Accuracy of Implant Impression Splinted Techniques: Effect of Splinting Material

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Three implant impression techniques, using 3 different splinting materials, were assessed for accuracy in a laboratory model that simulated clinical practice. For group A, an autopolymerizing acrylic resin was used to splint transfer copings. In group B, a dual-cure acrylic resin was used, and for group C, plaster, which was also the impression material, was used. A metal implant master cast with an implant master framework was made to accurately fit to the cast. This cast was the standard for all impressions. For each group, 15 impressions were made. Polyether impression material was used for groups A and B. The accuracy of the stone casts with the implant analogues was measured against the master framework, using strain gauges. A multiple analysis of variance with repeated measures was performed to test for significant differences among the 3 groups. Additional analyses of variance were carried out to locate the source of difference. The statistical analyses revealed that a significant difference existed between groups A and B and between groups B and C but not between groups A and C. Impression techniques using autopolymerizing acrylic resin or impression plaster as a splinting material were significantly more accurate than dual-cure acrylic resin. Plaster is the material of choice in completely edentulous patients, since it is much easier to manipulate, less time consuming, and less expensive.
(Int J Oral Maxillofac Implants 1999;14:885–888)

Key words: abutment, autopolymerizing acrylic resin, dual-cure acrylic resin, implant, impression plaster, transfer copings

A major objective of fabricating implant-supported restorations is the production of superstructures that exhibit accurate fit when connected to multiple abutments.[1–3] Because of the unique quality of the implant-bone relationship, a misfit will result in the accumulation of preload and loading stresses in the restorative complex, causing problems ranging from screw loosening to loss of osseointegration.[4–9]

A main requirement for obtaining such a fit is an accurate impression. Among the impression-making methods presented in the literature, the splinted technique has gained popularity and has proven to be the most accurate.[10,11] The purpose of this study was to assess the accuracy of 3 different splinting materials in a laboratory model that simulated clinical practice.

Materials and Methods

A metal implant master cast with an accurately fitting master framework was fabricated. The design, materials used, and impression procedures have been previously described[11] (Fig 1). From the master cast, 15 impressions were made for each of the 3 splinting materials.

Group A: Impression copings were connected to each other using an autopolymerizing acrylic resin (Duralay, Reliance Dental Manufacturer, Worth, IL) (Fig 2). Impressions were made using polyether impression material (Impregum F, ESPE, Seefeld, Germany).

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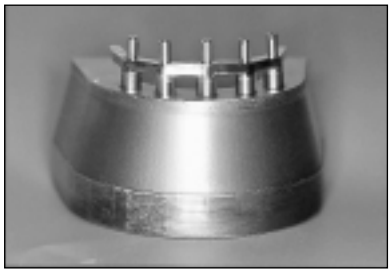
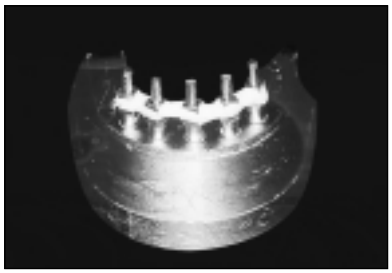


Fig 1 *(Left)* Experimental cast (master framework on master model).

Fig 2 *(Right)* Group A: Splinted impression copings on master cast (self-curing acrylic resin).



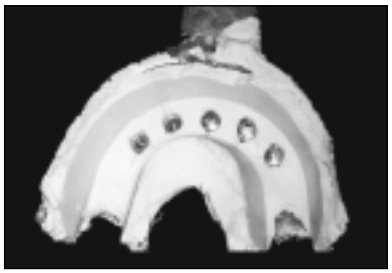


Fig 3 *(Left)* Group B: Splinted impression copings on master cast (light-curing acrylic resin).

Fig 4 *(Right)* Group C: Plaster impression with abutment analogues.

Table 1 Frequencies of the 4 Strain Gauges in Each Group*

	Group A				Group B				Group C			
Impression no.	1	2	3	4	1	2	3	4	1	2	3	4
1	203	292	318	541	175	404	274	200	313	140	090	003
2	320	226	112	340	6211	2441	290	663	155	492	076	458
3	003	339	201	320	278	536	201	564	353	194	317	181
4	325	050	039	067	221	194	016	304	352	192	966	006
5	125	252	082	344	388	920	474	376	766	373	312	148
6	046	203	868	380	005	126	127	801	355	094	631	063
7	193	131	092	159	879	713	655	473	060	248	181	016
8	306	271	086	468	3441	6401	094	186	882	495	169	295
9	017	349	352	002	157	200	388	241	145	212	293	224
10	002	381	467	286	202	242	114	766	274	140	409	312
11	024	024	181	012	032	282	223	224	580	210	111	574
12	345	248	233	115	212	639	803	682	221	695	269	018
13	542	498	475	456	2131	332	853	011	193	405	734	015
14	121	260	141	135	156	233	070	451	226	533	094	259
15	020	782	560	823	060	519	623	385	062	020	279	143

*Absolute values in microstrains.

Table 2 Means and SD for All Measurements

		Strain gauge			
Group	n	1	2	3	4
A	15	172.80 (164.46)	287.07 (183.06)	280.47 (229.88)	296.53 (223.91)
B	15	229.53 (157.97)	614.93 (471.17)	480.33 (393.19)	421.80 (235.21)
C	15	329.13 (241.04)	296.20 (191.76)	328.73 (260.03)	181.00 (175.13)

Group B: Dual-cured acrylic resin (Accuset, EDS, Hackensack, NJ) was used as the splinting material, and polyether was used as the impression material (Fig 3).

Group C: Impression plaster (Kerr Snow White Plaster No. 2, Kerr USA, Romulus, MI) was used as both the splinting and impression material (Fig 4).

The accuracy of the fit of the framework on the casts obtained from the different groups was tested using strain gauges. The examination method and criteria were previously described.[11]

Results

Table 1 displays the frequencies of the 4 strain gauges in each group. Table 2 shows the means and standard deviations for all measurements, and Table 3 shows the means and standard deviations for the 3 groups. A multiple analysis of variance (ANOVA) with repeated measures was performed to test for significant differences between the 3 groups. The ANOVA (Table 4) revealed statistically significant differences between the 3 groups. Additional ANOVA were carried out to locate the source of the difference. These statistical analyses revealed that a significant difference existed between groups A and B ($F_{(1)} = 7.96$; $P < .05$), between groups C and B ($F_{(1)} = 6.56$; $P < .05$), but not between groups A and C ($F_{(1)} = .25$; $P > .05$). The means displayed in Table 3 show that groups A and C were significantly more accurate than group B, and their overall discrepancies were also significantly smaller. Yet significant differences were also found within the groups, resulting in a significant interaction of group × strain gauge. Further analysis of variance revealed the source of interaction; significant differences existed between the groups only in strain gauges 2 ($F_2 = 6.60$; $P < .01$) and 4 ($F_2 = 4.46$; $P < .05$), where groups A and C were more accurate than group B. Yet in strain gauges 1 ($F_2 = 2.92$; $P > .05$) and 3 ($F_2 = 1.60$; $P > .05$) no significant differences were found between the groups. In general, significant differences were found between the 3 groups, but those differences did not repeat themselves in each of the 4 strain gauges.

Discussion

There is much discussion in the dental literature concerning the accuracy of fit between superstructures and abutments.[7,10,11] This standard of fit is required because of the unique quality of the implant-bone relationship. A misfit can result in the accumulation of preload and loading stresses in the restorative complex, causing problems ranging from screw loosening to loss of osseointegration.[4–9] Thus, the task is to create as accurate a fit as is clinically possible to avoid the accumulation of stresses and strains that will result in uncontrolled implant loading through the superstructure.[12–15]

The splinted impression technique has been shown to be a primary factor in increasing the fitting precision of the restorative complex.[10,11,16] In this study, impressions using copings splinted with either autopolymerizing acrylic resin or plaster were more accurate than those that used copings connected with a dual-cured acrylic resin. The intragroup readings (Table 4) were consistent,

Table 3 Means and SD for the 3 Groups

Group	Mean	SD
A	259.22	133.93
B	436.65	233.68
C	283.77	100.11

Table 4 Multiple Analysis of Variance with Repeated Measures Between the 3 Groups

	Sum of squares	Degrees of freedom	Mean square	F (*P*)
Between groups	1109172.08	2	554586.04	5.61*
Within groups	639420.91	3	213140.30	4.09†
Group × strain gauge‡	885993.39	6	147665.56	2.71†

*$P < .01$.
†$P < .05$.
‡Interaction between the 3 groups and the 4 strain gauges. Analysis of variance was carried out to determine whether the pattern of significant differences that was found in general between the groups repeats itself in each of the 4 strain gauges.

indicating that the technical procedures used throughout the study were accurate. The technique using dual-cured acrylic resin was significantly less accurate than the other 2 techniques. This may be caused by the incomplete polymerization of the dual-cured acrylic resin.[17–20] Even after a curing time of 24 hours, 25 to 45% of the double bonds remain unreacted.[17] Another reason may be that the shrinkage during polymerization of the dual-cured acrylic resin creates stresses at the impression coping/acrylic resin interface.[17] There is also significant importance to the intensity and direction of the light source that might have a negative influence on the adaptation of the dual-cured acrylic resin to the coping.[21,22]

Impression plaster sets rapidly, is quite accurate and rigid, and does not bend or distort[23]; it is also easy to manipulate, less time consuming to use, and less expensive. The exothermic reaction is negligible. A major disadvantage, however, is that plaster can be used only in completely edentulous patients in whom there are no anatomic limitations such as bony undercuts.

Conclusions

Under the conditions of the present study, impression techniques using autopolymerizing acrylic resin or impression plaster as splinting materials were significantly more accurate than those using dual-cured acrylic resin as a splinting material. Based on the results of this study, impression plaster would seem to be the material of choice for completely edentulous patients.

Acknowledgments

The authors express their deep appreciation to Ms Birgitta Sjoholm, Director, International Marketing, Nobel Biocare, Göteborg, Sweden, for her generous support; to Mr Y. Dror, Director, Department of Experimental Engineering, Vishey Israel, Holon, Israel, for invaluable assistance in the acquisition of the data; to Dentorient Fuss, Tel Aviv, Israel, for their assistance; to Mr Z Chakir, Tel Aviv, Israel, for his assistance; to Drs TJ Balshi and GJ Wolfinger for their assistance; to Dr BI Cohen, Hackensack, New Jersey, for his assistance; and to Ms Rita Lazar for her editorial assistance.

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