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

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Purpose: *The effect of different implant impression techniques on the accuracy of casts has been investigated mostly in vitro, and clinically relevant evidence is scarce. The purpose of this study was to investigate the effect of implant impression techniques—specifically, splinted versus nonsplinted—on the accuracy of fit of fixed implant prostheses in edentulous patients.* ***Materials and Methods:*** *This clinical study included 12 edentulous patients (13 edentulous arches). All patients had undergone computer-guided, prosthetically driven implant surgery. Splinted (with acrylic resin) and nonsplinted pickup implant impression techniques were used to generate two different casts. Intraoral verification jigs were made to fabricate a third index cast (prosthesis fabrication cast); these made up a control group. All patients were definitively rehabilitated with one-piece zirconia prostheses. The accuracy of fit of each prosthesis was evaluated indirectly by examining them clinically and radiographically while they were fit on the generated casts.* ***Results:*** *Of the 13 splinted casts, 12 presented with accurate clinical fit when the zirconia prosthesis was seated on its respective cast. Only 6 of the 13 nonsplinted casts showed accurate clinical fit. The zirconia prostheses fit accurately on all respective casts of the control group (prosthesis fabrication cast) as well as intraorally. The differences between the test groups and between the nonsplinted and control groups were statistically significant. No statistically significant differences were found between the splinted and control groups.* ***Conclusion:*** *There is clinical evidence that the splinted impression technique generates more accurate implant impressions and master casts than the nonsplinted technique for complete-arch, one-piece fixed prostheses.* Int J Oral Maxillofac Implants 2011;26:1267–1272

Key words: *accuracy of fit, dental implants, implant impressions, nonsplinted techniques, splinted techniques*

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The effect of an accurately fitted complete-arch fixed implant prosthesis on long-term success has been described by several investigators.[1–3] Ill-fitting frameworks may lead to an increased incidence of technical and/or mechanical complications. Such prosthetic misfit may also affect biologic structures, causing marginal bone loss and, potentially, compromising osseointegration.[3]

None of the prosthesis fabrication methods employed have been able to produce frameworks with absolutely passive fit.[4] The traditional lost-wax technique has been associated with misfit problems as a result of casting shrinkage.[5] Modern computer-aided design/computer-assisted manufacture (CAD/CAM) technology for the fabrication of implant prostheses has resulted in a significant improvement in implant framework adaptation.[6–9] In this context, an accurate three-dimensional reproduction of the intraoral position of the implants through the impression phase is necessary. Clinically, additional factors, such as number, angulation, and depth of implants, as well as impression

Fig 1a Splinted copings impression technique.

Fig 1b Nonsplinted copings impression technique.

Fig 1c Verification index cast serving as working cast and control.

materials, may affect the accuracy of implant impressions.[10] To date, several studies (published from 1990 to 2010 according to the PubMed electronic database) have compared the effect of splinted and nonsplinted impression techniques on the accuracy of implant casts.[11–31] Among these studies, some advocated the splint impression technique,[11–20] others advocated the nonsplinted technique,[21–23] and still others[24–31] reported no difference in the accuracy of the two approaches.

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 the appropriate impression technique in full-arch implant rehabilitations. Hence, the purpose of this clinical study was to investigate the effect of splinted and nonsplinted pickup impression techniques on the accuracy of fit for fixed implant prostheses in edentulous patients. The null hypothesis was that there is no clinically significant difference between these two implant impression techniques.

MATERIALS AND METHODS

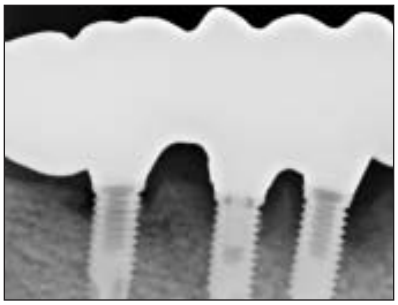
This study included 12 completely edentulous patients with 13 edentulous arches treated between May 2006 and September 2008 in the postdoctoral prosthodontics clinic at Columbia University College of Dental Medicine. Informed consent was obtained from all participants. For all patients, the indication of CAD/CAM-guided and prosthodontically planned implant positions was confirmed. A computed tomography–generated stereolithographic surgical template (Nobel Guide, Nobel Biocare) was used for implant placement.[32] External-hex narrow-, regular-, and wide-platform implants (Brånemark System, Nobel Biocare) were used for all patients. Institutional review board approval was obtained from the Columbia University Human Subjects Review Committee.

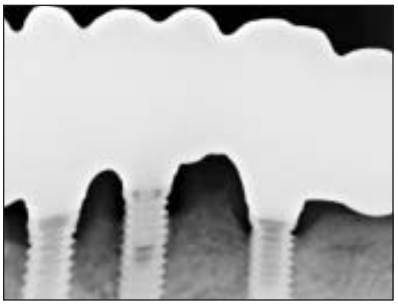
Implant Impression Procedures

One month after stage-two surgery, the feasibility of fixed implant prostheses was assessed by converting all patients' existing dentures into one-piece screw-retained provisional restorations. Patients were subjected to two types of implant impression techniques. Acrylic stock trays were used for all impressions. For the splinted (test group 1) implant impressions, a pickup technique was used. Impression copings were connected to the implants, and the seating of the copings on the implant platforms was confirmed radiographically. Then the impression copings were connected with dental floss and splinted to each other with visible light–polymerized acrylic resin (Triad Gel, Dentsply). The assembly was sectioned between all interimplant areas and bonded with a small amount of the same resin to prevent the development of tension between the copings (Fig 1a). For the nonsplinted (test group 2) implant impressions (Fig 1b), a second pickup impression was taken for each patient; this followed the same technique as the splinted group, but the impression copings were left free standing.

Polyether (Impregum, 3M ESPE) material was used for all impressions.[33] 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. The timing and pouring procedures were the same for splinted and nonsplinted impression techniques.

Standardized laboratory procedures were performed. First, implant analogs were connected to the impression copings and low-expansion (0.09%) type IV die stone (Silky-Rock, Whip Mix) 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 analogs. 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 to more accurate die casts.[30,34]





Figs 2a and 2b Periapical radiographs verifying intraoral fit.

Fig 3a Prosthesis on splinted cast.

Fig 3b Prosthesis on nonsplinted cast.

Fig 3c Prosthesis on control cast from verification index.

For the fabrication of the master implant cast (control group), temporary nonengaging abutments were directly connected to the implants intraorally and splinted with light-polymerized acrylic resin (Triad Gel, Dentsply).[13,35] After the complex was removed from the mouth, implant analogs were attached to the acrylic resin jig. Low-expansion die stone (Silky-Rock; Whip Mix) was used to pour a small layer of stone and fabricate the control master cast. This cast was used for fabrication of the implant prosthesis (Fig 1c). Three casts were generated for every patient as follows: group 1 (splinted) = cast generated from the splinted coping impression technique; group 2 (nonsplinted) = cast generated from the nonsplinted coping impression technique; and group 3 (control) = cast indexed from the verification jig.

For these patients, 13 implant-level, CAD/CAM zirconia frameworks were fabricated; they were supported by 80 implants. Established criteria, such as no open margins upon clinical and radiographic examination, were used to assess the clinical fit of the zirconia frameworks.[3,36] According to these methods, all the zirconia prostheses presented with clinical fit (no open margins), confirming the accuracy of the verification jig cast. Each zirconia framework was then 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, perpendicular to the implant-abutment connection, using a radiograph holder (Rinn Centrator Bite, Dentsply Rinn). Digital panoramic radiographs were also taken of each complete-arch zirconia framework. For each of the 13 prostheses of the three groups, radiographic assessment of clinical fit was done by two examiners who were not involved in patient treatment. The Cohen kappa score was used to assess interexaminer agreement. All zirconia frameworks presented with clinical fit, with no visible open margins upon strict radiographic examination by the two examiners (kappa = 1.0) (Figs 2a and 2b).

Measurements of Accuracy

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

The fit of the zirconia framework was assessed at four different points (buccal, distal, lingual, mesial) on each implant with a new 50-µm tip dental explorer (Hu-Friedy). A smooth transition was considered clinical fit, whereas a "catch" of the dental explorer was considered misfit. If an open margin of less than 50 µm was present, the tactile test could not detect the misfit. If all four measurements at each implant-abutment junction were accurate, the fit was scored as accurate. If one or more of the measurements was not accurate, the fit was deemed not accurate. If all the implant-abutment junctions of a prosthesis were scored as accurate, then the fit was judged as accurate (on the prosthesis level) (Figs 3a to 3c). The kappa score for interexaminer

Table 1 Accuracy of Fit of the Implant Prostheses (Prosthesis Level)

Subject	Group 1 (splinted)	Group 2 (nonsplinted)	Group 3 (control)
1	+	+	+
2	+	–	+
3	+	–	+
4	+	+	+
5	+	+	+
6	+	+	+
7	+	+	+
8	+	–	+
9	+	–	+
10	–	–	+
11	+	–	+
12	+	+	+
13	+	–	+
Total fit	12	6	13
Total did not fit	1	7	0

+ = fit; – = did not fit.

Table 2 Statistical Comparison of Groups

	Group 1	Group 2	Group 3
Group 1	–	.014*	.317
Group 2	.014*	–	.008*
Group 3	.317	.008*	–

*Significant difference (Wilcoxon signed-rank test; $P < .05$).

agreement was 1.0 for all measurements on casts in group 1, 0.949 for group 2, and 1.0 for the control group, showing nearly perfect interexaminer agreement.

Statistical Analysis

The Wilcoxon signed rank test for nonparametric dependent variables was used to compare the differences among the three groups. The level for statistical significance was set at 5% ($P < .05$).

RESULTS

The results of the study in terms of prosthesis accuracy are summarized in Tables 1 and 2. All but one of the definitive implant casts generated from the splinted impression technique were accurate (12/13). In contrast, only 6 of the 13 implant casts generated from the nonsplinted impression technique were accurate (6/13). Specifically, in group 1 (splinted), one zirconia framework presented with open margins at two implant-abutment interfaces. In group 2 (nonsplinted), 7 prostheses presented with open margins at 11 implant-abutment interfaces. The implant casts of group 3 (control) generated from the intraoral acrylic resin jigs were always accurate, which was verified both clinically and in the laboratory.

The difference between the working casts fabricated with the two different impression techniques was statistically significant ($P = .014$; Table 2). The difference between groups 2 and 3 ($P = .008$) was statistically significant. No statistically significant difference was found between groups 1 and 3 ($P = .317$).

DISCUSSION

The purpose of the present study was to evaluate the accuracy of implant impression techniques and the casts generated from them for complete-arch implant rehabilitations. The clinical factors that affect the accuracy of the implant impressions include *(1)* impression technique, *(2)* implant component compatibility and fit, *(3)* die stone materials and their properties, *(4)* pouring technique, *(5)* implant angulations and depths, *(6)* the number of implants, *(7)* the anteroposterior spread of the implants, and *(8)* interimplant distances 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 in the accuracy of master implant casts produced by the tested implant impression techniques was rejected. There was a significant difference in the accuracy of the implant techniques, with the splinted impression technique producing more accurate working casts. Dental explorers, the SST, and radiographs were used for assessment of fit.[3,36] The results of this investigation are in accordance with previously published in vitro studies that have advocated the splinting of impression copings during implant impressions.[11–20] Especially for edentulous patients receiving four or more implants, most in vitro studies advocated the splinted impression technique.[11–15,17,20]

Accuracy may be affected by the machining tolerance of components, differences in methods of measuring accuracy, and improvements in dental materials. Ma et al[37] showed that the machining tolerance of the implant components may compensate to some degree for small horizontal discrepancies. Phillips et al[22] did not section the acrylic resin splint for the splinted impression technique and reported more accurate results with the nonsplinted technique. In contrast, Assif et al also did not section the splint,

but they reported that the splinted technique was significantly more accurate than the nonsplinted technique.[12] Machining tolerances differ among different implant systems and represent an unknown variable in accuracy measurements. Moreover, the introduction of new splinting materials, such as composite resin or light-polymerizing acrylic resin, yielded better results; most in vitro studies published after 2003 advocate the splinted technique.[10]

The fact that all implants were placed with prosthodontically driven, computed tomography–generated templates standardized the conditions. Angulations of all implants were favorable for CAD/CAM one-piece screw-retained prostheses. The choice of a one-piece definitive prosthesis took into consideration the number and anteroposterior spread of implants, length of implants, and arch type.[38] Other options have also been proposed for the complete-arch fixed rehabilitation, including segmented prostheses and strategically positioned implants.[39] In this context, a splinted impression technique may be less significant when a segmented rehabilitation for edentulous or partially edentulous patients is contemplated.[10,39,40]

No specific range of acceptable misfit has yet been established.[37,41] However, the significance of passive clinical fit of an implant-supported prosthesis has been highlighted in the literature to prevent screw loosening and/or screw fracture, implant fracture, or prosthetic implant component wear and fracture.[1–3,42]

CONCLUSION

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 significantly more accurate working casts (group 1) than the nonsplinted 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 that achieved in group 3 (control).

ACKNOWLEDGMENTS

The authors wish to express their gratitude to Dr Chun-Jung Chen, Department of Restorative Dentistry and Biomaterials Sciences, Harvard School of Dental Medicine, for assistance in the development of the statistical analysis; and Dr Dennis N. Morea, Division of Prosthodontics, Columbia University College of Dental Medicine, for support and mentoring.

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