Comparison of the Accuracy of Different Transfer Impression Techniques for Osseointegrated Implants

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The aim of this study was to evaluate 3 transfer techniques used to obtain working casts of implant-supported prostheses through the marginal misfit and strain induced to metallic framework. Thirty working casts were obtained from a metallic master cast, each one containing 2 implant analogs simulating a clinical situation of 3-unit implant-supported fixed prostheses according to the following transfer impression techniques: group A, squared transfers splinted with dental floss and acrylic resin, sectioned, and re-splinted; group B, squared transfers splinted with dental floss and bis-acrylic resin; and group N, squared transfers not splinted. A metallic framework was made for marginal misfit and strain measurements from the metallic master cast. The misfit between the metallic framework and working casts was evaluated with an optical microscope following the single-screw test protocol. In the same conditions, the strain was evaluated using strain gauges placed on the metallic framework. The data were submitted to one-way analysis of variance followed by the Tukey test ($\alpha = 5\%$). For both marginal misfit and strain, there were statistically significant differences between groups A and N ($P < .01$) and groups B and N ($P < .01$), with greater values for group N. According to the Pearson test, there was a positive correlation between the misfit and strain variables ($r = 0.5642$). The results of this study showed that the impression techniques with splinted transfers promoted better accuracy than the nonsplinted technique, regardless of the splinting material used.

Key Words: Implant-supported prostheses, strain gauges, transfer technique

When properly indicated, an osseointegrated implant is the treatment of choice for partially and completely edentulous patients because the surgical technique is less traumatic, and it presents good esthetic results that provide satisfactory prosthetic rehabilitation. The prostheses are fixed to the osseointegrated implants and provide better retention, stability, and esthetics, thereby increasing the patient’s satisfaction.1–3

Despite the clinical relevance related to implant fixation, the longevity of the treatment is closely related to an accurate adaptation between the prosthetic components and fixations.4 The most substantial issue with prosthetic misfit is that implants, unlike teeth, do not have periodontal ligament.5 Therefore, all forces applied to the implants are transmitted directly through the alveolar bone without any form of damping on the bone-implant interface.6–8 The most common strains induced in implants are caused by mastication, phonation, and excessive overload due to poor adaptation and misfit of the prosthesis. This overload can be reduced when the prostheses are made using accurate procedures, such as the impression technique, cast pouring, infrastructure casting, porcelain coating, and prosthesis fixation type.9–12

The impression technique is one of the main factors that can cause marginal misfit and increase the strain on the implant-prostheses system, considering that the objective is to reproduce the relationship between the implants as accurately as possible.13 The impression also has the important purpose of registering the morphology of soft tissues.14,15 An inaccurate impression may result in prosthesis misfit, which may lead to biological and/or mechanical complications.13 Mechanical complications, such as screw loosening, screw fracture, implant fracture, and occlusal inaccuracy, have been reported as a result of prosthesis misfit.16–21 Biologically, the misfit that occurs from marginal discrepancy may cause adverse soft and/or hard tissue reactions due to increased biofilm accumulation.22–24

The transfer splint impression technique using acrylic resin has been widely practiced and studied.25–32 However, the disadvantage of this technique is the clinical time required for implementation. Constant research into improved techniques has led to a modified technique that uses bis-acrylic resin material. The bis-acryl resin is automatically mixed in the auto-mix gun and expressed as a heavy, very soft, and very viscous material.33 It has shown significantly lower shrinkage values compared with a monomethacrylate-based material.34 However, the literature is still limited regarding this new technique. There are questions about whether the technique increases the
strain on the prostheses system, and whether different impression techniques result in differences in marginal misfit and strain values.

The aim of this study was to evaluate three transfer techniques used to obtain working casts of implant-supported prostheses in terms of misfit and strain induced on the metallic framework.

**Materials and Methods**

Thirty (n = 10 of each type) stone working casts were obtained from a type IV dental stone (Herostone, Vigodent, Rio de Janeiro, Brazil), each one containing two implant analogs. A 4.1-mm cervical stand and a prosthetic hexagonal external connection (Conexao Prosthetic Systems, Sao Paulo, Brazil) were placed on the lower first molar (pillar A) and lower first premolar region (pillar B), which simulated a clinical situation with three-unit implant-supported fixed prostheses. The casts were made using 1 of 3 impression techniques. In group A, working casts were obtained using square transfers (Conexao) splinted with dental floss and acrylic resin (Duralay II, Polidental, Sao Paulo, Brazil) (Figure 1). After polymerization, the acrylic resin was sectioned and splinted again. In group B, working casts were obtained using square transfers (Conexao) splinted by dental floss and bis-acrylic resin (Luxatemp, DMG Chemisch-Pharmazeutische Hamburg, Germany) (Figure 2). In group N, working casts were obtained using square transfers (Conexao) and a nonsplinted impression technique.

A custom tray was made using methyl methacrylate resin (Jet, Classico, Sao Paulo, Brazil) to ensure uniform thickness of the impression material. The tray has an orifice to allow for use of the open tray impression technique with square transfers. Cylinders were placed on the tray like a tripod to ensure stability during the impression procedure and during pouring of the mold. A base of polyvinyl siloxane material (Flexitime Easy Putty, Correct Flow, Heraeus-Kulzer, Hanau, Germany) was made with notches to fit the custom tray in the same insertion axis. Thus, a uniform pattern impression was obtained according to the master cast, and the stone casts were standardized.

The impression transfers were screwed on the implants of the metallic master cast. The following impression procedures were used for the treatment groups.

In group A, the transfers were screwed on the implants of the metallic master cast and linked using unstrained dental floss; these were subsequently recovered using the powder-liquid paintbrush technique with acrylic resin (the Nealon technique). After polymerization, the dental floss-resin joint was sectioned with a diamond wheel and linked again to reduce possible strain from the polymerization shrinkage of the acrylic resin. After this step, the impression procedure was performed.

In group B, the transfers were splinted in a manner similar to the procedure used for group A; however, the interlace of dental floss was linked with the bis-acrylic resin using an autocure mix gun, and then the impression was performed.

In group N, the squared transfers were screwed to implant analogs placed in the metallic master cast, and then the impression was performed with square transfers not splinted.

The impressions for the 3 groups were made using polyvinyl siloxane material. The impression material (Flexitime Easy Putty) was manipulated using a tip and autocure mix gun. After 3 minutes, the transfers were unscrewed, the custom tray was removed from the master cast, and the analogs of the implants were screwed to the transfers so the mold could be subsequently filled with type IV dental stone (Herostone).

The dental stone was manipulated manually for 20 seconds and then mechanically for 40 seconds using the proportion of 100 g powder to 22 mL distilled water, according to the manufacturer’s instruction. The first portion of the dental stone was poured slowly into the impression without contacting the analog surface following the latex cylinder technique, and the latex cylinders were placed around the implant analogs to protect them. After the dental stone set, the latex cylinders were removed, and the resulting space was filled with the second portion of dental stone. After 60 minutes, the cast was removed from the impression. The impression techniques and the working casts were performed by the same operator.

A rectangular structure was waxed on the master cast with 20 mm × 5.0 mm × 5.0 mm dimensions. The wax pattern was included in investment (Rematitan Plus, Dentaurum, Inspringen, Germany) in a special ring for titanium melting. The ring was positioned in a heating oven (Vulcan 3.550, Dentsply International, Bogotá, Colombia). Commercially pure titanium (Tritan, Dentaurum) was melted in equipment composed of voltaic arc-melting by injecting molten metal in a vacuum
The metal framework finishing was made with aluminum oxide blasting and burs for titanium polishing. The marginal misfit measurements were performed with an optical microscope with accuracy of 1.0 μm and 120× magnification, according to the protocol for the single-screw test, to evaluate the passivity in implant-supported structures. The measurements were performed for a single examiner 3 times (intraclass correlation coefficient = 0.8691). An average for each framework-pillar set was performed. The gaps between the base of the implant analog and the gingival surface of the metallic framework in pillar B were observed when the screw of the pillar A was tightened. To standardize the position of the readings, a reference was made on each abutment with a hydrographic pen. The strain was assessed after the metallic framework was placed on the implant analogs of the cast. The framework screw was tightened with 32 Ncm torque, according to the manufacturer’s instructions. The measurements were performed by using strain gauges (Excel Sensors Engineering, Embu, Sao Paulo, Brazil), following the formation of a half Wheatstone bridge (Figure 3). One metal strain gauge was placed on the upper and lower surfaces of the framework, leaving a distance of 90° between them. The readings of the framework elastic deformation were made after all prosthetic screws were tightened. The electric signals were captured by a computer-controlled apparatus (ADS500, Lynx Electronics, Sao Paulo, Brazil) and processed using a specific software (AqDados 7, Lynx Electronics). Statistical analysis

The data submitted to the Kolmogorov-Smirnov test revealed normal distribution. Afterward, the Pearson test was used to evaluate the correlation between marginal misfit and strain. The between-groups comparison was done using one-way analysis of variance for the marginal misfit and strain followed by the Tukey test. A significance level of 5% was considered for all analyses.

**RESULTS**

Table 1 shows the means and standard deviations of the vertical misfit obtained for each group. The Tukey test revealed statistically significant differences between groups A and N (P < .01) and between groups B and N (P < .01), with greater values for group N.

Means and standard deviations of the strains are shown in Table 2. The Tukey test showed statistically significant differences between groups A and N (P < .01) and groups B and N (P < .01), with greater values for the group N.

Table 3 presents the Pearson correlation coefficient for marginal strain and misfit.

**DISCUSSION**

In a recent systematic review related to implant impressions, a large number of studies reported better accuracy with the splinted technique than the nonsplinted one. However, controversy exists in the literature regarding whether or not to adopt the splint procedure. Although some authors have
The polyvinyl-siloxane impression material was chosen for this study as it has been widely used in clinical practice and presents a dimensional stability compatible with achieving adequate, accurate casts for implant-retained impressions.18–24,35–37 A lower-expansion type IV dental stone was used because its characteristics are high resistance, hardness, and low hygroscopic expansion.56 In addition, some previous studies used the strain gauges measurement method to determine which technique introduces fewer distortion.25,28,30,57–59

The present study used the arrangement following the formation of a half-Wheatstone bridge by using 2 strain gauges on the framework (one parallel on the upper surface and the other perpendicular on the lower surface).30 This condition allowed for the measurement of the strain in the metallic framework, which represents a complementary way to do the linear analysis of the marginal misfit and not to measure the strain induced. The higher values of strain (496.94 μm) were found in group N, the same group that induced a higher level of marginal misfit; this demonstrates the inaccuracy of the nonsplinted technique.

The present study found that marginal misfit was responsible for the strain level induced on the infrastructure. The Pearson coefficient obtained for misfit and strain was \( r = 0.5642 \), indicating a moderate, though positive, relationship. According to this result, it can be understood that when the marginal misfit increases, the strain values also increase. In other words, the strain level establishes a dependency with the marginal misfit. This result is in accordance with the findings of some previous studies.51,60–63

The limitation of the study was that no cyclic loading was applied in the framework. It is claimed that the location and magnitude of occlusal forces can affect the amount and quality of the strain transmitted to the components of the bone-implant-prosthesis system.16 Based on this consideration, further studies are needed to verify the influence of different metals in fabricating the framework and the effect of mechanical cycles under different clinical situations.

**Conclusion**

Based on the results of this study, the following conclusion can be considered: the impression techniques with splinted transfers promoted better accuracy than a nonsplinted technique, regardless of the splinting material used.

**References**

Transfer Impression Techniques’ Accuracy


