Prosthodontics

Influence of the casting material on the dimensional accuracy of dental dies

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Abstract: The purpose of this study was to evaluate the dimensional accuracy of different materials used in the confection of dies. Two stainless steel standard models were confected. One of the models, which was 2 mm larger than the other model, was used to provide a uniform relief for the two-step putty-wash impression technique. Thirty impressions were obtained using a polyvinyl siloxane impression material and randomly divided into three groups (n = 10) according to the type of casting material: type IV dental stone, commercially available epoxy resin (Tri-Epoxy), and industrial epoxy resin (Sikadur). After the setting/polymerization of the casting material, the dimensional stability was measured in terms of the height, diameter of the base and diameter of the top from the obtained dies and from the standard metal model using a profile projector. Results were analyzed by ANOVA and Dunnet test ($\alpha = 0.05$). In the height values, no significant difference was observed between the groups, except for Sikadur casts, which showed lower mean values. The Tri-Epoxi group showed statistically lower mean base diameter values, compared with the other groups, and both epoxy resin groups showed statistically lower mean top diameter values, compared with that for the type IV dental stone group. We concluded that type IV gypsum and the commercially available epoxy resin showed similar behavior in most areas. The industrial epoxy resin did not show the same characteristics, although the diameter of the base obtained with it was similar to that obtained with type IV dental stone.

Descriptors: Dental Impression Materials; Epoxy Resins; Calcium Sulfate.

Introduction

Each step of a prosthetic rehabilitation must be meticulously executed to yield a satisfactory final result. Therefore, to obtain accurate and precise models with no distortion, it is important to acquire accurate impressions[1,2] and to use stable and precise die materials.

After the impression is ready, a material is selected for use in the die process. The types of material available have improved significantly in the past several decades, making it possible to obtain models very similar to the prepared tooth, which is necessary to obtain a satisfactory rehabilitation.[3] An ideal die material should have several important characteristics, such as accuracy, detail reproduction capability, adequate hardening time, minimum expansion, abrasion and compression resistances, easy

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and efficient manipulation, low toxicity, compatibility with the molding material, and low cost;[2,4] the detail reproduction ability is an important characteristic of both impression and die materials.[5,6]

There are several die materials that are commercially available, such as type IV and V gypsums, synthetic gypsum, epoxy resin, and metallic resin materials. The most commonly used gypsum material is type IV dental stone because of its low expansion, high resistance to compression, satisfactory hardness and excellent ability to reproduce details, although some concerns have been observed during handling.[7] One of these concerns is that gypsum is a water-based material. The water-powder ratio is an important factor because its alteration can increase the porosity and decrease the strength of the stone.[8,9] As an alternative to gypsum, resin-impregnated gypsum, epoxy resin, and polyurethane resin have been shown to present superior abrasion resistance[7] and detail reproduction, compared with improved dental stones[4,5,10]. However, studies evaluating their dimensional accuracy have shown conflicting results.[11,12]

Resin die materials have abrasion and rupture resistances and satisfactory detail reproduction that are higher than those of gypsum. Despite these advantages, the volumetric shrinkage of resin die materials during polymerization has limited their widespread acceptance.[13] In this sense, type IV resin-impregnated die materials have been shown to be more dimensionally stable than conventional type V dental stone,[13] whereas another study found no significant differences between conventional gypsum and type IV resin-impregnated stone.[4] Epoxy resin die materials exhibit volumetric shrinkage in the range of 0.1–0.4%,[11] and a previous study related this type of material to improved dimensional accuracy over type IV and V resin-impregnated gypsum materials.[13] However, in spite of higher detail reproduction observed for the epoxy and polyurethane die materials, this advantage itself does not compensate for the drawbacks of these materials.[14]

Therefore, the purpose of the present study was to compare the dimensional accuracy of models prepared with three different die materials used in dental practice. The null hypothesis tested was that epoxy resins would behave similar to the type IV dental stone.

Methodology

The materials used in this study are described in Table 1.

For the present study, two metal models were used as master dies. One model was 2 mm higher than the other to make a relief in the first step of a putty-wash technique using a polyvinyl siloxane impression material (Aquasil, Dentsply, Petrópolis, Brazil). The other metal model simulated a total crown of a premolar with a buccopalatal diameter of 6.50 mm and mesiodistal diameter of 3.12 mm. Later, individual trays were confected using PVC pipes with the same height to standardize the volume of impression and die materials used.

High-viscosity polyvinyl siloxane impression material (Aquasil, Dentsply, Petrópolis, Brazil) was used in the first step of the impression to make a relief in the trays. After that, the ultra-light base was inserted with a syringe in the tray for the final impression of the premolar metal master model. All impressions were allowed to polymerize at 37 °C in 100% humidity for one hour. A total of thirty impressions were obtained.

After that, the impressions were randomly divided into three groups (n = 10) according to the die material used, as follows:

- Dental stone group - type IV dental stone (Vel-Mix, Kerr, Orange, USA),
- Try-Epoxy group - commercial epoxy resin (Tri-

Table 1 - Product, classification and manufacturer of the materials used in the present study.

Product	Classification	Manufacturer
Aquasil	Polyvinyl siloxane impression material	Dentsply Ind. Com., Petrópolis, Brazil
Vel-Mix	Dental Stone Type IV	Kerr, Orange, USA
Tri-Epoxy	Dental Epoxy Resin	Tri-Dynamics Dental Co., Cherry Hill, USA
Sikadur 31	Industrial Epoxy Resin	Sika, Osasco, Brazil

Epoxy Die Material, Tri-Dynamics Dental Co., Cherry Hill, USA), and
- Sikadur group - industrial epoxy resin (Sikadur 31, Sika, Osasco, Brasil).

The type IV dental stone was mixed with the manufacturer's recommended water:powder ratio (23 ml/100 g) under a vacuum of 710 mm Hg for a 60-second spatulation period. The stone was vibrated into the impression and allowed to set for one hour at ambient room temperature and humidity before removal from the impression. For both epoxy resin groups, the casts were made individually and in accordance with the manufacturers' recommendations. The material was allowed to cure for four hours. After seven days, the height, base diameter, and upper diameter of the obtained dies were measured using a Deltronic DV-114 Profile Projector (Deltronic, São Paulo, Brasil), and software readings were performed. Statistical analysis was performed using ANOVA and pos-hoc Dunnet tests (α= 0.05).

Results

The mean values of height, base diameter and top diameter of each evaluated die material are shown in Table 2.

Height values ranged from 6.547 mm (Sikadur) to 6.636 mm (Dental stone). No significant difference was observed among the groups, except for the Sikadur die material, which had a statistically lower mean value.

In the base diameter, values ranged from 6.435 mm (Tri-Epoxi) to 6.468 mm (Sikadur). The Tri-Epoxi group showed a statistically lower mean value, compared with that for the other groups.

In the top diameter, both epoxy resin groups showed statistically lower mean values than the master model, and the Dental stone group had a statistically higher mean value, compared with that of the master model.

Discussion

Making an impression and pouring are critical steps in the process of producing successful crowns and bridges in oral rehabilitation[8], and the dimensional stability of impressions, models and dies are important factors in these processes.

Thus, the present study aimed to compare the dimensional accuracy of different die materials, some of which are commonly used in the dental practice, whereas others are possible new alternatives. To avoid any influence of the impression technique, a polyvinyl siloxane was selected because it is compatible with all die materials tested.

Previous studies have reported the compatibility of the polyvinyl siloxane with the type IV gypsum.[5-6] In another study,[15] the compatibility between epoxy resins and polyvinyl siloxane was excellent.

In addition to the effects of temperature and the materials used, the thickness of the impression material influences the mold and can produce excessive distortion of the impression.[16,17] The use of individual trays (standardized PVC pipes) is advantageous, because the thickness of the material, in this case polyvinyl siloxane, is less, and the material therefore produces only minor dimensional changes in the impression. Two metal devices were used as standard models to obtain the dies. As explained previously, one of the metal models was 2 mm higher than the other to produce the relief space for the impression; this is the most faithful and efficient technique to manufacture standard dies.[18,19] Clinically, this situation can be achieved with temporary restorations before the impression.[18,19]

The type of die material, its ease of use and the time required for confection are factors to consider

Table 2 - Mean values (mm), standard deviations (mm) and porcentual alteration (%) of height, base diameter and top diameter of each evaluated material.

Material	Height	%	Base Diameter	%	Top Diameter	%
Metal Die (control)	6.631 (0.01) a		6.466 (0.01) a		5.204 (0.01) b	
Dental Stone IV	6.636 (0.01) a	0.075	6.466 (0.02) a	0	5.227 (0.02) a	0.441
Tri-Epoxi	6.631 (0.02) a	0	6.435 (0.02) b	–0.479	5.179 (0.02) c	–0.480
Sikadur	6.547 (0.10) b	–1.266	6.468 (0.02) a	0.030	5.159 (0.07) c	–0.864

Distinct letters in the column indicate significant difference, Dunnet test ($p < 0.05$).

when selecting the die material to use. In this regard, dental stone can be easily vibrated into the impression, and it is claimed that a die obtained with it can be ready for use within one hour. However, one study found that dental stone continues to expand for 96 hours after mixing.[20] No current die materials offer a genuinely short setting period, which would facilitate a faster transfer of copings, confection of diagnostic waxups, or other in-house or chair-side laboratory procedures. In this study, the measurements were performed after seven days, based on the assumption that this period is an average time of onset labor by prosthetic laboratories.

Based on the results of the present study, both epoxy resins showed generally lower mean values in the evaluated parameters, compared with those for the master metal model (Table 2). Sikadur was associated with lower mean height and top diameter values, whereas Tri-Epoxy presented lower mean base and top diameter values. This can be explained by the fact that, during polymerization, this type of material presents shrinkage. This material, before polymerization, is composed of reactive monomers that are linked by Van der Waals forces. The mean distance between monomers at this moment is 4 Å, which produces a minimal potential energy. However, after polymerization, monomers are linked by covalent bond, and the mean distance between monomers is reduced by 20%, which results in a significant volumetric shrinkage.[7,13] Thus, dies obtained from epoxy resins generally presented lower mean values, compared with those for the master model.

Conversely, dies confected using type IV stone (Dental stone group) had the tendency to expand, as also observed in previous studies.[11,21] The process of gypsum crystallization is an expansive growth of crystals from a core of crystallization.[7] Based on the interlacing of dihydrate crystals, the growth of the core crystals can combine and block the growth of adjacent crystals. If this process is repeated by thousands of crystals during their growth, an external tension will be developed that leads to expansion of the mass, and the product of the gypsum reaction is larger than its external volume but smaller in crystalline volume.[7] Based on these characteristics of gypsum, restoration adjustments are more easily performed when there is a slight expansion to the die.[11] In contrast to this study, gypsum dies were elsewhere reported to be smaller than the standard specimen.[22-24]

Sikadur 31 industrial epoxy was used in this study to determine whether it is possible to add another material for the routine everyday dental industry. Sikadur 31 is relatively cheap, compared with the epoxy resins traditionally used in dental practices, is not marketed as a dental industry material, and can be found at construction material stores.

Conclusions

Based on the results obtained and the methodology applied, the Sikadur group showed satisfactory values because even if there was a significant difference in relation to the dental stone group in height and top diameter regions, this difference was very small and, in many cases, may be clinically acceptable. However, further studies should be conducted with this material.

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