The influence of impression coping splinting on the accuracy of the open-tray technique

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The objective of this study was to examine the effect of splinting of the impression copings on the accuracy of the cast when the open-tray technique is used. An epoxy master cast with 3 implants was fabricated. The first 2 implants were parallel to each other and perpendicular to the horizontal plane (implants A and B), and the third implant (implant C) had a 25-degree inclination. A passively fitting metal framework that was fabricated over this master cast was used to measure accuracy of fit. Ten casts were fabricated from this epoxy resin master cast with the use of polyether material and the open-tray technique. For the first 5 casts, the impression copings were splinted with dental floss and autopolymerizing acrylic resin; in the next 5 casts, the impression copings were not splinted. The metal framework in the master cast was fixed in the new specimens, and the microgap between this prosthesis and the implant analogs was evaluated. The specimens were observed under an optical microscope, and microgap measurements were made on photographs taken at a standardized magnification of 40×. The inclined implant C had the smallest mean microgap among the 3 implants, but the differences were not statistically significant. Microgaps for all 3 implants were smaller when they were splinted, but the difference from the mean of the nonsplinted counterpart was statistically significant only for the inclined implant. The results suggest that there is no clinical advantage in splinting the impression copings for parallel implants. On the other hand, when the implants are not parallel, splinting of the impression copings can result in greater accuracy of the fabricated cast.

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The accuracy of the master cast for implant restorations is an important factor to achieve the needed precision of fit between the implant abutments and the prosthesis. The first report concerning the accuracy of an implant impression was published in 1985.[1] The authors used the open-tray technique and performed simultaneous intraoral splinting of the implant impression copings with acrylic resin.

Since that time, 2 implant impression techniques have been established in clinical practice: the open-tray and closed-tray techniques, each combined with the indicated impression copings. With the open-tray technique, in cases of multiple implants, the impression copings can be splinted or freestanding. Although numerous studies have examined the implant impression accuracy—and the corresponding accuracy of the working cast—of the open-tray technique, there is no clear clinical guideline about the efficacy of splinting or not splinting the impression posts.[2-16]

In vitro studies by Papaspyridakos et al examined the impression accuracy associated with splinted or nonsplinted implant impression copings when polyether impression material and the open-tray technique were used.[2,3] Splinting of the impression copings with autopolymerizing acrylic resin resulted in more accurate implant impressions.

The greater accuracy of the open-tray technique is supported by many researchers.[4-6] However, not all studies have considered the important parameter of impression coping splinting. Most studies examined implants that were parallel to each other.[4,6,7,9,10] Fewer studies have investigated nonparallel implants.[3,5,8,13]

Reddy et al compared the impression accuracy of the open- and the closed-tray techniques for parallel and nonparallel implants.[11] Both techniques resulted in the same impression accuracy, regardless of the implant inclination.

Studies by Gallucci et al and Mpikos et al have shown that parallel implants result in more accurate impressions than nonparallel implants.[8,12] Mpikos et al examined 4 parallel internal and external connection implants, 1 impression material (polyether), and 2 impression techniques (open and closed tray).[12] The impression technique had no effect on the implant impression accuracy when internal connection implants were used.

Tsagkalidis et al compared the impression accuracy of splinted and nonsplinted impression copings in association with the open- and closed-tray techniques.[13] They found no statistically significant differences between splinting and not splinting for implant inclinations up to 15 degrees. When the inclination of the implant increased, splinting resulted in more accurate impressions.

The current literature does not provide definitive proof as to which implant impression technique is the most accurate.

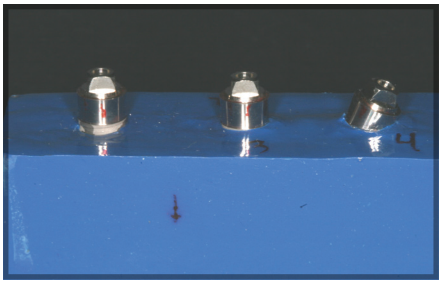


Fig 1. Master cast.

Fig 2. Metal framework used to measure the marginal gap.

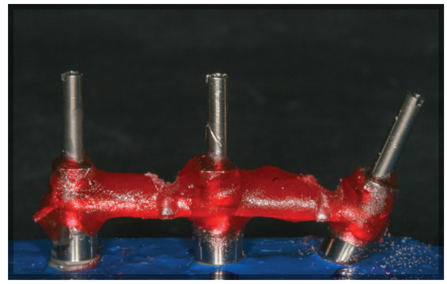


Fig 3. Splinted implant impression posts.

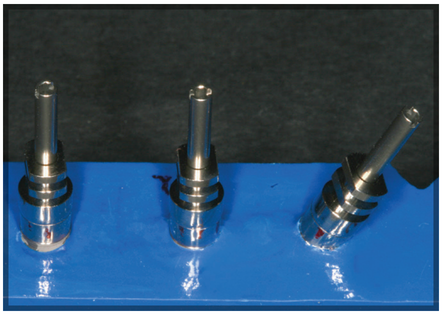


Fig 4. Freestanding implant impression posts.

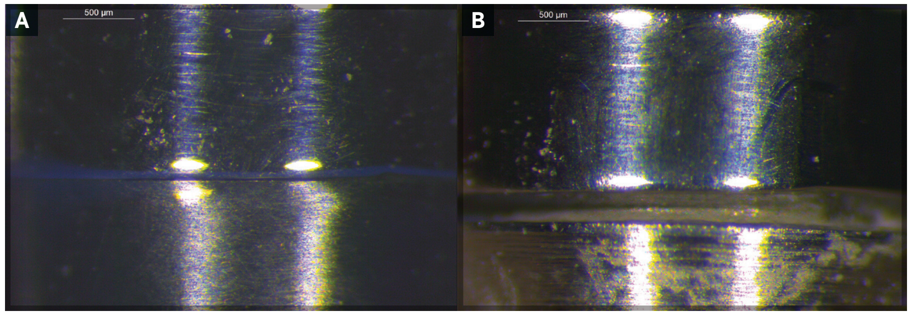


Fig 5. Resulting marginal gaps. A. Parallel, nonsplinted implant (implant B). B. Nonparallel, nonsplinted implant (implant C).

Parameters such as implant type (internal or external connection), impression coping splinting, and implant inclination have a direct impact on the impression accuracy and the resulting precision of the master cast.[14-16]

The objective of this study was to examine the effect of splinted and nonsplinted impression copings on the accuracy of the cast when the open-tray technique is used for parallel and inclined implants. The null hypothesis was that there would be no differences in the accuracy of casts produced from impressions with splinted and nonsplinted impression copings for parallel and nonparallel implants.

Materials and methods

An epoxy resin master cast was fabricated utilizing 3 external connection dental implants with a diameter of 3.4 mm (Xive TG, Dentsply Sirona). The implants were embedded in the epoxy resin with the use of an electronic paralleling device (Fig 1). Two implants (implants A and B) were placed perpendicular to the horizontal plane and parallel to each other (0-degree inclination), while the third implant (implant C) was placed with a 25-degree inclination to the vertical plane.

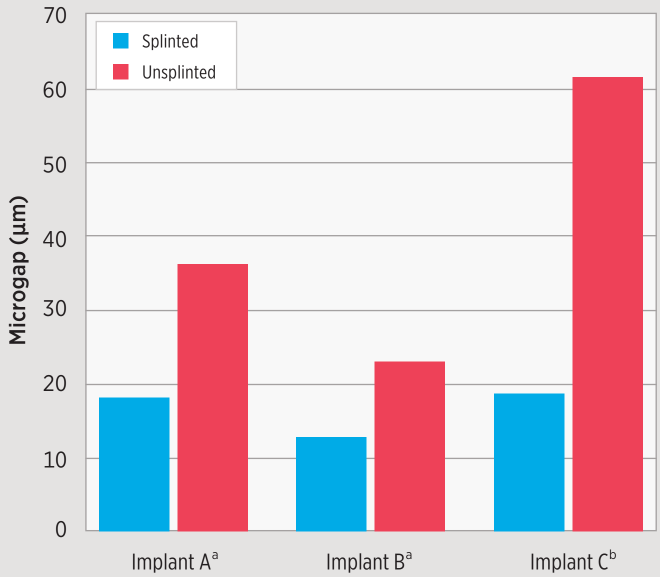
A screw-retained metal framework was waxed, sprued, and cast out of a base metal alloy. After casting, the framework was cut, fit, and soldered to achieve passive fit over the implants (Fig 2). The framework was initially screwed on the first implant analog (implant A) with a torque of 20 N/cm. The resulting initial microgap at the implant-analog surface for implants B and C was measured with the use of an optical microscope (Leica Microsystems), and photographs of the fitting surfaces of all the analogs were taken at a standardized magnification of 40×. The framework was later fixed by the retaining screw on the inclined analog (implant C), and the fit was evaluated accordingly on the other 2 implants (implants A and B). These initial microgap values were recorded for each specimen, to be used for the calculation of the final microgap value.

Rotary instruments were used to create 5 nonparallel, 2-mm-deep grooves on the sides of the master cast surface to allow precise orientation of the custom tray. A light-polymerizing resin tray material (Triad, Dentsply Sirona) was used for the fabrication of 2 custom impression trays, 1 for each impression technique tested.

Closed-tray transfer copings (Xive TG impression posts D, 3.4-4.5 mm, Dentsply Sirona) were connected to the implants on the epoxy resin cast. The consistency of the impression material thickness was ensured by injecting addition silicone material (Exabite II NDS, GC America) around the copings, creating a consistent 2-mm space. The tray material was packed over the silicone relief and carefully positioned over the copings on the master cast until the orientation grooves were completely engaged. Light polymerization was performed with a visible light–curing device (Triad 2000, Dentsply Sirona) for 6 minutes. Following polymerization, the trays were stored at room temperature for 24 hours according to the manufacturer's instructions. The same custom tray was used for all 5 impressions in each group. Polyether tray adhesive material was applied on the inner surface of every custom tray and allowed to dry for 30 minutes to ensure uniform treatment for all specimens.

Long open-tray transfer copings (Xive TG impression copings, Dentsply Sirona) were connected to the implants with a torque of 20 N/cm, according to the manufacturer's instructions. A polyether impression material (Impregum Penta, 3M ESPE) was used for all impressions. The material was mixed in a special

Chart. General mean microgap for implants A, B, and C (n = 5).



[a]No statistically significant difference between splinted and nonsplinted implants ($P > 0.05$; analysis of variance).

[b]Statistically significant difference between splinted and nonsplinted implants ($P < 0.01$; analysis of variance).

Table. Effect of interaction of technique and inclination on general mean marginal microgap of implant C.[a]

		Microgap (µm)		95% CI	
Technique	Inclination[b]	Mean	SE	LB	UB
Splinted	A	37.33	16.77	1.78	72.89
	C	0	16.77	–35.55	35.55
Nonsplinted	A	122.86	16.77	87.31	158.42
	C	0	16.77	–35.55	35.55

Abbreviations: LB, lower bound; UB, upper bound.

[a]The dependent variable is the general mean marginal microgap of implant C.

[b]Framework fixed on implant A (0-degree inclination) or implant C (25-degree inclination).

automixing device (Pentamix 2, 3M ESPE) and syringed around the copings, while the tray was loaded and positioned to engage the orientation grooves. Finger pressure was applied until polymerization was completed.

Ten impressions, 5 for each group, were performed using the open-tray technique. In the first group, the impression posts were splinted by means of dental floss and a 3- to 4-mm-thick band of autopolymerizing resin (GC Pattern Resin, GC America) in the middle of their height (Fig 3). In the second group, the impression posts were left unsplinted (Fig 4). The impressions were visually inspected for the presence of bubbles or other deficiencies and stored at room temperature for 24 hours. They were washed with tap water and dried with an air stream.

External hex implant analogs (Xive TG implant laboratory analogs, Dentsply Sirona) were hand tightened over the impression posts, and the new master casts were fabricated using hard dental stone. Type IV die stone material (Silky Stone, Whip Mix) was mixed with water, in the ratio suggested by the manufacturer, in a vacuum mixing device for 30 seconds. The mixed stone was poured in the impressions and allowed to set for 24 hours. Five specimens (stone casts), each containing 3 implant analogs, were fabricated for each group.

The resulting microgaps were evaluated using the passively fitting cast framework that was fabricated on the initial epoxy resin master cast. The framework was initially screwed on the first implant analog (implant A) with a torque of 20 N/cm. The resulting microgap was measured at the implant-analog surface for implants B and C with the use of an optical microscope. Photographs of the fitting surfaces of all the analogs were taken at a standardized magnification of 40× (Fig 5). Six photographs were taken at the contact surfaces of each implant analog, 2 at each of the mesial, distal, and labial analog surfaces. Three measurements were performed for each photograph, and their mean value was calculated. The photographs were analyzed with the use of a software program (Adobe Photoshop CS4, Adobe Systems). The 3 surfaces of each analog were evaluated, and a general mean value (g-mean) was calculated from the mean values for the microgap on each surface for every implant. The framework was later fixed by the retaining screw on the inclined analog (implant C), and the fit on the other 2 implants (implants A and B) was evaluated accordingly. The final microgap value for each measurement was calculated by subtracting the initial microgap value from the new microgap value.

The microgap values were statistically evaluated by ANOVA and categorical regression analysis with the use of a statistical software program (SPSS 13.0, IBM).

Some details of this experimental method have also been reported in a previous publication.[17]

Results

The g-mean (overall) results from the measurements of the microgap at the implant-framework interface are presented in the Chart. There were differences in the g-mean values of the microgaps for the 3 implants and the 2 techniques (splinted and nonsplinted), but the differences were statistically significant only for the inclined implant (C) ($P < 0.05$; ANOVA).

The Table represents the interaction of the 2 influencing factors, *technique* and *inclination*. When the framework was fixed on implant C (25-degree inclination), no marginal gap value was detected with either technique. When the framework was fixed on implant A (0-degree inclination), the marginal gap value was 37.33 µm when copings were splinted and increased to 122.87 µm for freestanding copings. As indicated by these findings, the marginal gap on implant C was affected by both the inclination and the technique.

A categorical regression test was performed for implants A and C to further investigate the interaction of technique and inclination as well as their impact on the marginal gap. This analysis was not performed for implant B, since no statistically significant differences were noted on the previous statistical tests. Categorical regression results indicated that, for implant A, the impression accuracy was influenced 98.5% by the inclination of the implants and only 1.5% by the splinting. Implant C was affected 75.0% by the implant inclination and 25.0% by the technique (splinting or no splinting).

Discussion

The purpose of this study was to examine the effect of splinted and nonsplinted impression copings on the accuracy of the cast when the open-tray technique was used for parallel and inclined implants. The null hypothesis was that there would be no differences in the accuracy of casts produced from impressions with splinted and nonsplinted impression posts for parallel and nonparallel implants. The results supported partial rejection of the null hypothesis, indicating that the impression technique has a direct impact on impression accuracy, especially for nonparallel implants.

Al Quran et al compared different impression techniques for parallel implants: closed tray, open-tray nonsplinted, and open-tray splinted.[4] All techniques resulted in accurate impressions, and any differences were clinically acceptable. All the implants in their study were parallel, however, unlike the present study, which included an inclined implant. Moreover, the experimental model in the study by Al Quran et al was complicated, including many special manufacturing techniques.[4] In contrast, the present study used a simpler experimental laboratory model and was more clinically relevant since it incorporated an inclined implant fixture. Nevertheless, the results of both studies suggest that, for parallel implants, the accuracy of the resulting impression is acceptable regardless of the impression technique.

A systematic review by Kim et al suggested that splinting of impression copings resulted in superior impressions compared with other impression techniques, especially when multiple implants are used.[14]

Studies of implant impression techniques present great variety, and researchers follow different experimental methods, materials, and statistical analyses. For this reason, it is difficult to compare the findings of many research projects. If the existing literature is classified by whether or not the implant impression copings were splinted and the type of impression material, the studies of Papaspyridakos et al, Reddy et al, and Kim et al support splinting of impression copings.[2,3,11,14] In contrast, Baig found no statistically significant difference between splinting and not splinting.[6,9] The authors of the present study suggest that the closed-tray technique should be followed only to facilitate clinical procedures, since both techniques have been proven to be of equal accuracy.

In the present study, the gap between the metal framework and the implant analog was calculated through measurement on photographs taken through an optical microscope. This procedure was first applied on this research project and is clinically relevant since it incorporates the use of an inclined implant fixture.

Another factor that prevents direct comparison of different research findings is the implant connection type (internal or external). This parameter could influence impression accuracy in the following manner: On external connection–type implants, the impression coping fits over an external hexagon (0.7-1.0 mm high). On internal connection–type implants, the impression coping fits inside the implant, to a depth of 2-4 mm; therefore, it is harder to remove the coping when the open-tray technique is used.[12] In the present study, external connection–type implants were used. The advantage of this type of connection is that the abutment fits directly over the implant body without any other interference that could result in inaccuracies during measurements.

A systematic review by Papaspyridakos et al, based on 72 in vitro and 4 clinical studies, concluded that the splinted impression technique is more accurate in most cases.[3] Implant angulation also affects the accuracy of the implant impressions. However, there are insufficient studies to test the effect of implant connection type.[3]

Splinting of implant impression copings is a time-consuming procedure that could result in distortion and consequent impression inaccuracy due to acrylic resin shrinkage over time.[18] Nevertheless, the present study suggests that splinting of the implant impression copings results in more accurate impressions and therefore in a more precise fit of the implant restoration, especially when implants are not parallel.

Conclusion

When the open-tray technique and polyether material are used for the impression of parallel implants, impression coping splinting does not result in more accurate impressions. However, splinting of the impression copings results in more accurate impressions when the open-tray technique and polyether impression material are used for nonparallel implants.

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