ORIGINAL ARTICLE

Dimensional accuracy with epoxy resin models

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https://doi.org/10.14436/2447-911x.17.1.102-111.oar

Submitted: January 21, 2020

Revised and accepted: February 01, 2020

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How to cite: Serraglio BL, Grassia-Júnior CF, Vitti RP, Miranda ME, Brandt WC. Dimensional accuracy with epoxy resin models. J Clin Dent Res. 2020 Jan-Apr;17(1):102-11.

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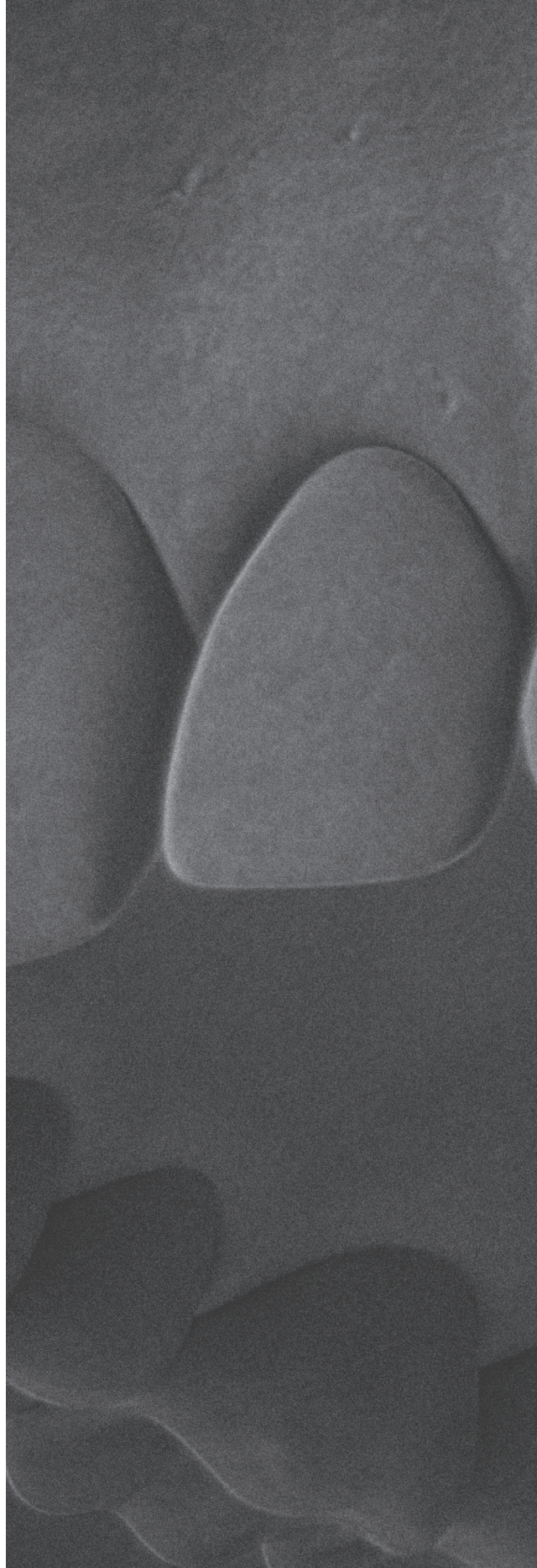

ABSTRACT: Objective: The aim of this study was to evaluate and compare the dimensional accuracy of models made with type IV dental stone and epoxy resin with different base/catalyst pastes ratios. **Methods:** A metallic maxillary model with 14 and 16 teeth prepared for full crown without 15 tooth was used for the impression. The impressions were performed with addition silicone (Express XT). The models (n = 10) were made with type IV dental stone (Durone, Dentsply), epoxy resin (Sikadur 32, Sika) with 2:1 ratio (base/catalyst pastes) and modified epoxy resin with a 2:0.8 ratio (base/catalyst pastes). The dimensional change were measured with a digital caliper on the occlusal (M-D), cervical (V-P) and occlusal-cervical (O-C) surfaces. Three measurements were made on each surface. The data were analyzed by analysis of variance (one-way ANOVA) and Tukey's test (α = 0.05). **Results:** On V-P surface (16), the modified epoxy resin showed differences with dental stone. On M-D (14 and 16), the dental stone showed no difference with metallic model, however the epoxy resin and the modified epoxy resin showed differences with metallic model well as dental stone. On O-C surface (14) there was a difference in dimensional accuracy between epoxy resins and dental stone. On O-C surface (16), the dental stone showed no difference compared to the metallic model. Dental stone showed 0.27% of horizontal expansion and 2.85% of vertical expansion. The epoxy resin showed -1.15% (horizontal) and from -1.00% to -2.94% (vertical) shrinkage mean. **Conclusions:** Type IV dental stone special showed no dimensional change with metallic model. Epoxy resin, regardless of the proportion used, showed the highest values of dimensional change (shrinkage). **Keywords:** Dimensional Chanfe. Dental Stone. Epoxy Resin.

INTRODUCTION

There are many steps necessary to develop a prosthetic rehabilitation with direct and indirect steps, which can constitute a potential source of errors. Several clinical and laboratory materials and protocols have been developed in order to minimize these possible errors.[4] Among the steps involved in indirect restorations, two steps play a fundamental role: impression and models.

Addition silicones are elastomers available to obtain molds when indirect restorations are necessary. These materials have good dimensional stability, easy handling and high accuracy in copying buccal details.[9] Dental stone is the most material used to obtain models and dies, but it has negative properties, such as low resistance to impact and abrasion, dimensional instability, and low tensile and compression strength.[12]

Epoxy resins could be an alternative to manufacturer dies/models. These materials have some advantages over dental stone because they are compatible with most impression materials and they have greater resistance to abrasion and compression than dental stone, in addition to high resilience.[6]

In the balance between expansion and shrinkage of the different materials to obtain dental models, the fidelity and maintenance of the reproduction of details are the main concerns. Therefore, identifying, quantifying and controlling the dimensional changes of the materials used is essential to enable more accurate processes to manufacturer of dental prostheses.[14]

In order to reduce the epoxy resin shrinkage that occurs during the polymerization process, and to make it a material that can compete with dental stone, its chemical formulation must be changed, which will allow a longer working time and less shrinkage during the polymerization process.[7,17] Due to the need to obtain accurate, durable and strength models, it is considered opportune to carry out a study in which it is proposed to evaluate the dimensional change of two types of materials when used to make models in a fixed prosthesis.

Thus, the aim in this study was to evaluate the dimensional accuracy of models obtained with type IV dental stone and epoxy resin with different base/catalyst pastes ratios. The null hypoth-

esis is that the two formulations of epoxy resin would similarly with type IV dental stone.

MATERIALS AND METHODS

To obtain the standard metallic model, an one-step putty/light-bod impression technique was performed with addition silicone (Express XT, 3M ESPE) on complete maxillary arch with perforated stainless steel tray. The mold was filled with type IV dental stone (Durone, Denstply) in the ratio of 100 g of powder to 19 ml of distilled water. After the mold-model separation, the dental stone model remained at room temperature and humidity to four days.

The teeth abutment preparation was carried out according to basic principles for fixed prosthesis: both on the lateral and occlusal surfaces of the 14 and 16 teeth, minimal/sufficient wear was performed to create a space for a metallic structure and later application of the ceramic in order to build a three-element fixed metal-ceramic prosthesis.

The impression with addition silicone was also performed on metallic model with teeth abutment. The mold was filled with wax and the lost-wax casting technique was used to create a standard model with a preparation for fixed prosthesis on the abutment teeth 14 and 16 (Fig 1).

A metal tray (nº 3) was used to make the impression with addition silicone (Express XT, 3M ESPE). The handling procedure was performed following the manufacturer's instructions. The tray was filled

Figure 1: Standard metallic model.

with impression material completely homogenized. The mold was stored for 30 minutes for elastic recovery (Fig 2).

After visual examination, the molds were filled with type IV dental stome (Durone, Dentsply). The mold-model set was stored during dental stone crystallization time at room temperature. Then, the mold-model separation was performed (Fig 3).

The experimental groups were composed of epoxy resin models. The epoxy resin (Sikadur 32, Sika) was handled according to the manufacturer's instructions (2:1 ratio). In the other group (experimental) the resin handled in 2:0.8 ratio. The pastes were homogenized for one minute using a metal spatula. The mold was filled with epoxy resin and after reins polymerization, the model-model separation was performed (Fig 4).

The distances on the occlusal (M-D), cervical (V-P) and occlusal-cervical (O-C) surfaces of the 14 and 16 teeth were measured using a digital caliper (Messen).

Then, the data were submitted to normality test (Kolmogorov-Smirnov test) and analysis of variance (ANOVA-one way) with Tukey test ($\alpha = 0.05$).

Figure 2: Addition silicone mold.

Figure 3: Dental stone model.

Figure 4: Epoxy resin model.

RESULTS

The mean values of the measurements of the different surfaces of the 14 and 16 teeth, with the percentage of dimensional changes, of the different materials (metallic, dental stone, epoxy resin and modified epoxy resin models) are described in Tables 1 and 2.

The results showed no significant difference in dimensional changes between the materials on V-P surface of the 14 tooth (Table 1), but on the same surface of the 16 tooth, the modified epoxy resin showed a statistically different result to dental stone and metallic model (Table 2). On M-D occlusal surface on both teeth (14 and 16), the dental stone showed no significant differences with the metallic model. However, epoxy resin and modified epoxy resin showed differences with metallic and dental stone models (Tables 1 and 2). On the other hand, the O-C surface of the 14 tooth showed a difference in values between epoxy resins and dental stone (Table 1), whereas the 16 tooth showed no differences between dental stone and metallic models (Table 2).

The dental stone models presented shrinkage on two surfaces: O-C of the 16 tooth (-0.35%) and M-D of the 14 tooth (-0.21%). All other surfaces suffered expansion. On the other hand, both epoxy resins groups showed shrinkage in all surfaces (Tables 3 and 4).

DISCUSSION

According to the results, the hypothesis was rejected. All models produced for this study were inaccurate as well as all materials showed differences with metallic model. This result demonstrates the difficulty in copying precisely the buccal structures and obtain highly accuracy models (without dimensional changes). In addition to the expansion resulting of the dental stone crystallization and the shrinkage from the polymerization reaction of the epoxy resin, the impression procedure also generates dimensional changes, especially when tilting movements are performed by operator.[9,12,14]

Overall, for the 14 tooth all materials showed dimensional changes. On V-P surface, the materials showed no statistically significant differences in dimensional changes between them. It is necessary to emphasize that the expansion of the dental stone is in according to the expansion set by the manufacturer (0.12%). On M-D occlusal surface, the tested materials also showed dimensional changes. On O-C surface, the results presented dimensional changes that did not differ statistically between the materials and with the metallic model (Table 1).

The molar (16) showed significant differences in dimensional changes between the materials and the metallic model. The epoxy resins evaluated showed shrinkage in all surfaces measured, while the dental stone presented shrinkage only on O-C surface (-0.35%). On V-P surface, the dental stone had similar results with metallic model and epoxy resin. On M-D occlusal surface, the epoxy resin models showed similar results, differing from the dental stone and metallic models. On the O-C surface, all materials analyzed showed contraction, and the resins showed similar behavior between them (Table 2).

The epoxy resin models were smaller than metallic model, since there was dimensional change in all surfaces analyzed. This was probably due

Table 1: Means (mm), standard deviation (±SD) e percentage (%) of the dimensions of the 14 tooth.

Groups	V-P	%	M-D	%	O-C	%
Metallic Model	7,79 (0,06)[a]	-	4,76 (0,05)[a]	-	5,97 (0,01)[ab]	-
Dental Stone	7,80 (0,03)[a]	0,13[a]	4,75 (0,01)[a]	-0,21[a]	6,14 (0,14)[a]	2,85[a]
Resin 2:1	7,74 (0,08)[a]	-0,64[a]	4,67 (0,02)[b]	-1,89[b]	5,91 (0,16)[b]	-1,00[b]
Resin 2:0.8	7,73 (0,09)[a]	-0,77[a]	4,66 (0,05)[b]	-2,10[b]	5,83 (0,07)[b]	-2,35[b]

Different letters indicate statistical difference for columns ($\rho<0.05$).

Table 2: Means (mm), standard deviation (±SD) e percentage (%) of the dimensions of the 14 tooth.

Groups	V-P	%	M-D	%	O-C	%
Metallic Model	9,70 (0,03) [a]	-	7,90 (0,01) [a]	-	5,79 (0,01) [a]	-
Dental Stone	9,74 (0,02) [a]	0,41 [a]	7,93 (0,04) [a]	0,38 [a]	5,77 (0,04) [a]	-0,35 [a]
Resin 2:1	9,66 (0,06) [ab]	-0,41 [ab]	7,80 (0,06) [b]	-1,27 [b]	5,62 (0,13) [b]	-2,94 [b]
Resin 2:0.8	9,60 (0,09) [b]	-1,03 [b]	7,81 (0,05) [b]	-1,14 [b]	5,58 (0,11) [b]	-3,63 [b]

Different letters indicate statistical difference for columns ($\rho<0.05$).

to shrinkage that occurs during the polymerization process of the resin. The type IV dental stone showed models larger than metallic model, indicating the expansion suffered by dental stone during the setting (crystallization) process.[7,17] Another possibility for dental stone models oversized in relation to the metallic model is the possible stretch that occurs (vertical direction) with the impression material when the mold is removed from the buccal structures and the metallic model. Besided the effects of temperature and materials used, the thickness of the impression material influences the mold and can produce excessive dimensional change in the impression.[1,11,16] It is possible that in the vertical direction there is a greater contact surface between the impression material and tooth depending on the perimeter area, causing a dimensional change in the mold.[8]

The shrinkage of epoxy resins occurs due to the polymerization process, where there is an initial exothermic process.[3,6,15] Meanwhile, the dental stone models showed less expansion in the cervical than occlusal surface. This phenomenon can be explained by the water that rises to the surface when water-powder mixture is trembled in the model's vibration. Consequently, there is a tendency for a greater amount of dental stone powder on the model's surface, and thus produces a greater degree of setting expansion.[15]

Models manufacturer with epoxy resin present a technique more sensitive and longer than dental stone. Its shrinkage during the polymerization process provides undersized models.[2,3] Handling requires the use of powerful centrifuges and vibrators, which are not present in most of the dental offices. Therefore, manufacturers must attempts to minimize shrinkage, during polymerization, modifying the chemical formulation or using new techniques.[2]

The dimensional changes presented by the mold's materials will reflect a discrepancy in the adaptation of the prostheses. If a type IV dental stone, which shows an expansion of 0.35%, was used to manufacture a 10 mm crown, the final restoration would have a calculated discrepancy of 35 μm. If an indirect technique were optimized to produce restorarions well adapted using the type IV dental stone, the epoxy resin molde, which is smaller than dental stone, would provide a clinically unacceptable restorarion, which would not fit on the abutment teeth.[10]

The results of this study showed that modified epoxy resin did not show less shrinkage, corroborating with other studies.[13] Thus, it is important to emphasize that changing the base/catalyst ratio will not obtain an epoxy resin with properties similar to dental stone. Thus, we must change the chemical structure of epoxy resins as well as the polymerization conditions, enabling their large-scale use in Dentistry.

Future studies should be carried out comparing the industrial epoxy resin with the dental epoxy resin, to verify if they present the same dimensional performance, determining whether the industrial epoxy resin can be a viable alternative for dental application.

CONCLUSION

The type IV dental stone did not show significant dimensional changes with metallic model. The epoxy resin, regardless of the proportion, showed significant dimensional change compared to the metallic model.

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