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Study of Dimensional Interfaces in Indirect Relining

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Abstract

The indirect relining of complete dentures with acrylic resin causes dimensional changes at denture bases. The purpose of this in vitro study was to compare the dimensional changes of a thermally activated relining material (Paladon®65) with those of a self-activated relining material (Lucitone® and Palapress® Vario) across different thicknesses and different locations in the palatal area in several casts. In total, 60 relinings were performed, which included the preparation of 15 relinings for each of the four different thicknesses of 1, 2, 3, and 4 mm. The goal was to produce 900 experimental units that could be measured in an inverted research metallurgical microscope. Bonferroni tests were used for multiple comparisons. The self-polymerizing Palapress® Vario resin at thicknesses of 1 and 2 mm at point 3, which corresponds to the palate midpoint, achieved the best results.

Keywords: Acrylic resins, Denture bases, Denture liners, Denture rebasing

Introduction

In so-called developed societies, drastic reductions in birth rates have led to predominantly elderly populations [1,2]. This phenomenon is attributable to several factors, among which the most important are undoubtedly improved health care access and the widespread promotion of better integration of community health programs in populations such as that noted in a study by Heft, et al. in 2003 [3].

Misalignments of complete dentures must be overcome by using a base that has a peripheral beam that is sufficiently rigid to resist distortion and ensure stability. Bases that have these defects should be corrected with relinings to achieve their primary function, which is to maintain integrity of the stomatognathic system [4-6]. Nowadays, relinings are made with acrylic resins however there are other materials that can be used. Acrylic resins suffered a huge evolution in the last few decades, once they were produced with a rubber derivated substance before 1900 [7,8]. Acrylic resins derived from ethylene belong to several groups and the resins that are used in dental medicine are those derived from acrylic acid and methacrylic acid, which polymerize when combined [9]. The acrylic resin used in the bases of removable dentures is polymethyl methacrylate [10,11]. This material is used in dentistry since 1936 because it has the primary advantage of ease of handling and preparation [12]. When mixed, the polymer and methyl methacrylate monomer form a mass, which is due to the plasticization of the polymer via monomer addition and that can be chemically activated at room temperature or by heating [9,13,14].

Polymethyl methacrylate is the most studied material in prosthodontics, and exhibits notable flexibility [15-17]. Authors, such as Jagger, et al. [18] have enhanced the properties of polymethyl methacrylate to achieve easier handling and improve its aesthetic properties. These authors reinforce the idea that the main disadvantage of acrylic resins is their poor fracture toughness.

The aim of this study was to valorize the dimensional discrepancies of thermo- and self-activated relinings; compare the alterations that can be produced with self-polymerized acrylic resin and with thermo-polymerized acrylic resin; compare the different degrees of maladjustment caused by 4 types of thickness of relining materials on dentures bases; and evaluate the changes in various points of palatine region on the several model groups.

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Materials and Methods

This study included the preparation of plaster models with four different thicknesses of denture base maladjustment (1, 2, 3 and 4-mm thick).

The first step was the creation of a plaster model (initial model) made based on a simulation of a completely edentulous cast (typodont model). The main cast (Figure 1) was prepared using type III plaster (Cristacal, Madrid, Spain) mixed using a vacuum machine (Ugivac 4 - UGIN® Dentaire, Seyssins, France). All steps were performed in the same room (Lab room ISCSN) at 20 ± 1º Celsius.

We then used industrial silicone (UGIN® Dentaire, Seyssins - France) to make 60 reproductions of the models that would be the ultimate representations of the completely edentulous cast (Figure 2).

All casts were duplicated on the same day under the same temperature conditions (20 ± 1º Celsius) and with the same powder/water ratio (100g/24ml). In total, 61 models were made from the initial model, including 60 models made to conduct the experimental study and 1 made with the goal of manufacturing 60 models with different degrees of maladjustment (1 mm, 2 mm, 3 mm, and 4 mm) for the completion of dentures based in acrylic resin.

To standardize the 15 models required for thickness, cobalt-chromium matrices were produced (Figure 3). This alloy was selected because of its melting time, which could not be changed after inclusion in the muffle during relining. Four matrices were created with different thicknesses.

The simulation matrices with 4 different thicknesses were measured with a Mitutoyo Digital micrometer (manufactured in Tokyo, Japan) at 6 different points to evaluate the thickness variations.

After the creation of simulation matrices, we proceeded to the duplication process which was the same as described above, with the difference on the aggregation of the respective simulation matrix in the simulation models. Each thickness model was replicated 15 times, originating 60 models. The 60 models with different degrees of maladjustment were responsible for the elaboration of the complete denture bases. These models were made using type III plaster (Figure 4).

In all 60 models with different thicknesses, bases were fabricated using two sheets of modeling wax (nº 9, Vertex®, Zeist, Netherlands) with a final thickness of approximately 2 mm. This laboratory step resulted in the construction of 60 acrylic resin bases that simulated the complete dentures in which the relinings would be performed. The acrylic resin used in manufacturing the acrylic bases was heated polymerize resin (Paladon 65 Heraeus Kulzer®, Hanau, Germany).

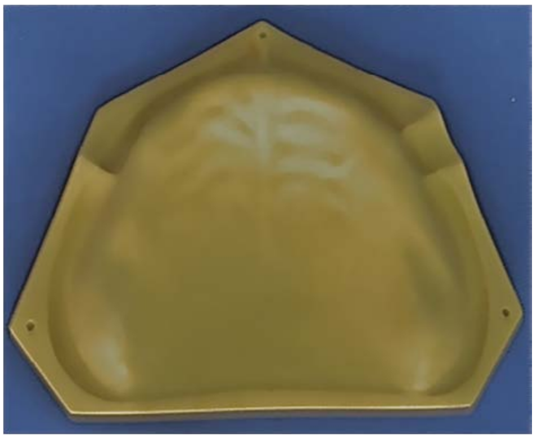

Figure 1: Typodont model of the initial cast.

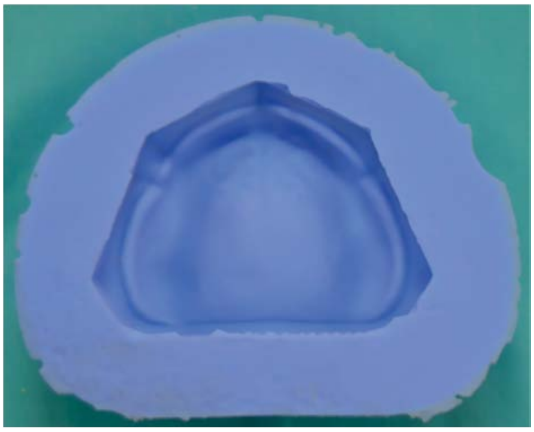

Figure 2: Duplication basis produced with industrial silicone to replicate the initial cast

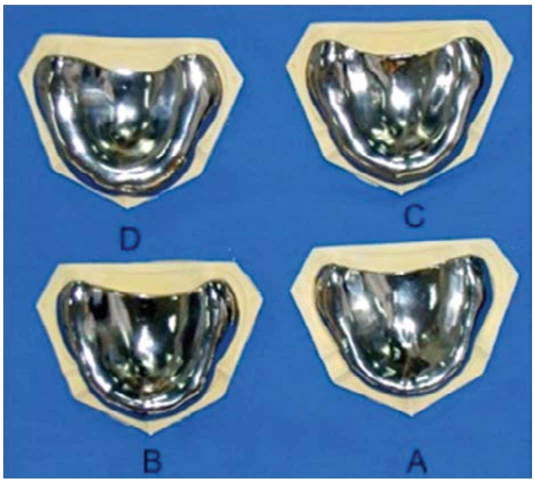

Figure 3: Cobalt-chromium matrices representing different thickness. A) Matrix with 1 mm thickness; B) Matrix with 2 mm thickness; C) Matrix with 3 mm thickness; D) Matrix with 4 mm thickness.

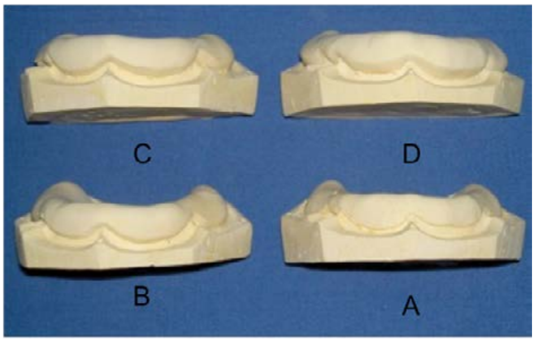

Figure 4: Duplicated models with 4 different thicknesses. A) Model with 1 mm thickness; B) Model with 2 mm thickness; C) Model with 3 mm thickness; D) Model with 4 mm thickness.

In this experimental study, several acrylic resin trademarks were used to interpret the results of the various dimensional changes that occurred in the different methods of relining.

In total, 60 relinings were performed according to prescribed methods and standards of each manufacturer. The relinings made with self-polymerized resins were performed using a dental reline jig (Figure 5-7). The following three acrylic resins were used in this study:

1 - Paladon® 65 Heraeus Kulzer®, Hanau, Germany (thermal polymerizable resin)

2 - Palapress® Vario Heraeus Kulzer®, Hanau, Germany (self-cured resin)

3 - Lucitone® Fast-PorTM Dentsply®, York, USA (self-cured resin)

Figure 5: Model fixation in the dental reline jig and placing the corresponding matrix.

Figure 6: Placement of denture base on the matrix.

Figure 7: Dental reline jig closure.

The finishing of the complete denture bases was performed by removing the acrylic excess only after relining. To prepare the measurement methods for the interface between the relinings bases and the plaster models, we performed the steps described below which were performances on Mechanical Engineering and Industrial Management department of the University of Oporto.

The cuts of the samples were initiated with the union of the plaster bases and the bases of the relinings by applying a cyanoacrylate-based adhesive (Super Cola 3, Loctite®, Henkel Iberica S.A., Barcelona) around the rim of the models and then placing the denture bases in position with a static load of 1 Kg over 1 minute.

The following steps were used to cut the models with the attached bases on a device equipped with a diamond mechanical saw with irrigation (TR 60 - Struers®, Rochester, Kent, England) (Figure 8).

In the set base-model 3, transverse cuts were made parallel to each other (Figure 9), distal to the canines (cut A), mesial to the first molar (cut B), and posterior to the palatine region (cut C).

Cross sectional cuts divided the models into 180 different pieces for analysis. Microscopic analysis of the models was performed to observe the various sectors and study the dimensional changes in the anterior, middle and posterior portions of the palate.

After the three areas were sectioned for each model, the various sections were polished to allow the observation and microscopic measurement of the pieces.

The polishing of the three parts of each relining was accomplished with two polishers, Rotopol-21 (Struers®) and Ballerup, (Denmark).

The cuts of the models/relinings were measured at 5 different points that corresponded to the bottom of the right and left atria, the right and left alveolar ridges, and the midline of the palate. This point was previously calibrated.

To clarify the locations of the measurement points used in analysis, one number was attached to each corresponding point

Figure 8: Device used to cut the models.

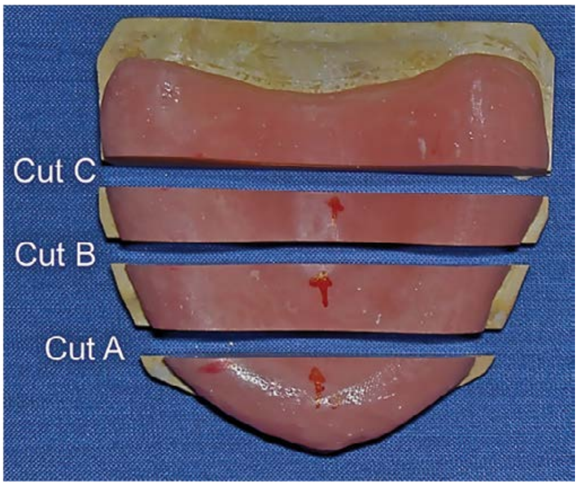

Figure 9: Transverse cuts for microscopical analysis. Cut A - cut distal to the canines; Cut B – cut mesial to the fist molar; Cut C - cut posterior to the palatine region.

(Figure 10): P1, background of the right atrium; P2, right alveolar crest; P3, midline; P4, left alveolar ridge; and P5, background of the left atrium.

The measurements were made at the interface between the acrylic resin relinings and the plaster models. This procedure was only possible because after the relining of the models they were placed in a dental reline jig ensuring that there was no expansion of the plaster models. Due to the cross sections and measurement points of the models, 900 measurements were made to compare the dimensional changes in the acrylic resins and the maladjustments. The measurements taken at the interface were confirmed with a device coupled to the microscope lens called a micrometer, which was connected to a measuring apparatus (Olympus OSM, D4, micrometer eyepiece with digital counter, Tokyo - Japan).

The methodology used for the statistical analyses of the data was analysis of variance (ANOVA) with factors due to the fixed nature of the variables involved and also the experience of prior planning experience to the ensure the randomness of the experimental units assigned to each treatment. Each treatment was replicated 5 times to minimize measurement errors.

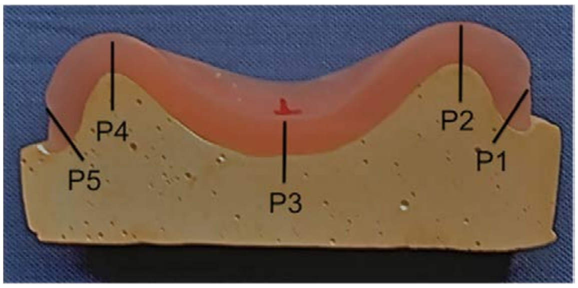

Figure 10: Measurement points of the cross sections. P1 - background of the right atrium; P2 - right alveolar crest; P3 - midline; P4 - left alveolar ridge; P5 - background of the left atrium.

Results

The analysis of the residues of the factor thickness revealed that the distributions were approximately symmetrical at each level, although some discrepancies existed, particularly at the 4-mm thickness. The average distance was also observed to increase with increasing thickness. Regarding the type of resin used, the distribution was also symmetrical for each level, and Palapress® Vario exhibited the lowest average value.

Symmetry also existed in the palate measurement points, and P3 presents the lowest average value. Symmetry also existed in all cuts of the cross sections. Cut A had the lowest average value. Because the percentages of outliers were not significant, to ensure the equality of observations in each treatment (level combination of factors), ANOVA was used for the total set of observations. Several models were used, and all the sample values corresponding to 900 observations were included. After verification of the 37 cases it was obtained the final model and the general linear model (GLM) of the Statistical Package for Social Science (SPSS) was used. ANOVA was then performed, and the results are shown in Table 1.

The results in Table 1 indicate that at the overall significance level of 5%, the hypotheses for all factors and interactions were rejected ($p<0.05$), indicating there were statistically significant differences in the variable distances due to the effects of the individual factors and the effects of the combinations of the levels of each of the factors (i.e., two-by-two, three-by-three and overall). In the final model, the coefficient of determination was r^2=0,837, meaning that the model comprised approximately 83.7% of the total variance.

Bonferroni's tests were performed for multiple comparisons and the conclusions withdrawn in the final model was that there were statistical differences (value $p<0.05$) in all resin types, between the different thicknesses and in the palate measuring points between the P3 position and all of the others points.

From the multiple comparison tests that were performed, the following relations were established:

The average values of the distance according to the thickness can be sorted as follows:

$\mu_{1\,mm}<\mu_{2\,mm}<\mu_{3\,mm}< \mu_{4\,mm}$

The mean distances according to each resin used can be ordered as follows:

Variation parameters	Squares count	Degrees of freedom	Squares Average	F	Valor p
Thickness	274895,285	3	91631,762	366,777	,000
Resin	112537,977	2	56268,988	225,229	,000
Area	117861,141	4	29465,285	117,941	,000
Cut	157052,396	2	78526,198	314,319	,000
Resin thickness *	33077,132	6	5512,855	22,066	,000
Thickness * Area	23497,578	12	1958,132	7,838	,000
Resin * Area	13814,802	8	1726,850	6,912	,000
Thickness * Resin * Area	30068,407	24	1252,850	5,015	,000
Thickness * Cut	13675,565	6	2279,261	9,123	,000
Resin * Cut	5031,968	4	1257,992	5,035	,001
Thickness * Resin * Cut	6879,284	12	573,274	2,295	,007
Area * Cut	27318,435	8	3414,804	13,669	,000
Thickness * Area * Cut	15262,430	24	635,935	2,545	,000
Resin * Area * Cut	8528,282	16	533,018	2,134	,006
Thickness* Resin * Area * Cut	20371,218	48	424,400	1,699	,003
Error	170633,867	683	249,830		
Total	5043877,000	863			

Table 1: ANOVA analysis for the Final model

$\mu_{\text{Palapress® Vario}} < \mu_{\text{Lucitone®}} < \mu_{\text{Paladon® 65}}$

The mean distances from the location of the palate measurement points can be ordered as follows:

$\mu_{P3} < \mu_{P4} < \mu_{P1} < \mu_{P5}$

The average values of the distance to the transverse cross section can be ordered as follows:

$\mu_{\text{Cut A}} < \mu_{\text{Cut B}} < \mu_{\text{Cut C}}$

Discussion

The relining of complete dentures is a very common clinical procedure. Matsumura, et al. [19] reported that self-polymerizable resin is the material of choice in indirect relinings. Machado, et al. [20] studied the contraction of materials and compared two resins, one of which was a self-polymerizing resin and the other was a thermal polymerizing resin, and showed that the thermal polymerizing resin exhibited higher instability immediately after polymerization.

There are other laboratory-based methods for the polymerization of prosthesis bases that decrease curing time, such as microwaves. According to Blagojevic, et al. (1999), the acrylic resin polymerization method using a polymerizing unit is not inferior to the method using microwaves. However, microwave-induced polymerization is disadvantageous due to the cost of equipment and maintenance. Regarding porosity, Compagnoni, et al. conducted a study in which no significant differences in porosity were observed between the traditional method of polymerization and the microwave polymerization method. The injection of polymethyl methacrylate is another polymerization method that was introduced by Pryor in an attempt to reduce the shrinkage of acrylic resin during the polymerization process.

Peyton [21] studied the adaptation of denture bases and concerts held in dentures. The models in his study were divided into two parts, and the measurements were taken with a panoramic comparator in 9 distinct points of the transverse sections. In addition, the study by Consani, et al. [22] was performed with maxillary models by virtue of being the most subject to dimensional differences.

It has been reported that acrylic resin shrinkage occurs primarily in the palate because of the gap between the palate portion and the template during polymerization. Notably, in our study, self-polymerizable resins exhibited better dimensional behavior than thermal polymerizing resins, and Palapress® Vario exhibited the best adaptation at all thicknesses studied. These results are similar to those of other studies that have compared the two types of resin in relinings [23]. Our results are similar to those of Machado, et al. [4] in which self-polymerizable and thermal polymerizing resins were studied.

As referred by Jorge e cols [24] the self-polymerized resins are more cytotoxic and porous than thermos-polymerized resins. The most evident signals of cytotoxicity verified on self-polymerized resins are erythema, mucosal erosion and the burning sensation in the mucosa and tongue. However, the cytotoxicity of acrylic resins is more active on the first 24 hours and disappears in the following hours [25]. In our study we use indirect self-polymerized resins to minimize the cytotoxicity of the acrylic resin [26].

In our study we stabilized our models in a denture reline jig during the laboratorial procedures as referred by Bolouri e cols, [27] which ensures a better compaction during the polymerization process. This process allows minimalize the distortion risk in both thermo- and self-polymerized resin [28].

In analyzing the results, we found virtually no difference in the dimensional changes between the thicknesses of 1-4 mm. However, when comparing the thicknesses of 1-2 mm with the thicknesses of 3-4 mm, statistically significant differences were noted. Greater degrees of maladjustment were associated with worse relining efficacy. Polukoshko, et al. [28] reported that larger increments in acrylic resin are associated with greater changes after polymerization due to shrinkage.

In assessing the results, we verified that the distance at the interface of the denture base/plaster model increased from the inside to the outside and that point P3 (the center palate point) presented a lower statistical degree of maladjustment. The anterior zone of the palate was the sector with the greatest maladjustment. The outer areas of the indirect relinings of the complete dentures exhibited greater mismatches. Cut C corresponded to the most posterior portion of the palate and exhibited the greatest distance in microns.

Consani, et al. [22] obtained similar results in their study of the dimensional changes in denture bases. These authors concluded that the most posterior area of the palate showed the greatest dimensional instability.

Our main concern when conducting this experimental study was identifying which of the resins exhibited the smallest degree of maladjustment. This concern was possible to evaluate because of the use of an inverted microscope. Regarding the microscopic analysis, it was necessary to make parts that allowed for observation and measurements at the interface between the acrylic resin and the plaster model using an inverted microscope. Consani, et al. [22] and Pow, et al. [29] used a linear comparison microscope to perform measurements of the dimensional changes that occurred in the acrylic resins. Although it was a complex process, this process allowed for the evaluation of acrylic resin behavior in several palatal areas.

Conclusion

In our study we concluded that the relinings made with the self-polymerized resin are better than thermo-polymerized resin, and the Palapress® Vario resin exhibited better adaptation than Lucitone®.

Regarding the maladjustment, the smaller the thickness better are the clinical results. When the dentures maladjustments occur at the middle and anterior part imply a relining with better clinical adaptation than the maladjustments in the peripheral or posterior area.

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