Impression Techniques for Multiple Implants: A Photoelastic Analysis. Part I: Comparison of Three Direct Methods

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The purpose of this article was to compare through photoelastic analysis the stress distribution in 3 direct transfer techniques for implants with splinting. Three photoelastic resin blocks were made with 2 implants placed parallel to each other and 2 square transfer copings splinted. Both transfers were splinted with acrylic resin chemically activated in 3 different techniques: metallic sticks (T1), prefabricated acrylic bars (T2), or dental floss (T3). A circular polariscope was used, and the distortion energy (E) was calculated in 4 periods: 20 minutes and 3, 24, and 36 hours. Statistically significant differences were found among the 3 techniques (P < .05). The dental floss presented the greatest distortion energy values (T3 = 0.469 Kgf/mm²) and the metallic sticks the lowest values (T1 = 0.0 Kgf/mm²). Thus, the metallic sticks technique (T1) appears to be the most accurate protocol to be used for implant-supported prosthesis with multiple abutments.

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

INTRODUCTION

Implantology currently consists of a reliable oral treatment that follows scientific and clinical evidence. Despite the proven success of rehabilitations with implants throughout a long period of time, many difficulties still persist without solution. Among them, the lack of passivity of implant-supported dentures may cause biological complications of the surrounding tissues or mechanical failures of the dentures and implant systems, and thus receives great attention from researchers.

Attention in all stages of prostheses manufacturing can contribute to avoiding the absence of passivity, and a fundamental stage to be observed is the impression procedure. The objective of the impression procedure in implantology is to obtain the most accurate copy of the implant analogues and the surrounding oral tissues, avoiding instabilities in the prosthetic device.

The most commonly used transfer techniques for implant-supported prostheses with multiple abutments are indirect, direct, and direct splinted. Some authors have noted that the impression made by the direct transfer technique for implants with splinting is more accurate than that of other techniques. Chemically activated acrylic resin is frequently used to fabricate intraoral splinting to join impression copings during the open-tray implant impression technique. However, some splinting methods can be used, each with advantages and disadvantages. The technique that uses dental floss as a framework for chemically activated acrylic resin is used thoroughly and demands longer clinical time for application. Other splinting forms are prefabricated bars and metal sticks, which use a smaller amount of acrylic resin and need less time for their conclusion.

The search for accuracy during the impression
procedure and construction of the definite casts are essential in dental and implant-supported prostheses. However, an important difference between natural teeth and dental implants is the fact that dental implants do not move in response to applied loads. As titanium implants do not have a periodontal ligament, intensive loads are transmitted and distributed to the adjacent bone. Thus, the accuracy of the impression phase is more significant because of the absence of mobility in the implants, while the periodontal ligament allows certain mobility to the teeth, compensating for part of the instability. The absence of mobility of the implants happens because of the intimate contact between titanium and bone structure, which, under load, moves as a unit without relative movement of the bone and of the titanium, making possible the transfer of tensions throughout the whole interface.

Photoelastic stress analysis is based on the property of some transparent materials to exhibit colorful patterns when submitted to loads and viewed with polarized light. This array of colored patterns is called isochromatic fringes. Studies with photoelastic analysis have been thoroughly conducted to determine the stress distribution around natural teeth, abutments of removable partial prosthesis and fixed partial prosthesis, and around endosseous implants under complete dentures or to determine stresses around endosseous implants supporting fixed prostheses.

Because of the disagreement in the literature regarding transfer techniques of implant-supported prostheses with multiple abutments, the aim of this article was to compare, through photoelastic analysis, the distribution of stress in 3 direct transfer techniques with splinting.

**METHODS**

First, an acrylic resin master model was made in the following dimensions: 100 mm in height, 40 mm in width, and 17 mm in thickness. This master acrylic block was used as a model for fabricating the 3 photoelastic models, and a wood box was used as a tray to achieve the impression of those models in silicon.

To obtain the models in resin, a preliminary archetype was made using 2 square transfer copings (Sistema de Implantes Nacionais, São Paulo, SP, Brazil), which were fixed on the surface of the acrylic master model with a small amount of green wax (Horus, Herp Produtos Dentários LTDA, Rio de Janeiro, RJ, Brazil). The components were placed parallel to each other with a distance of 25 mm between them and of 37.5 mm between the components and the lateral edges (Figure 1).

The group formed by the model in acrylic and the transfers was positioned inside the wood box, and the upper faces of the transfers were fixed with green wax (Figure 2). According to the manufacturer’s instruction, 400 mL of silicon was manipulated, and the mixture was poured into the wood box. After 24 hours, the master model was removed from the mold, leaving the transfers inside the silicon (Borracha Silicone ABS-10 Azul, Polipox Indústria e Comércio Ltda, São Paulo, SP, Brazil).

Hex implants were screwed to the transfers (Sistema de Implantes Nacionais). The photoelastic resin and the catalyzer (resin CMR-201 and toughener CME-252, Polipox Indústria e Comércio Ltda) were manipulated for 15 minutes to obtain 3 rectangular models, according to the instructions of the manufacturer. The resin was poured in the 3 silicon molds. After a period of 24 hours at room temperature, the transfers were unscrewed from the two implants, allowing the separation between mold and model. All photoelastic blocks were evaluated with a circular polariscope to verify the lack of residual stress (Optical Comparator Type PJ300, Mitutoyo MFG Co Mfg LTD, Tokyo, Japan).

Square transfer copings were screwed, with torque of 10 N, on the implants contained in the photoelastic model (Figure 3). The models were repositioned and reevaluated in the polariscope to guarantee that any stress in the photoelastic model would be due to the polymerization contraction of the resin used in the experiment.

Three direct impression techniques (T) of implants with splintage were evaluated: metallic sticks associated with acrylic resin chemically activated (T1); prefabricated bar in acrylic resin chemically activated, used after period of 36 hours from the beginning of the polymerization (T2); and dental floss associated with acrylic resin chemically activated (T3). Readings were accomplished in 4 different periods: 20 minutes and 3, 24, and 36 hours after the indexation with the acrylic resin (Dencrilay, Dencril, Com e Ind de Plásticos Ltda, Caieiras, SP, Brazil).

In the first technique (T.1), metallic sticks were positioned, with 2 mm of diameter, connecting the transfers and fixed, initially, with cyanoacrylate base...
sticker (Super Bonder, Henkel Ltda, Brazil), and later chemically activated acrylic resin was added just around the transfers to conclude that fixation.

For accomplishment of the prefabricated bar technique (T.2), a bar was made in chemically activated acrylic resin with incisions that allowed the fitting of the transfers present in the photoelastic model. It was fixed for a period of at least 36 hours before it was positioned and attached on the transfers of the photoelastic model.

The technique (T.3) consisted of interlacing the transfers with 20 cm of dental floss, and on it, 0.8 g of chemically activated acrylic resin was inserted, so that the union of the transfers occurred. In this technique, before accomplishing the insertion of the resin on the dental floss interlaced with the transfers, the model was positioned in the polariscope to guarantee that the dental floss had not induced stress on the transfers. This fact could amplify the effect produced by the contraction of the chemically activated acrylic resin.

For the photoelastic analysis, the method of Tardy was used. Currently, the method of Tardy is preferred to the other methods once auxiliary instruments are not required, and the analyzer of the polariscope serves as a compensation device. Also, the precision of approximately 0.02 fringes can be reached.\(^{30}\) The apex of both implants was evaluated in 2 areas. Each area contained 9 points disposed in line perpendicular to the long axis and tangent to the apex of the implant. The areas were determined as AA’ and BB’ to facilitate grouping the data. These areas were chosen because, in pilot studies, they were the ones that suffered greater induction of tensions (Figures 4 through 9).

The relation between the sequence of the fringes (N) and their distances (mm) to the point of origin was set (Table 1). The tables were imported to the program Matlab (1994–2007, The Mathworks, Inc, Natick, Mass), and Cartesian graphs were created. The distance between the positions of the fringes was 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 2 analyzed lines (Figure 5) 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. The distortion energy per unit of volume represents the unit of dimensional tension, known as U (N/m\(^2\) or Kgf/mm\(^2\)).\(^{31}\) After the calculation of those energies, statistical

![Figure 1](https://example.com/image1)
![Figure 2](https://example.com/image2)
![Figure 3](https://example.com/image3)
![Figure 4](https://example.com/image4)
analysis was accomplished through the tests of Friedman and of Wilcoxon (P < .05).

**RESULTS**

The values of the distortion energy (E) generated in the areas AA' and BB', by the 3 techniques in all observations, are disposed in Table 2 (Figures 5 through 10). The distortion energy (E) observed in the area AA' after 36 hours was zero for the metallic sticks technique (T1). However, for prefabricated bar (T2) and dental floss (T3) techniques, values of 0.205 Kgf/mm² and 0.384 Kgf/mm² were observed, respectively. For the BB' area, also after 36 hours, the distortion energy (E) values were 0, 0.169, and 0.469 Kgf/mm², for techniques 1, 2, and 3, respectively.

The Friedman test showed statistically significant differences between the 3 techniques (Table 3). As the test of Friedman cannot indicate the direction of these differences, the Wilcoxon test was applied to the series of data (Table 4). The metallic sticks technique (T1) presented the lowest values, free of tensions. However, the prefabricated bar technique (T2) showed values satisfactorily low, mainly up to 3 hours. The dental floss technique (T3) presented the greatest dimensional alterations.

**DISCUSSION**

Implant-supported dentures present great range in accuracy resulting from the fabrication process. An
impression procedure that reproduces the intraoral relationship of implants is the first step in achieving an accurately fitting prosthesis. Lack of passivity of implant-supported dentures may cause biological complications of the surrounding tissues and mechanical failures of dentures or implant systems.

Photoelastic analysis has been widely used in dentistry to study the biomechanical stress transfer in several kinds of prostheses. The technique used also facilitates a 2-dimensional view of the stress concentration. The results of this study are in agreement with the literature. Statistically significant differences among the 3 evaluated transfer techniques emphasize the relevance of selecting adequate technique to be used. Although largely used, the technique with dental floss generated the worst results.

The use of prefabricated bars with activated chemically acrylic resin, for the splinting of the transfers, has been proposed in some studies. According to those studies, the acrylic resin bar should be used after its polymerization, corresponding to a period of 17 minutes. Better results are reached after a period of 24 hours. When great resin volumes are used for splinting the transfers intraorally, polymerization contraction can produce distortions. To reduce these effects, in the present study a time was saved before those bars were fixed to the transfers, producing the splinting. The prefabricated bar technique is suggested for transferring implants, since lower values of tension were found in this study when compared with the dental floss technique. Within the period of 3 hours, this technique showed values close to the ones of the metallic stick.

However, in this study, dimensional alterations between the periods of 24 and 36 hours were identified. Thus, the time saved for the use of the bar should be ideally of 36 hours and not only 17 minutes or 24 hours, which is in agreement with previous studies, which related the absence of dimensional alteration of acrylic resin chemically activated after 30 hours. The advantages of the resin bar technique are mainly the nonexistence of complexity and the need for a smaller amount of acrylic resin during the impression procedure.

In the present research, the results confirmed statistical difference between the metallic sticks and dental floss techniques. Also, the distortion energy shows the acrylic resin volume interfered in the transfer process, because of the larger amount of resin used. The residual stress on the matrix of chemically activated acrylic resin could have been released during the impression procedure, causing misfit of the abutments’ position on the definite cast. The distortion increases proportionally with the volume of the acrylic resin used. This result is in contradiction with other studies, which found the volume of acrylic resin used in the transfer procedure did not affect the accuracy of the definite cast.

**Conclusions**

Considering the methodology of this study, it is possible to conclude the following:

- Transfer technique of multi-implants using metallic sticks presented the best results, since there was no tension described.

### Table 2

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<th>Variable</th>
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<td>AA’, 20 min</td>
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<td>AA’, 36 h</td>
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**Table 3**

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*P < .05.

**Table 4**

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<tr>
<td>T1 T3</td>
<td>.012*</td>
</tr>
<tr>
<td>T2 T3</td>
<td>.012*</td>
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*P < .05.
The technique with a prefabricated bar can be an alternative when the cast is produced within the period of 3 hours.

The resin volume interfered in the transfer process, because of the larger amount of resin used.

The period saved for the use of the bar should be ideally of 36 hours and not only 17 minutes or 24 hours, because of the absence of dimensional alteration of acrylic resin chemically activated after 30 hours.

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**REFERENCES**


