Chapter 7

Effect of Splinted and Nonsplinted Impression Techniques on the Accuracy of Fit of Fixed Implant Prostheses in Edentulous Jaws: A Comparative Study

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Effect of Splinted and Non-splinted Impression Techniques on the Accuracy of Fit of Fixed Implant Prostheses in Edentulous Jaws: A Comparative Study

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ABSTRACT

Statement of problem: The effect of different implant impression techniques on the accuracy of casts has been investigated mostly under in vitro laboratory conditions and clinically relevant evidence is scarce.

Purpose: The purpose of this study is to investigate the effect of implant impression techniques on the accuracy of fit of fixed implant prostheses in edentulous patients. The null hypothesis is that there is no significant difference between splinted and non-splinted implant impression techniques.

Materials and methods: This clinical study included 12 edentulous patients (13 edentulous jaws). The same surgical and prosthodontics procedures were followed for all patients. All patients had undergone CAD/CAM-guided, prosthetically-driven implant surgery. Splinted (with acrylic resin) vs. non-splinted, pick-up implant impression techniques were used to generate two different casts serving as two test groups. Intraoral verification jigs were made to fabricate a third index cast (prosthesis fabrication cast), serving as control group. All patients were definitively rehabilitated with one-piece, CAD/CAM zirconia prostheses, which presented with accurate clinical fit. The accuracy was evaluated indirectly by assessing the fit of zirconia prostheses on the generated casts of the test groups, clinically and radiographically.

Results: Out of the 13 casts of test group 1 (splint), 12 presented with accurate clinical fit when the zirconia prosthesis was seated on its respective cast. Only 6 out of the 13 test group 2 (non-splint) casts showed clinical fit. The zirconia prostheses fit accurately in all respective casts of the control group (prosthesis fabrication cast) as well as intraorally. The differences between groups 1 and 2 (p=0.014) and groups 2 and control (p=0.008) were statistically significant. No statistical difference was found between groups 1 and control (p=0.317).

Discussion: Under the limitations of this study, the null hypothesis was rejected. There is clinical evidence that the splinted impression technique generates more accurate implant impressions and master casts than the non-splinted technique for complete arch, one-piece fixed prostheses.

Keywords: implant impressions, splinted techniques, non-splinted techniques, accuracy of fit
INTRODUCTION
The effect of an accurate fit of complete arch fixed implant prostheses on the long-term success has been described by several investigators.\textsuperscript{1-3} Ill-fitting frameworks may lead to increased incidence of technical/mechanical complications. Such prosthetic misfit may also affect biological structures, causing marginal bone loss and potential compromise of osseointegration.\textsuperscript{3}

None of the prosthesis fabrication methods employed have been able to produce frameworks with an absolute passive fit.\textsuperscript{4} The traditional lost wax technique has been associated with misfit problems due to casting shrinkage.\textsuperscript{5} Modern CAD/CAM technology for the fabrication of implant prostheses resulted in a significant improvement of the implant frameworks adaptations.\textsuperscript{6,12,13,14} In this context, an accurate 3-D reproduction of the intra-oral position of the implants through the impression is necessary. Clinically, additional factors such as number, angulation, depth of implants, and impression materials may affect the accuracy of implant impressions.\textsuperscript{15} Up to date, several studies (published from 1990 to 2010 according to PubMed electronic database) have compared the effect of splinted versus non-splinted impression technique on the accuracy of implant casts.\textsuperscript{16-36} Out of these studies, some studies advocated the splint impression technique,\textsuperscript{16-25} other studies advocated the non-splinted technique,\textsuperscript{26-28} whereas another group study\textsuperscript{29-36} reported no difference.

The effect of different implant impression techniques on the accuracy of implant casts has been investigated mainly under in vitro laboratory conditions. Therefore clinically related data could provide relevant information for the selection of appropriated impression technique in full-arch implant rehabilitations. The purpose of this clinical study is to investigate the effect of splinted and non-splinted pick-up impression techniques on the accuracy of fit for fixed implant prostheses in edentulous patients. The null hypothesis is that there is no clinically significant difference between these two implant impression techniques.

MATERIALS AND METHODS
This study included 12 fully edentulous patients with 13 edentulous jaws that were treated between May 2006 and September 2008 in the postdoctoral Prosthodontic clinic at Columbia
University College of Dental Medicine. Informed consent was obtained for all participants. For all patients, the indication of CAD/CAM-guided and prosthodontically-planned implant position was confirmed. A CT-generated stereolithographic surgical templates (Nobel Guide, Nobel Biocare USA) was used for implant placement. External hex, NP, RP and WP implants (Branemark System; Nobel Biocare USA) were used for all patients. Institutional Review Board (IRB) approval was obtained by Columbia University Human Subjects Review Committee.

**Implant impression procedures**

One month after second stage surgery, the feasibility of fixed implant prosthesis was assessed by converting all patients existing dentures into one-piece screw-retained provisional restorations. Patients received two types of implant impression techniques. Acrylic stock trays were used for all impressions. For the splinted (test group 1) implant impressions, a pick-up technique was used. Impression copings were connected to the implants and the seating of the copings on the implant platforms was radiographically confirmed. Then, the impression copings were connected with dental floss and splinted to each other with visible light polymerized acrylic resin (Triad gel; Dentsply, Milford, Del). The assembly was sectioned between all inter-implant areas and bonded with a small amount of the same resin to avoid tension among the copings. (Fig 1a)

The impression material used for all impressions was polyether (Impregum; 3M ESPE, St Paul, Minn). In the modified stock trays, openings were drilled to accommodate the guide pins of the impression copings in the open tray mode. After 6 minutes, the guide pins were unscrewed and the impression was removed from the mouth. For the non-splinted (test group 2) implant impression (Fig 1b), a second pick-up impression was taken for each patient following the same technique as the splinted group but with free standing impression copings. The timing and pouring procedures were similar with the impressions taken for the splinted technique.

Standardized laboratory procedures were performed. First, implant analogues were connected to the impression copings and low expansion (0.09%) type IV die stone (Silky Rock; Whipmix Corp, Louisville, Ky) was mixed under vacuum and an initial pour of the impression was carried out. The first pour of the die stone was up to the middle of the implant analogues. After at least
30 minutes, the second pour of the same vacuum-mixed die stone was carried out. This double pouring technique aims to minimize the volumetric expansion of the stone and has been shown to lead in more accurate die casts. 35,39

For the fabrication of the master implant cast (control group), temporary non-engaging abutments were directly connected to the implants intraorally and splinted with light polymerized acrylic resin (Triad gel; Dentsply). 13,40 After removing the complex from the mouth, implant analogues were attached to the acrylic jig. Low expansion die stone (Silky Rock; Whipmix Corp) was used to pour a small layer of stone and fabricate the control master cast. This cast was used for the implant prosthesis fabrication. **(Fig 1c)** Three casts were generated for every patient as follows:

- **GROUP 1 (SPLINTED):** Cast generated from the splinted coping impression technique
- **GROUP 2 (NON-SPLINTED):** Cast generated from the non-splinted coping impression technique
- **GROUP 3 (CONTROL):** Cast indexed from the verification jig

For these patients, 13 implant-level, CAD/CAM zirconia frameworks were fabricated, supported by 80 implants. Established criteria, such as no open margin upon clinical and radiographic examination, were used for the assessment of clinical fit of the zirconia frameworks. 3,41

According to these methods, all the zirconia prostheses presented with clinical fit (no open margin) confirming the accuracy of the verification jig cast. Each zirconia framework was tried-in and the single screw test (SST) was used for the intraoral evaluation. Standardized periapical radiographs were taken with the long cone parallel technique perpendicularly to the implant-abutment connection using a radiograph holder (Rinn centrator bite; Dentsply Rinn, Elgin, Ill). Digital panoramic radiographs were taken as well with each complete arch zirconia framework. For each of the 13 prostheses of the 3 Groups, assessment of clinical fit was done radiographically by 2 examiners other than the restorative clinician. Cohen’s kappa score was used to assess the inter-examiner agreement. All zirconia frameworks presented with clinical fit with no visible open margin upon strict radiographic examination by the two examiners (k=1.0), not involved in patient treatment. **(Figs 2, a and b)**
**Accuracy measurements**

The SST was also used in the laboratory to assess the prosthetic fit. Each zirconia framework was seated on its respective Group 1 (splint) cast and Group 2 (non-splinted) cast. They were retained by tightening at 10Ncm the screw of the most distal left implant. Two examiners blinded towards casts groups, performed all the measurements of the accuracy of fit of the frameworks on the different casts. *(Figs 3, a-c)*

The fit of the zirconia framework was assessed at 4 different points (buccal, distal, lingual, mesial) with a new 50μm tip dental explorer (Hu Friedy USA, Chicago, Ill). A smooth transition was considered clinical fit, whereas a “catch” of the dental explorer was considered misfit. If an open margin of less than 50μm was detected, the tactile test would not be able to detect the misfit. If all 4 measurements at each implant-abutment junction were accurate, the fit was scored accurate. If 1 or more out of the 4 measurements was not accurate, the fit was deemed not accurate. If all the implant-abutment junctions of prosthesis were scored accurate, then the fit was judged as accurate (prosthesis level). *(Figs 3, a-c)* The k-score for inter-examiner agreement was 1.0 for all measurements on casts at Group 1, 0.949 for the Group 2 and 1.0 for the Control Group, showing perfect inter-examiner agreement.

**Statistical analysis**

Wilcoxon’s Signed ranks-test for non-parametric dependent variables was used to compare the differences among the 3 groups for statistical significance. The level for statistical significance was set at 5% (P<0.05).

**RESULTS**

The results of the study in terms of prosthesis accuracy are summarized in Tables 1, 2 and 3. All but one of the definitive implant casts generated from the splinted impression technique were accurate (12/13). Only 6 out of the 13 implant casts generated from the non-splinted impression technique were accurate (6/13). Assessment of clinical fit was done with dental explorers, SST and radiographs. Specifically, in Group 1 (splinted) one zirconia framework presented with open margins at two implant-abutment interfaces. In Group 2 (non-splinted) 7
prostheses presented with open margins at 11 implant-abutment interfaces. The implant casts of Group 3 (Control) generated from the intraoral acrylic jigs were always accurate, which was verified both clinically and in the laboratory.

The difference between the working casts fabricated with the 2 different impression techniques was statistically significant. (Table 3) The differences between groups 1 and 2 (p=0.014) and groups 2 and 3 (p=0.008) were statistically significant. No statistical difference was found between groups 1 and 3 (p=0.317).

DISCUSSION

The purpose of the present study was to evaluate the accuracy of implant impression techniques and generated casts for complete arch implant rehabilitations. The clinical factors that affect the accuracy of the implant impressions could identified as: 1) the impression technique, 2) the implant component compatibility and fit, 3) the die stone materials and their properties, 4) the pouring technique, 5) the implant angulation and depth, 6) the number of implants, 7) the anterior-posterior (A-P) spread of the implants, 8) the inter-implant distance and the curvature of their spread.

This study included stringent clinical, laboratory and radiographic criteria for quality control of all patients in this study cohort. The null hypothesis that there would be no clinical difference on the accuracy of master implant casts produced by the tested implant impression techniques was rejected. There was a significant difference on the accuracy of the implant techniques, with the splinted impression technique showing more accurate working casts. Dental explorers, SST and radiographs were used for assessment of fit. Results of this investigation are in accordance with previously published in vitro studies that have advocated the splinting of impression copings during implant impressions. Especially for edentulous patients with 4 or more implants, most in vitro studies advocated the splinted impression technique. Accuracy outcomes may be affected by the machining tolerance of components, differences in methods for accuracy measurements, and improvements in dental materials. Ma et al. showed that the machining tolerance of the implant components may compensate to some degree for small horizontal discrepancies. Philips et al. did not section the resin splint for the splinted impression technique and reported more accurate results with the non-splinted one. On the
other hand, Assif et al. did not section the splint as well, but reported that the splinted technique was significantly more accurate than the non-splinted.\textsuperscript{27} The machining tolerance differs among different implant systems and is an unknown variable in the accuracy measurements. Moreover, the introduction of new splinting materials like composite resin or light polymerizing acrylic resin yielded better results as most \textit{in vitro} studies published after 2003 advocate the splinted technique.\textsuperscript{15} The fact that all implants were placed with prosthodontically-driven, CT-generated templates standardized the conditions. Angulations of all implants were favourable for CAD/CAM manufactured one-piece screw-retained prosthesis. The choice of one-piece definitive prosthesis was made taking into consideration the number and antero-posterior spread of the implants, length of implants and arch type.\textsuperscript{9} Other options have also been proposed for the complete arch fixed rehabilitation with segmented prostheses and strategically positioned implants.\textsuperscript{43} In this context, a splinting impression technique may be less significant when a segmented rehabilitation for edentulous or partially edentulous patients is contemplated.\textsuperscript{15,43} No specific range of acceptable misfit has yet been established.\textsuperscript{44,45} However, the significance of passive clinical fit of the implant-supported prosthesis has been highlighted in the literature in order to prevent screw loosening and/or screw fracture, implant fracture, prosthetic implant component wear and fracture.\textsuperscript{1-3}

**CONCLUSIONS**

The null hypothesis that there would be no clinical difference on the accuracy of master implant casts produced by the tested implant impression techniques was rejected. Under the limitations of the present study, the following conclusions can be drawn:

1. The splinted impression technique yielded statistically significant more accurate working casts (group 1) than the non-splinted technique (group 2).
2. The control group (verification jig) produced clinically accurate casts in all clinical situations.
3. The accuracy achieved with group 1 (splinted) was similar to the group 3 (control).
REFERENCES


### TABLE 1 – ACCURACY OF FIT OF THE IMPLANT PROSHESES (PROSTHESIS LEVEL)

<table>
<thead>
<tr>
<th>Subject</th>
<th>01</th>
<th>02</th>
<th>03</th>
<th>04</th>
<th>05</th>
<th>06</th>
<th>07</th>
<th>08</th>
<th>09</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>Total fit</th>
<th>Total not-fit</th>
</tr>
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<tbody>
<tr>
<td>Group 1 (splinted)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Group 2 (non-splinted)</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Group 3 (Control)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>13</td>
<td>0</td>
</tr>
</tbody>
</table>

“+” : Fit  
“-“ : Not fit

### TABLE 2 – CUMULATIVE RESULTS (PROSTHESIS LEVEL)

<table>
<thead>
<tr>
<th>Implant Casts</th>
<th>Zirconia (n=13) Implant Frameworks</th>
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<tr>
<td>Group 1 (splinted technique)</td>
<td>12/13 Clinical fit</td>
</tr>
<tr>
<td>Group 2 (non-splinted technique)</td>
<td>6/13 Clinical fit</td>
</tr>
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<td>Group 3 (Control)</td>
<td>12/13 Clinical fit</td>
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TABLE 3 – STATISTICAL ANALYSIS (WILCOXON’S SIGNED RANKS TEST)

<table>
<thead>
<tr>
<th></th>
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<th>Group 2</th>
<th>Group 3</th>
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</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>-</td>
<td>0.014*</td>
<td>0.317</td>
</tr>
<tr>
<td>Group 2</td>
<td>0.014*</td>
<td>-</td>
<td>0.008*</td>
</tr>
<tr>
<td>Group 3</td>
<td>0.317</td>
<td>0.008*</td>
<td>-</td>
</tr>
</tbody>
</table>

*“*”: significant difference (P<0.05)
FIGURES

Fig 1a: Splinted copings impression technique

Fig 1b: Non splinted coping impression coping

Fig 1c: Verification index cast serving as working cast and control
**Fig 2a:** Periapical radiograph verifying intraoral fit

**Fig 2b:** Periapical radiograph verifying intraoral fit

**Fig 3a:** Prosthesis on splinted cast

**Fig 3b:** Prosthesis on non-splinted cast

**Fig 3c:** Prosthesis on control cast from verification index