G2. The data from phases c and d were significant different from other phases when compared intra groups, for both inclusion methods evaluated. **Conclusion:** Group G2 exhibited the greatest alterations. After polymerization, group G1 (inclusion with silicone barrier complemented with dental stone type III) demonstrated higher distance between the points (expansion) while group G2 revealed reduced distance (contraction).

KEYWORDS

Complete denture; Acrylic resins; Polymerization.

RESUMO

As alterações dimensionais das próteses podem comprometer a adaptação e retenção associadas à alteração oclusal, que são considerados fatores relevantes para a confecção de prótese total. **Objetivo:** O objetivo deste estudo foi o de avaliar o deslocamento linear dos dentes durante o processamento de próteses totais superiores submetidas a dois métodos de inclusão e polimerização convencional. **Material e Métodos:** Vinte próteses totais superiores foram fabricadas: G1- inclusão com barreira de silicone, e G2 inclusão com barreira de gesso tipo IV. Pontos foram marcados nas superfícies incisal do incisivo central direito e cúspides dos segundos molares para permitir as mensurações lineares das réplicas através do “software” AutoCAD. A avaliação dos deslocamentos dos dentes artificiais para ambos os grupos foi realizada em diferentes momentos: a) dentadura encerada, b) dentadura encerada e parcialmente incluída com gesso ou silicone, c) após completa inclusão, d) dentadura incluída após a polimerização, e) dentadura aderida ao modelo após a demuflagem, f) dentadura separada do modelo, g) dentadura após o acabamento e polimento, h) após a permanência em água a 36° durante sete dias. **Resultados:** Ocorreram alterações lineares no posicionamento dos dentes artificiais para ambos os grupos e em todos os períodos da inclusão, com maior alteração para o grupo G2. Os dados das fases c e d foram significativamente diferentes das outras fases quando comparados intra grupos, para ambos os métodos de inclusão avaliados. **Conclusão:** O grupo G2 exibiu as maiores alterações. Após a polimerização, o grupo G1 (inclusão com barreira de silicone complementada com gesso tipo III) demonstrou as maiores distâncias entre os pontos (expansão) enquanto o grupo G2 revelou as distâncias reduzidas (contração).

PALAVRAS-CHAVE

Dentaduras completas; Resinas acrílicas; Polimerização.

INTRODUCTION

The complete dentures are clinically significant due to the high incidence of edentulous patients that need rehabilitation with efficient and comfortable dentures to allow social adaptation and participation.

So, the clinical and laboratorial phases should not be neglected to avoid failures on final result. The dimensional alterations of denture base result in loss of adaptation and retention associated to altered occlusion. All these factors are considered relevant for fabrication of complete dentures and should be further evaluated. According to this, a study to minimize these alterations should consider the materials, techniques for inclusion and polymerization, and professional skill.

Although, even following these considerations, it's suggested to replace the denture in articulator after polymerization to assess alterations on teeth position due to inherent characteristics of the materials as stone expansion, acrylic resin shrinkage or stress release after deflasking. All these occurrences allow alterations on teeth position with great effect on occlusal relation and may alter the previously established vertical dimension or generate deflective premature contacts leading to failure of masticatory system. According to this, Wesley et al. [1] and Sidhaye & Master [2] demonstrated the importance and necessity for harmonization of occlusal contacts before dentures insertion.

Many studies have been developed to minimize these complications related to materials and techniques. In 2003, Gennari Filho et al. [3] evaluated the alteration on artificial teeth position considering three inclusion methods (dental stone type III, silicone and dental stone type IV) submitted to polymerization in warm water.

The measurements were carried out with a graphic software (AutoCAD 2000) to measure

the distance between points marked on the teeth. The study demonstrated that investing with dental stone type IV barrier resulted in minor alterations. Similarly, Shibayama et al. [4] evaluated the alteration on artificial teeth position after investing with dental stone type III or silicone barrier associated to polymerization in warm water bath or using microwave energy. The linear measurements were based on points marked on cusps of molars, premolars and central incisor and demonstrated minor alterations on artificial teeth position for inclusion with silicone barrier and microwave polymerization. Slaviero et al. [5] evaluated the influence of polymerization methods on the alteration of occlusal vertical dimension and the horizontal positioning of artificial teeth and 64 specimens were made, simulating a maxillary total denture waxed from a standard maxillary denture divided into two groups: Group 1 - The resins were submitted to polymerization in a hot water bath, Group 2 - The same resins were submitted to polymerization by microwave energy. They concluded that there was no statistically significant difference between the conventional polymerization method and the polymerization method by microwave, related to the stability of occlusal vertical dimension and horizontal positioning of artificial teeth on the specimens evaluated.

Some authors believe that the flasking and polymerization technique for resins can introduce stresses during processing which may lead to denture base distortions, artificial teeth displacement and increases in the occlusal vertical dimension. Based on these statements, Silva-Concílio et al. [6] investigated if the association of microwave heat-activation and bimaxillary flasking minimizes the possible increases in OVD after prostheses processing measured using a digital caliper before and after prostheses processing. The values showed that OVD increase in all groups after polymerization regardless of flasking and polymerization methods however, the prostheses invested in bimaxillary flasks showed the lowest change in

OVD regardless of the polymerization method. Salloum [7] mentions that no research has been conducted to examine the effect of using high-expansion dental stone (type V) as an investing material on the OVD. Twenty sets of simulated upper and lower dentures were processed by the compression molding technique. Specimens were equally divided into 2 groups. In the dental stone type III group, the lower, middle, and upper parts of a flask were filled with dst III. In the dental stone type V group, the procedure was the same as in the dst III group, except that the middle layer was made of high-expansion dst V. Changes in the OVD were measured before and after denture processing. The results showed that both groups increase the OVD but significantly less in the group V. Was concluded that high-expansion stone V can be recommended as an investment material to reduce the increase in the occlusal vertical dimension

Caetano et al. [8] evaluated the influence of three metallic flask systems for acrylic resin denture processing on tooth displacement and framework misfit of mandibular fixed implant-supported complete denture: conventional flask, double flask and occlusion flask. Framework misfit in all the implants and the linear distances between teeth were measured before and after denture processing using an optical microscope. The results showed that all the measured distances presented changes in tooth displacement after denture processing and the differences between the flask system were not statistically significant.

It is relevant to understand the inclusion phases in which occur the highest alterations of the material, since it allows greater control during procedures, such as water/powder ratio, stone mixture and type, quality of the stone and silicone coating, polymerization method through microwave energy or hot water bath and, professional technical skills. So, many studies have been developed to clarify and minimize the alterations during processing of acrylic resins and provide comfortable prostheses and healthy life for patients.

MATERIALS AND METHODS

The artificial teeth were mounted in a maxillary edentulous cast (2D – 32M - Vipi Plus – Dental VIPI Ltda. Pirassununga, São Paulo, Brazil) molded with duplication material Silibor (Clássico Artigos Odontológicos Ltda, São Paulo Brazil) to reproduce 20 similar waxed maxillary complete dentures divided into 2 groups with 10 replicas.

Group 1 – Inclusion with silicone barrier (Labor Mass – Dental VIPI Ltda. Pirassununga, São Paulo, Brazil) complemented with dental stone type III (Rio, Rio Claro, São Paulo, Brazil)

Grupo 2 – Inclusion with dental stone type IV (Durone, Dentsply, Petropolis, Brasil) surrounding teeth complemented with dental stone type III.

Determination of points for measurements:

Points were marked on cusps of teeth of a waxed replica randomly selected. The points determined some segments: “A” – segment between second molars, “B” – segment between left second molar and right central incisor, and “C” – segment between right central incisor and right second molar. These points were similarly marked in all replicas using a guide of colorless acrylic resin perforated in the region of the points and evidenced with graphite (Figure 1).



Figure 1 - Waxed dentures with points marked in all replicas.

The evaluation of artificial teeth displacement for both groups was carried out in the following conditions:

- a) waxed denture;
- b) waxed denture invested with silicone or dental stone type IV barrier with partial pouring with dental stone type III without covering of incisal and occlusal surfaces;
- c) complete flasking of waxed denture;
- d) denture into flask after polymerization;
- e) denture attached to the cast after deflasking;
- f) denture separated from the cast;
- g) denture after finishing and polishing;
- h) denture after storage in water at 36° during 7 days.

The investing of the flask was completed with stone pouring on surface isolated with vaseline to allow visualization of cusps and incisal surface. If necessary, this portion could be removed during analyses (Figures 2 and 3).

Measurements:

The prostheses were scanned (Scan Jet 6100C–HewlettPackard) to allow measurements between the marked points. A metallic block (1.0 cm X 1.0 cm) was also scanned to provide real values and allow resizing of casts. The prostheses was scanned after each phase for



Figure 2 - Denture flasking with stone.

comparison and determination of artificial teeth displacement (Figures 4, 5 and 6).

The images were transported to the software AutoCAD 2000 for measurement between the points corresponding to the segments previously described. The scanning of each prostheses was carried out immediately after each phase (Figure 7).



Figure 3 - Denture flasking with silicone.



Figure 4 - Prosthesis was scanned after polymerization.



Figure 5 - Denture scanned attached to the cast after deflasking.



Figure 6 - Denture scanned separated from the cast.

Data were submitted to the analysis of variance (ANOVA) and Tukey’s test was performed with a level of significance set at $p < 0.05$.

RESULTS

The artificial teeth position’s linear measurements were influenced by the phase of denture fabrication, regardless the inclusion method, with dental stone or silicone barrier (Table 1).

Table 2 shows the means of linear alteration of teeth position corresponding to the sum of the 3 segments (A, B and C) of all prostheses in each inclusion phase for both groups. It was observed that the means for phases c (complete flasking of waxed denture) and d (denture into flask after polymerization) were significantly lower than other phases, regardless the inclusion method.

Table 1 - Two-way repeated measures ANOVA of denture inclusion methods for linear alteration of teeth position

Sources of variation	df	SS	MS	F	P
Inclusion method	1	0.003	0.003	3.664	0.058
Phase of denture manufacturing	7	0.105	0.015	21.649	0.000*
Inclusion method x Phase of denture	7	0.001	0.000	0.183	0.988

* $p < 0.05$ indicates statistical significance. df=degree of freedom, SS = Sum of Square, MS = Mean Squares, F = Distribution, P= Statistics.

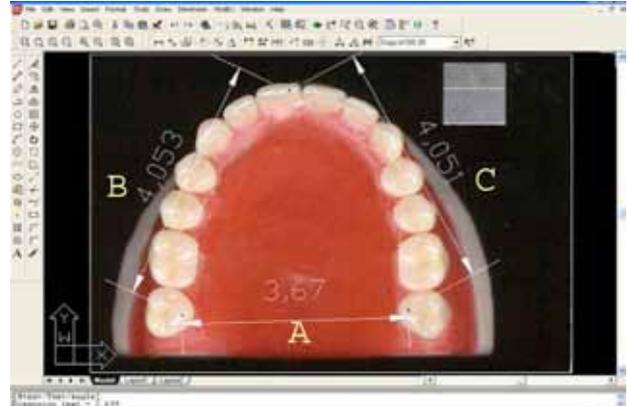


Figure 7 - Measurement between points through AutoCad software.

Figure 8 illustrates the linear alteration of teeth position for each inclusion phase for both inclusion methods. Dental stone and silicone barriers exhibited similar behavior between the phases of waxed denture (WD) and barrier formation (BF) with minor reduction of the distance between the points (0.002 cm) without statistically significant difference. In this study, the barrier with partial covering of teeth was established to expose the occlusal and incisal surfaces and allows visualization and scanning of the points.

The greatest alterations in the groups GI and GII were exhibited when the flasks were filled with stone (CF) with statistically and clinically significant displacement. The

Table 2 - Mean values (standard deviation) of linear alteration of teeth position for each inclusion phase, regardless the inclusion method

	Linear alteration (cm)
Waxed dentures	3,911(0.020) A
Barrier formation (dental Stone type IV or silicone)	3.903 (0.024) A
Denture into flask filled with Stone	3.845 (0.030) B
Denture into flask after polymerization	3.845 (0.029) B
Denture attached to the cast after deflasking	3.903 (0.026) A
Denture separated from the cast	3.898 (0.022) A
Denture after finishing and polishing	3.902 (0.026) A
Denture after storage in water during 7 days	3.905 (0.028) A

Means followed by the same capital letter in column do not differ ($p < 0.05$: Tukey)

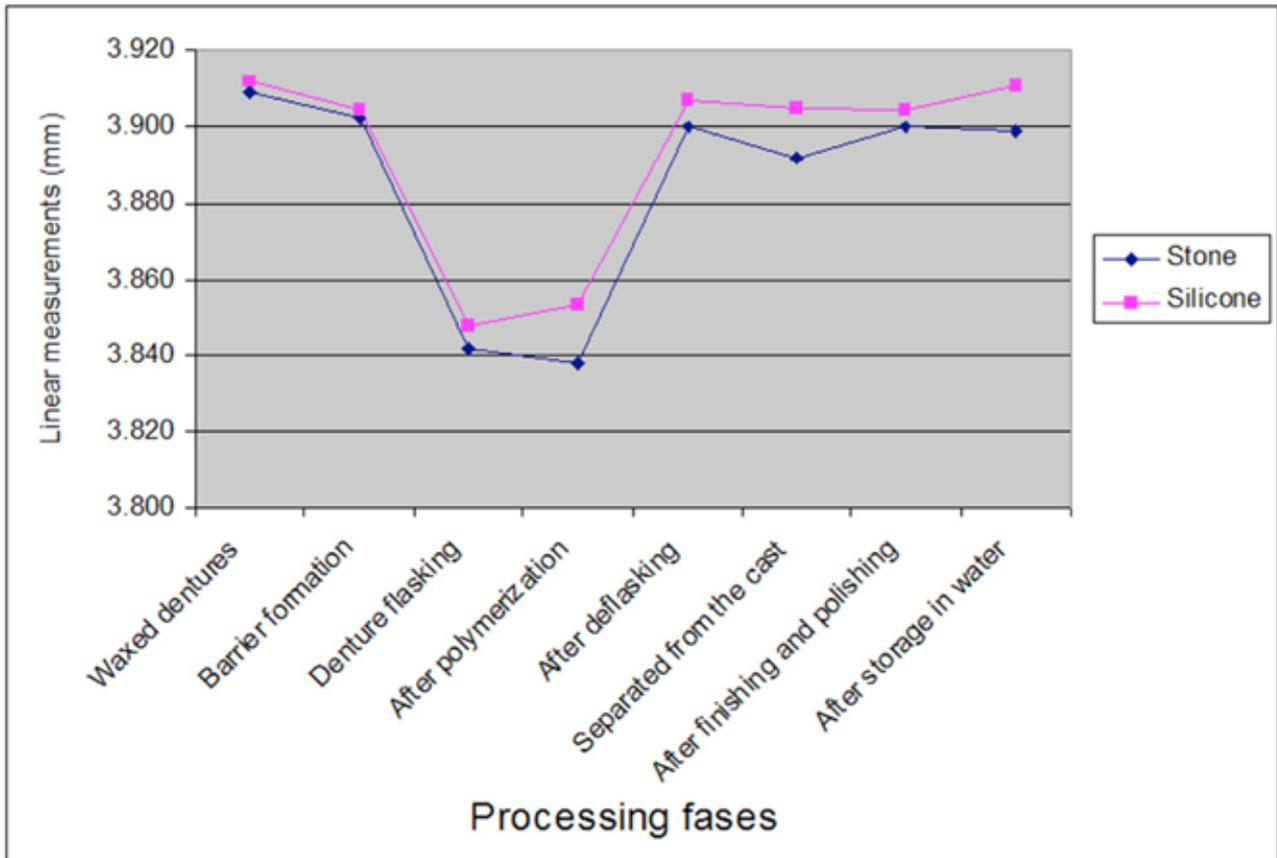


Figure 8 - Values of the segments of the dentures in each inclusion fase for both groups.

group with silicone barrier presented reduced alteration (- 0.056cm, $p < 0.01$) in comparison to the group with stone barrier (- 0.061 cm, $p < 0.01$), within each group (intra group) in the two periods of analysis. This probably results from the elastic characteristic of silicone that allows greater stone expansion as reported by Gennari Filho et al [9].

After acrylic resin polymerization (AP) with the flask still filled with stone, the group with silicone barrier exhibited slight expansion, which means an increase in the distance between the points (0.004 cm), while the group with stone barrier demonstrated characteristic of contraction (- 0.005 cm). In the initial phase, the group with silicone barrier demonstrated reduced alteration on artificial teeth position with statistically significant differences ($p < 0.01$) while the group with stone barrier

presented higher reduction ($p < 0.01$), within each group. This difference probably resulted from the resiliency of silicone layer placed between the stone poured for flask filling and the polymerized denture.

DISCUSSION

The stress generated during acrylic resin polymerization was lower in the prostheses protected with silicone barrier that demonstrated minor dimensional alteration due to movement provided by the material. Contrarily, the rigid barrier generates higher stress that results in greater alterations on artificial teeth position when it is released. Probably the movements resulted from several factors due to inherent characteristics of the materials as polymerization shrinkage of the resins, water loss and sorption, polymerization method and time, deflasking

method, and type of polishing (Skinner & Cooper [10]; Nishii [11]; Shibayama et al. [4] and Goiato et al. [12]). Regarding to research it is questioned the possible influence of replication models in changing the position of the teeth, considering that they were obtained by the technique of melted wax into molds, repositioned with acrylic teeth and that it shrinks in the hardening. However, from the models obtained in wax that it was initiated the search. Therefore, these changes in wax can not influence the results. On the other hand, measurements performed by a computer graphics program (AutoCad) are consecrated considering the papers published by Shibayama [4], Gennari Filho [3] and Mazaro [13].

It has been shown that the processing technique, rather than the choice of the resins, seems to be the dominant variable with respect to dimensional changes [14] and the conventional method is the most applicable method for curing acrylic resin due to its simplicity, relatively good accuracy and considered the gold standard for comparison with other techniques [15]. So, Among denture processing methods, injection molding has always been interesting for researchers because of compensation of polymerization shrinkage due to the pressure exerted by injection of the acrylic resin and showed less dimensional changes compared to conventional processing [16] due to smaller resin particles, lower polymerization temperature, absence of resin film formation between the two halves of the flask, and absence of displacement of the two halves of the flask during resin packing [17]. In addition to this, the double flask technique is another method of interest. Simultaneous polymerization of maxillary and mandibular complete dentures with teeth in occlusion through investing in a double special flask has been described as a more rapid and efficient method to polymerize prostheses than the conventional method [18] and independent on the investment material. Double flasking technique shown to be the most

effective method to reduce changes in artificial teeth positioning [19].

In our study, after deflasking, there was higher stress release in both groups, which is demonstrated by recovery to the initial position (in wax) in the graph. This fact resulted from recuperation of acrylic resin and removal of the barrier that increased the distance between the points. The prostheses of the group with stone barrier presented higher expansion (0.061 cm, $p < 0.05$) in comparison to the group with silicone barrier (0.054 cm) that exhibited data similar to the initial position. This probably occurred since the prostheses already presented minor alteration in relation to the initial data in the anterior phase.

Both groups presented contraction without statistically significant difference after separation of the prostheses from the casts. The group with silicone barrier exhibited greater stability with minor contraction (-0.002 cm) in comparison to the group with stone barrier (-0.008 cm).

Usually, the teeth displacement follows the linear contraction to decrease the distance between the reference points in both groups, which is in agreement with Goiato et al. [12], Gennari-Filho et al. [3] and Shibayama [4].

After mechanical polishing, the prostheses of the group with stone barrier exhibited greater alterations with increased distance between the points (0.008 cm) similar to the initial positioning of the artificial teeth while the group with silicone barrier remained stable (-0.001 cm). However, the differences were not statistically significant for both groups. After storage of the prostheses in water at 37° during 7 days, expansion was noted in the group with silicone barrier with recovery to the initial measures while the group with stone barrier remained stable in comparison to the previous phase (after polishing). In general, the greater displacement in comparison to the initial position (wax) occurred after complete filling of the flasks with

dental stone type III following barrier formation with reduced distance between the teeth. On the contrary, deflasking increased these distances resulting in almost complete recovery.

Although these dimensional alterations are statistically insignificant, they are clinically harmful since any alteration on teeth position may jeopardize the adjustment and maintenance of ideal occlusion. According to Mahler [20], each horizontal displacement of 0.01 cm represents a 1.0 mm increase on vertical dimension. Clinically, the remounting of prostheses in articulator after processing is extremely important to provide an appropriate occlusal adjustment, mainly in posterior teeth. All these factors are essential to allow comfort and function of the dentures, and avoid negative effect resultant from premature contacts and alteration on occlusion established in wax.

CONCLUSION

According to the results, it can be concluded that:

1. Linear alterations on artificial teeth position occurred for both groups in all inclusion phases.
2. Both groups exhibited recovery to the initial position (in wax) after fabrication and storage.
3. The greatest alterations on artificial teeth positioning were exhibited in the group with stone barrier.
4. Both groups presented the greatest alterations during filling of the flask with stone and after deflasking.

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