Assessment of a Synthetic Type IV Cast and a Resin Polyol Used in the Fabrication of Dental Models

Stéphanye T Carvalhal, Mário GN Gomes, Adriana S Malheiros, Leticia M Gonçalves, Matheus C Bandeca, Etevaldo M Filho, Rudys Rodolfo De Jesus Tavarez

ABSTRACT

Objective: To evaluate the dimensional changes, reproduction of details, and surface roughness of a type IV cast and a resin used to fabricate dental models.

Materials and methods: Two commercial brands of materials were evaluated: a type IV synthetic cast (Fuji Rock) and a polyol resin (Novox). Twenty samples were obtained from polyvinyl siloxane molds that reproduced the surface of a metal master model standardized according to the American National Standards Institute/American Dental Association specification no. 19. The materials were used according to the manufacturer’s instructions and divided into two groups (n = 10). Each mold was photographed immediately after molding and 1 hour after molding. The obtained models were also photographed and measurements were obtained by using Image J software. The paired t-test was used to compare the molding materials and one-way analysis of variance (ANOVA) was used to compare the dimensional changes between the groups at a significance level of 5%.

Results: Statistically significant differences were observed between the models fabricated with the polyol resin and type IV synthetic cast with regard to reproduction of surface details, surface roughness, and dimensional stability (p < 0.05), with the resin providing superior surface detail reproduction and greater dimensional accuracy.

Conclusion: The polyol resin exhibited superior behavior regarding detail reproduction, surface roughness, and dimensional change compared with the type IV synthetic cast.

Keywords: Calcium sulfate, Cast, Physical properties.

INTRODUCTION

The successful fabrication of dental prostheses depends on models that accurately replicate oral tissues, and these models are mostly obtained from gypsum products. Proper manufacturing of these models is very important for correct fitting of the prosthetic as problems with these models can lead to flaws and distortions in the final work. This can result in an ill-fitting prosthesis that causes discomfort to the patient, who will subsequently not use them. The models should be dimensionally accurate. The quality of the impression material, the die material, and the compatibility between these materials affect the precision. Various commercial brands of dental cast are available, and these brands differ in origin and behavior; the correct choice of this material is the responsibility of the dental surgeon or dental prosthesis technician. Although dental casts exhibit moderate precision, good reproducibility, and ease of manipulation, their low dimensional stability is a shortcoming.

Casts have different origins. The mineral cast is obtained by heating gypsum, and this cast is partially composed of calcium sulfate dihydrate (CaSO₄·2H₂O), which is converted into calcium sulfate hemihydrate (CaSO₄·1/2H₂O). Changing the calcination technique allows the attainment of casts of varying quality with different applications, such as type I, II, III, and IV casts, with the latter being more resistant and harder. Moreover, it is possible to obtain synthetic casts by introducing phosphoric acid by-products during the fabrication process; these by-products have properties similar to those of...
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mineral casts, differing only in the size and form of the crystals.1

The addition of the gypsum compounds such as resin polymers to the cast in order to improve its properties has raised questions that have prompted research and development of new products. The need to find materials that resemble dental structures more precisely and the use of epoxy resins in dentistry have been described for decades.8 A new generation of products has been developed with characteristics that are superior to those of casts, such as surface smoothness, abrasive resistance, and detail reproduction.9-11

Resin casts,1 epoxy resins,9-11 and polyol resins12 have been used as alternatives to conventional casts because they have superior characteristics.1,9-12 Models obtained from epoxy resin exhibit abrasive resistance and good detail reproduction; however, they undergo volumetric shrinkage due to polymerization.13 A resin material made from epoxy and polyol resins has recently been introduced in the market with the commercial name of Novox.12 According to the manufacturer, the main characteristics of this alternative molding material are the absence of dimensional change, better detail reproduction, and a smoother and brighter surface.

Therefore, the aim of this study was to assess the dimensional accuracy, detail reproduction capacity, and surface roughness of a type IV cast and a polyol resin indicated for the fabrication of dental models. The null hypothesis tested in this study is that no difference exists between the models obtained from the two materials.

MATERIALS AND METHODS

The properties of 20 samples from two dental molding materials were assessed. The samples were divided into two experimental groups: Group 1 (n = 10), a type IV synthetic cast (Fuji-Rock GC; America Inc., USA), and group 2 (n = 10), a polyol-based resin (Novox-Talladium, Spain). All materials were used according to the manufacturer’s recommendations regarding ratios, setting time, polymerization, and working time.

A stainless steel device was used to fabricate 20 trays in 2-mm round acetate plates (Bioart) (fabricated according to specification no. 19 of the American Dental Association).14 They were divided into groups 1 and 2 (n = 10 each) and were used to obtain the models (Fig. 1).

Three parallel and equidistant lines of different depths were present on the upper surface of the device (X = 37 µm, X′ = 25 µm, and X″ = 10 µm); the lines were intercepted perpendicularly at their extremities by two other lines (Y and Y′) of 25 µm depth (Fig. 2). The distance between lines X and X′ was used to determine the dimensional change of the material. The number of visible lines in the models was used as a visual score to determine detail reproduction (Table 1) based on the scores proposed in the literature.15 The images were assessed according to the number of lines reproduced in the molds under artificial and visible light.

A roughness meter SJ-201P (Mitutoyo, Tokyio, Japon) was used to evaluate the surface roughness of each material. We obtained three measurements in different areas of each specimen. Surface roughness was determined by using the mean of the three measurements (µm).

Table 1: Visual scores according to the number of lines reproduced

<table>
<thead>
<tr>
<th>Visual score</th>
<th>Number of lines</th>
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<tbody>
<tr>
<td>0</td>
<td>None of the 3 lines were visible</td>
</tr>
<tr>
<td>1</td>
<td>Only line X was visible</td>
</tr>
<tr>
<td>2</td>
<td>Line X was visible and line X′ up to two intersections</td>
</tr>
<tr>
<td>3</td>
<td>Line X and line X′ were completely visible</td>
</tr>
<tr>
<td>4</td>
<td>All lines X, X′, and X″ were visible</td>
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To fabricate the samples, the device was molded using polyvinyl siloxane impression material (Elite HD+ Regular Consistency; Zhermack, Italy). A universal adhesive for silicone (Zhermack, Italy) was used to adhere the material to the trays. These trays were filled, placed in position, and subjected to a constant load of 1 kgf. Before molding, the metal device was placed in water at a controlled temperature of 37 ± 2°C to simulate the temperature of the oral cavity. The molds were stored for 1 hour in a dry place for elastic recovery and subsequent pouring. All molds were photographed immediately after molding and 1 hour after molding with a Nikon D90 camera, Macro Medical 120-mm lens.

The specimens in group A were prepared with a type IV synthetic cast at a ratio of 25 gm of powder to 5 ml of distilled water. The powder was manually incorporated into the water for 10 seconds, with subsequent mixing under vacuum for 1 minute. The material was poured onto the mold at low vibration and was kept in a dry place for a setting time of 1 hour. The models thus obtained were photographed immediately and were scored visually for detail reproduction based on the number of lines reproduced.

The specimens in group 2 were prepared with a polyol resin at a ratio of 2.5 ml of activator to 10 ml of base, with mixing for 20 seconds to obtain a homogeneous product. Care was taken to eliminate water from the surface of the molds because the product is highly hydrophobic. The models were stored in a dry place for polymerization for 1 hour. Subsequently, they were separated from the molds, visually assessed, and photographed. The images were digitally analyzed and were evaluated by using Image J image analysis and processing software.

The paired t-test was used to compare the molding materials and one-way analysis of variance (ANOVA) was used to compare the dimensional changes between the tested groups.

RESULTS

The measurement results of the molds and models are shown in Graph 1. The paired t-test revealed a statistically significant difference (p < 0.05) for both the type IV cast and polyol resin.

When the differences in measurements (dimensional change) were compared by using the one-way ANOVA test, a statistically significant difference (p < 0.05) was observed between the two groups (Table 2 and Graph 2).

With regard to detail reproduction, the results showed that the polyol resin reproduced 100% of the lines present on the surface of the device (X, X', and X''), whereas the reproduction capacity of the type IV cast was only 66.6% of the lines (X and X''). All specimens and respective images were evaluated.

Statistically significant differences were found between the surface roughness of the two materials (p < 0.05) (Graph 3).
Table 2: Difference between the dimensional change in the type IV cast and polyol resin models

<table>
<thead>
<tr>
<th>Group</th>
<th>Mold-model</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type IV cast</td>
<td>0.17 ± 0.09*</td>
<td>3.63 ± 1.86*</td>
</tr>
<tr>
<td>Polyol resin</td>
<td>0.07 ± 0.10**</td>
<td>1.56 ± 2.02**</td>
</tr>
</tbody>
</table>

Different symbols (* or **) indicate significant statistical differences, p < 0.05

DISCUSSION

The null hypothesis proposed in this study was rejected based on the statistically significant differences in dimensional stability, detail reproduction, and surface roughness of the assessed materials.

Polyvinyl siloxane was used to fabricate the molds that were the basis for the models. This material exhibits excellent detail reproduction and dimensional stability when compared with other elastomeric materials, and it is highly compatible with the materials used in previous studies. The use of individual trays allowed the thickness of the molding material in all samples to be standardized.

The type IV synthetic cast is described as a material that offers good detail reproduction, dimensional accuracy, and resistance because its crystals are more homogeneous than those of other types of casts. However, it exhibits higher linear expansion between 72 and 96 hours.

The cast crystallization process generates a growth of crystallization nuclei, causing an expansion of the mass of the material. This presumably explains why this material exhibited a greater dimensional change than the polyol resin used in the study. In addition, the results obtained from the assessment of detail reproduction showed that the type IV cast was inferior to the polyol resin (i.e., it did not reproduce line X = 10 µm). This suggests that, although the molding material used has high reproduction accuracy, the accurate replication of the surface details of the mold depends on the reproduction capacity of the modeling material, as shown in a previous study.

The analysis of the surface of the polyol resin models showed superior detail reproduction and smoothness.

Although the cast exhibits inferior detail reproduction and dimensional accuracy, it is the material of choice for the production of dental models because of its high compatibility with other materials, ease of manipulation, low cost, and commercial availability. On the other hand, the polyol resin is still difficult to obtain because it does not exhibit dimensional change because this requires an exothermic reaction between a large quantity of the product and the medium, which does not occur during the fabrication of a dental model.

CONCLUSION

According to the results and the methods used in this study, we have drawn the following conclusions:

- The type IV synthetic cast exhibited inferior dimensional accuracy compared with the polyol resin.
- The polyol resin used to obtain dental models exhibited superior reproduction capacity and surface smoothness compared with the type IV synthetic cast.

REFERENCES

11. Gujarlapudi MC, Reddy SV, Madineni PK, Ealla KK, Nuna VN, Manne SD. Comparative evaluation of few physical properties of polymers with excellent qualities. Its use is recommended to develop models with greater accuracy, detail, and increased brightness and surface smoothness. A comparison of the dimensional stability between a type IV cast and three epoxy resin-based materials did not show significant differences. In the present study, the polyol resin exhibited behaviors similar to those of epoxy resins, showing superior results compared with those obtained with the type IV cast with regard to dimensional stability, detail reproduction, and surface roughness.

According to the manufacturer, the polyol resin does not exhibit dimensional change because this requires an exothermic reaction between a large quantity of the product and the medium, which does not occur during the fabrication of a dental model.