Impression Techniques for Multiple Implants: A Photoelastic Analysis. Part II: Comparison of Four Acrylic Resins

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Four commercial brands of chemically activated acrylic resin were compared through photoelastic analysis. Photoelastic resin blocks were made with 2 implants placed parallel to each other and 2 square transfer copings splinted. Both transfers were splinted with chemically activated acrylic resin: Dencrilay, Duralay I, Duralay II, and GC. Data were analyzed by 2-way analysis of variance and Tukey test ($P < .05$). Statistically significant differences were found among the 3 brands of chemically activated acrylic resin. Dencrilay showed greater dimensional alteration. Duralay I and GC are recommended for the transfer of the position of the multi-implants.

Key Words: dental implant, impression, photoelasticity, implant-supported prosthesis

INTRODUCTION

The main goal of fabricating implant-supported restorations is the production of superstructures that exhibit accurate fit when connected to multiple abutments.\textsuperscript{1,2} The requisite for obtaining such a fit is a precise impression. The adaptation precision, between prosthetic infrastructure and implant or tooth, is one of the great challenges of the oral rehabilitators. Particularly, the lack of passivity of the prosthetic devices has received great attention from researchers.\textsuperscript{3–9} Several materials are involved in the execution of adaptation precision, among them, the chemically activated acrylic resin that is used frequently and that is susceptible to dimensional alterations.\textsuperscript{10,11} Assif et al\textsuperscript{10} investigated the accuracy of direct implant impression techniques with the use of various splinting materials and found that more accurate results were obtained by using techniques in which chemically activated acrylic resin or impression plaster was used as the splinting material.

Hsu et al\textsuperscript{12} and Herbst et al\textsuperscript{13} after evaluating the distortion of abutment position on the master cast, concluded that the volume of Duralay acrylic resin used to splint implant transfer copings is an insignificant factor in impression transfer accuracy. However, in the first part of this research report, we show that the resin volume interfered with the transfer process due to the larger amount of resin used. These results are in agreement with those of other studies.\textsuperscript{14}

Del Acqua et al\textsuperscript{15} compared the dimensional accuracy of 2 impression techniques: Duralay splinted impression copings and metal splinted impression copings for implant-supported prostheses. They used the same impression material, and it was suggested that a more accurate working cast can be fabricated using metal splinted impression copings.

Due to the controversial results, this article presents results of a photoelastic analysis compar-
ing 4 commercial brands of chemically activated acrylic resins that are frequently used during the direct transfer technique of implants: Dencrilay, Duralay I, Duralay II, and GC Pattern.

**METHODS**

A master acrylic model was fabricated to be used as matrix for the photoelastic models. The methodology is described in the first part of this report. Three rectangular photoelastic models were obtained according to the instructions of the manufacturer (Figure 1). All photoelastic blocks were evaluated with a circular polariscope to verify the lack of residual stress (type PJ300 optical comparator, Mitutoyo Mfg Co Mfg Ltd, Tokyo, Japan).

The impression technique of implants with splintage with dental floss consists of interlacing the transfers with 20 cm of dental floss to which chemically activated acrylic resin is added. Four types of acrylic resins were tested: Dencrilay (Dencril, Com e Ind de Plásticos LTDA, Caieiras, SP, Brazil), Duralays I and II (Reliance Dental Mfg Co, Worth, Ill), and GC Pattern (G.C. América Inc, Tokyo, Japan). The amount of 0.8 g of chemically activated acrylic resin was inserted for each type of resin so

**FIGURES 1–9.** Figure 1. Transfers positioned on the implants on the photoelastic model and work screws with torque of 10 N. Figures 2 and 3. Photoelastic response in areas AA’ (left) and BB’ (right) after period of 36 h with the Duralay I resin. Figures 4 and 5. Photoelastic response in areas AA’ (left) and BB’ (right) after period of 36 h with Duralay II resin. Figures 6 and 7. Photoelastic response in areas AA’ (left) and BB’ (right) after period of 36 h with GC resin. Figures 8 and 9. Photoelastic response in areas AA’ (left) and BB’ (right) after a period of 36 h with Dencrilay resin.
that union of the transfers occurred. Before adding
the resin on the dental floss, the model was
positioned in the circular polariscope to guarantee
that the dental floss had not induced tension on the
transfers. After the indexation, the samples were
observed in 4 time periods: 20 min, 3 h, 24 h, and
36 h.

During the photoelastic analysis, the Tardy
method was used. Currently, this method is
preferred over the other methods once auxiliary
instruments are not required and the analyzer of the
polariscope serves as a compensation device. Also, a
precision of approximately 0.02 fringes can be
reached\(^{16}\) (Figures 2 through 9).

Photoelasticity is mostly used in cases where
mathematical methods become quite cumbersome
to determine the stress distribution in a material.
This stress analysis is based on the property that
some transparent materials exhibit colorful patterns
when submitted to loads and viewed with polarized
light. This array of colored patterns is called
isochromatic fringes. Unlike the analytical methods
of stress determination, photoelasticity gives an
accurate picture of stress distribution even around
abrupt discontinuities in a material. Studies using
photoelastic analysis have been thoroughly con-
ducted to determine the stress distribution around
natural teeth, on abutments of removable partial
prosthesis and fixed partial prosthesis, and around
endosseous implants under complete dentures, and
to determine stresses around endosseous implants
supporting fixed prosthesis.\(^{17}\)

The relationship between the sequence of the
fringes (N) and their distances (mm) to the point of
origin was set (Table 1). The tables were imported
into MATLAB software (1994–2007, The MathWorks,
Inc, Natick, Mass) and Cartesian graphs were
created. The distance between the positions of
the fringes is represented in the x-axis and their
sequences in the y-axis.

The distortion energy (E) distributed in the area
corresponding to each of the two analyzed lines
was obtained by calculating the area below each
curve of the graphs representative of the relation
fringe order (N) and distance from the point
of origin of the load (Figure 10). The distortion energy
per unit of volume represents the unit of dimen-
sional tension, known as U (newton per square
millimeter \([\text{N/m}^2]\) or kilogram-force/square millime-
ter \([\text{kgf/mm}^2]\)).\(^{18}\) After calculating these energies,
statistical analysis was conducted using Friedman
and Wilcoxon tests \((P < .05)\).

**RESULTS**

The E values for AA’ and BB’ areas obtained for the
resins Dencrilay, Duralay I, and GC Pattern are
shown in Table 2. Figures 2 through 9 present the
photoelastic responses in 36 h. The significance
level was established at .05 in a bilateral test.

Analysis of variance and Tukey test were applied
to verify statistically significant differences among
values of the energies in AB areas for all resins used
(Dencrilay, Duralay I, Duralay II, and GC) during the
dental floss technique (Table 3 and 4).

Table 4 shows that the values obtained with
Dencrilay resin were significantly higher than the
values obtained with the Duralay I and GC resins;

<table>
<thead>
<tr>
<th>Points, cm</th>
<th>Fringe order, N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.194</td>
</tr>
<tr>
<td>0.5</td>
<td>0.161</td>
</tr>
<tr>
<td>1.0</td>
<td>0.128</td>
</tr>
<tr>
<td>1.5</td>
<td>0.106</td>
</tr>
<tr>
<td>2.0</td>
<td>0.100</td>
</tr>
<tr>
<td>2.5</td>
<td>0.072</td>
</tr>
<tr>
<td>3.0</td>
<td>0.067</td>
</tr>
<tr>
<td>3.5</td>
<td>0.028</td>
</tr>
<tr>
<td>4.0</td>
<td>0.017</td>
</tr>
</tbody>
</table>

Figure 10. Area AA’ with Dencrilay resin after 36 h (E = 0.384 kgf/mm\(^2\)).
Duralay II presented intermediate values. However, no statistically significant differences were found between Dencrilay and Duralay II resins, as well as among Duralay I, Duralay II and GC resins (Table 4).

**DISCUSSION**

The best impression technique for multiple implant prostheses has not yet been identified. The accurate transference of the implants from the dental arch to the definite cast is fundamental to ensure the absence, or at least a decrease, of misfit in the final prosthetic device. Abutment position distortion has often accompanied transfer impression techniques. The impression materials and the technique used for the transfer of the position of the implants ensure an excellent adaptation of the prosthetic components.

The impression technique that uses dental floss as a framework so that the chemically activated acrylic resin can splint the transfers is applied broadly in clinical practice. In this study, 4 acrylic resins were used in this technique: Dencrilay, Duralay I, Duralay II, and GC Pattern. A comparison, via photoelastic analysis, revealed significantly different dimensional alterations among these resins. Tension was observed in all groups tested, indicating that the dental floss technique is not appropriate for splinting during the impression of implants.

Because this method involves larger resin volumes, it is more susceptible to distortions than other direct impression techniques, such as metallic sticks. Fillho et al compared 4 splinting techniques for impression copings of implants: direct technique with square copings without union in open trays; square copings splinted with dental floss and autopolymerizing acrylic resin; square copings splinted with dental floss and autopolymerizing acrylic resin, sectioning, and splinting again with autopolymerizing acrylic resins; and square copings splinted with prefabricated acrylic resin bar. They also concluded that the square copings splinted with a prefabricated acrylic resin bar presented the best results among the pick-up impression techniques evaluated.

However, if dental floss framework is the method of choice, materials that result in less distortions are requested. Autopolymerizing acrylic resins are used a great deal in dental practice, and for splinting during impression techniques, Duralay I and GC Pattern are preferred because they showed less tension based on the findings of this study.

**CONCLUSIONS**

Under the conditions of this study, some conclusions can be drawn: Dencrilay resin showed greater dimensional alterations compared with the others acrylic resins; Duralay I and GC Pattern resins are suggested to be more appropriate for splinted impression copings of multi-implant prostheses.

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**Table 2**

<table>
<thead>
<tr>
<th>Analyzed variable</th>
<th>F</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duralay I × Duralay II × GC × Dencrilay</td>
<td>7.444</td>
<td>.001*</td>
</tr>
</tbody>
</table>

*P < .05.

**Table 3**

Analysis of variance and Tukey test results: F values and probabilities for the values of AB obtained for the acrylic resins

<table>
<thead>
<tr>
<th>Resin</th>
<th>N*</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duralay I</td>
<td>8</td>
<td>.0201</td>
<td></td>
</tr>
<tr>
<td>GC</td>
<td>8</td>
<td>.0221</td>
<td></td>
</tr>
<tr>
<td>Duralay II</td>
<td>8</td>
<td>.0327</td>
<td>.0327</td>
</tr>
<tr>
<td>Dencrilay</td>
<td>8</td>
<td>.0401</td>
<td></td>
</tr>
</tbody>
</table>

*α = .05

*N indicates sample.
The dental floss technique for splinting and the use of chemically activated acrylic resin are not recommended to splinted impression copings of multi-implant prostheses, because all samples showed tension on the impression copings.

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