

Comparison of the accuracy of fixture-level impression making after splinting prosthetic components

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ABSTRACT

Considering the effects of different impression-taking techniques on the dimensional accuracy of the final cast and controversies over the best technique in implant dentistry, the present study was undertaken to evaluate the effects of three different open-tray impression techniques on the dimensional accuracy of final casts for implants. A two-piece metallic index was prepared and a patient's jaw was simulated by placing self-cured acrylic resin in the lower part of the index. Then 2 holes were produced in the acrylic resin at a specific distance from each other, and the analogs were placed in these holes. Three different open-tray impression techniques were evaluated using the upper segment of the index, which mimicked the specific tray. The dimensional accuracy of the casts was evaluated by comparing the distances between the predetermined points on the implant analogs and the positions of the points with similar distances on the master model. A digital caliper (accurate to 0.01 mm) was used to measure the distances. The differences in the measurements on the final casts were analyzed with SPSS 16, using Kruskal-Wallis test. Post hoc Mann-Whitney U test was used for two-by-two comparisons. There was a significant difference between the group in which the analogs and impression copings were not splinted and the group with impression coping splinting without analog splinting and the group with simultaneous splinting of the impression copings and implant analogs, in relation to distances between similar points on the master model. In this context, the second and third techniques better reconstructed the positions of the points. Splinting of impression copings with Duralay acrylic resin prevented the movement of impression copings during the impression-taking procedure and despite an increase in the accuracy of impression taking during splinting of analogs by Duralay acrylic resin, the increase in accuracy was not significant statistically; therefore, splinting of the impression copings without splinting of the analogs is recommended due to an increase in impression-taking accuracy and facilitation of laboratory procedures.

Keywords: Dental implants; dental impression techniques; splinting; prosthetic components; acrylic resin.

1. INTRODUCTION

The advent of dental implants led to a revolution in the field of dentistry, promoting complete or partially edentulous patients to use dental implants to compensate edentulism. Widespread research has been undertaken to increase the longevity of dental implants. One of the study fields in this context is to increase the adaptation accuracy of implant-supported prostheses and the accuracy of impression making, which include improvements in clinical restorative techniques and ensuring the quality of the techniques and materials in different steps of fabrication of implant-supported prostheses [1-3].

The first step in the fabrication of import-supported prostheses is to accurately register the 3D position of implants in the oral cavity, which is achieved through the impression-taking procedure [4,5]. The accurate transfer of the position of implants to casts depends on several factors, including the type of the material used for impression taking, the position and angulation of implants, the accuracy of the connection of analogs to the impressions, the type of the stone used and the technique used to prepare the stone cast [6,7].

Each implant has a specific impression coping which can be used for accurate registration of implant position and its transfer to the cast. Transferring the impression coping along with the impression tray from the patient's oral cavity is an important

and vital step inaccurate registration of the position of the implant [8].

Of all the impression-making techniques introduced to date, open tray and closed tray techniques have received more attention and emphasis [8].

Researchers who support the closed tray technique believe that seating of copings within the impression material out of the oral cavity increases visibility and access [9]. The chief disadvantage of this technique is that if the impression copings are not accurately placed within the impression material the final prostheses will not exhibit an accurate fit [8]. Many researchers, including Spector et al and Rodney et al have shown that the open tray method is more accurate than the closed tray technique [8]. The type of the impression material, too, affects the accuracy of the final prosthesis; it has been shown that the accuracy of the impression increases with an increase in the hardness of the impression material [10-13].

In addition to the technique used for taking impressions and the type of the material used, splinting of impression copings affects the accuracy of implant impression making. It has been reported that the most common reason for the inaccuracy of the implant impression is a change in the position of impression copings within the impression and in the casts as a result of it. In

this context, it is possible to splint the copings to help preserve their positions during retrieval of the impression in the open tray technique [14,15].

Apart from the advantages mentioned, problems might occur during splinting of impression copings, including the possibility of the fracture of the splint material or shrinkage resulting from the polymerization of the acrylic resin used for splinting; use of a proper material for this purpose and use of a proper technique such as maintaining a small space between the acrylic components of the splint and filling the gaps after shrinkage of the independent segments of the splinting material might result in a decrease in shrinkage during polymerization [16-18].

A proper material for splinting impression copings is the auto-polymerizing Duralay acrylic resin because it exhibits low shrinkage during polymerization [14,19]. The results of several studies have shown that splinting impression copings with a proper material increases the accuracy of impression taking [20,21].

Research has shown that no stresses should be exerted on the implants in order to preserve the health of the tissues around the final implant-supported prostheses [22].

Researchers have concluded that the passivity of the implant-supported prosthesis is an important prerequisite for achieving an

implant with proper longevity and for counteracting problems after the delivery of the prosthesis such as screw loosening, screw fracture and bone loss around the implant; however, achieving a prosthesis with completely passive fit is almost impossible [23].

Therefore, attempts should be done to decrease the odds of prosthesis misfit, increase the accuracy of impression-taking steps and manufacture more accurate casts to minimize the problems associated with implant-supported prostheses [24,25].

To date, extensive research has been devoted to the effects of different impression-taking techniques, the type of impression material, the angulation of implants relative to each other, splinting of impression copings and the splint material on increasing the precision of the fit of prostheses. However, it appears that after placing the fixture analogs on impression copings and pouring of the final cast, expansion of the stone during setting might result in the displacement of the impression coping and analog within the impression material [16, 6, 27], which might be a source for errors in the fabrication of the final implant-supported prosthesis.

Therefore, the current study was performed to evaluate the accurate position of implants at the fixture level (open tray) using two different techniques for splinting prosthetic components during impressing the taking and preparation of casts.

2. MATERIALS AND METHODS

A total of 8 samples were included in the present in vitro study, considering the results of a pilot study and by considering a difference of 0.02 unit (significant clinically) at standard deviation=0.012, $\alpha=0.05$ and a study power of 80%; however, to increase the validity of the study, the sample size was increased by 20% and 12 samples were included in each group.

To standardize the samples and the impression-taking process, first an aluminum index was designed by a CNC unit and fabricated (figure 1). The index was composed of two components: segment A (the lower segment) and segment B (the upper segment), which were coupled with male and female parts and fixed. Two holes in the direction of impression copings were placed in the segment B, which played the role of the impression tray; the diameter of the holes was greater than the diameter of the impression copings so that the heads of the impression copings would exit the holes.



Figure 1. Aluminum Index.

In addition, the dimensions of the cavity were consistent with the length of the impression copings (Pick-up, Hex, Short

Impression Copings, Dentis Corporation, South Korea) so that the head of the impression coping screw would be positioned at least 2 mm out of the hole, making it easy to unscrew the screw from the outer side. The length, diameter and gingival height of the copings were 23, 5 and 2 mm, respectively (Figure 2).



Figure 2. Inserting fixture analogs by surveyor.

In order to prepare a model similar to a human jaw with implants, first the segment A was coated with Vaseline. The auto-polymerizing acrylic resin (Ivoclar, Vivadent AG, Liechtenstein) was poured into the segment to fill its height, which mimicked the patient's jaw. A dental milling machine was used to create 2 holes in the acrylic resin, measuring 4.25 mm in diameter and 12 mm in-depth, so that 1 mm of the analog head would be positioned out of the acrylic resin to make it possible to measure the distance between the two analogs. To make sure that the analogs were parallel, the positions were evaluated with the use of a surveyor and the analogs were placed on a transverse plane. The two analogs (Lab Analog, Dents Corporation, South Korea) were

placed within the holes with the use of auto-polymerizing acrylic resin (figure 2). After a complete setting, each analog was numbered, with the number 1 or 2 being written on each analog. The distance between the most distal points of the analogs on the model was measured with the use of MITUTOYO digital caliper (Digital Vernier Caliper, 0-150 mm; 0.01 precision). To this end, first a line was drawn parallel to the horizontal width of the metallic index at the most distal points of both analogs tangent to them and the distance between these two lines was measured with calipers by one operator and recorded. Considering the ICC coefficient, the mean of 4 measurements was used to report this distance, which was considered as the real distance between the two implants.

The three study groups were compared with each other in order to compare the different statuses of splinting of segments.

Group 1: The impression-taking procedure was carried out using the open tray technique without splinting the prosthetic components and the cast was prepared conventionally.

Group 2: The impression copings were splinted with the use of Duralay acrylic resin (Pattern Resin LS, GC America Inc, USA) and an open tray technique was used to take impressions. The cast was poured conventionally.

Group 3: The impression copings were splinted with Duralay acrylic resin and the open tray technique was used to make an impression. Before pouring the cast, the analogs, too, were splinted with Duralay acrylic resin.

Group 1 procedural steps: First the impression copings we placed on the analogs and the open tray technique was used for taking impressions with the use of additional silicon materials with putty and wash consistency (Panasil, Additional-Silicone Kettenbach/Germany). To this end, the additional silicon impression material was placed within segment B in putty consistency and the wash was injected around the impression copings. Then it was fitted on segment A until it set completely. Then the screws of the impression copings were unscrewed from the upper part of segment B and segment B was removed along with the impression material. Then appropriate analogs were connected to the impression copings within the putty. The acrylic resin in segment A was eliminated and Type IV stone (with setting expansion of approximately 0.1%) was replaced with it. Then the combination of segment B and the impression material containing impression copings with suitable analogs were placed with Type IV stone (Welmix, GC America Inc., USA) with a powder-to-liquid ratio of 100 gr of powder to 20 mL of water, with a mixing time of 1 minute on a vibrator. After the stone set (after 40 minutes) the distance between the outermost parts of the analogs was measured using the method described above. The distance was measured 4 times by one operator using a digital caliper and the mean was reported.

Group 2 procedural steps: In order to standardize the volume of the splinting material in this group, the first Vaseline was applied to segment B. Then the putty impression material was placed within it and segment B was fitted on segment A to set, which contained the impression copings. The impression material was removed from segment B along with the impression copings. The periphery of the impression copings was marked and the impression material was cut with a #13 scalpel blade. This way the

index was fabricated of the putty material, measuring 4×20×4 mm (Figure 3).

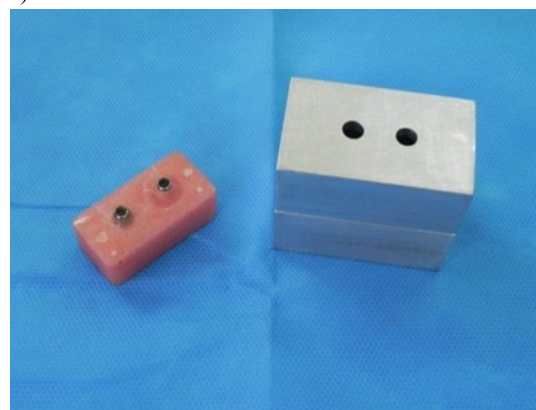


Figure 3. Representative model of analogs in acrylic.

Then Duralay acrylic resin was poured within the index, which set after a while. Then the index was removed and the Duralay splint was sectioned in the middle at a thickness of a carbon disk. This way the volume of the Duralay acrylic resin decreased to the thickness of a carbon disk, resulting in a decrease in shrinkage during polymerization of the acrylic resin. After placing the impression copings that had been prepared and filling the gap between the two segments of Duralay splint with Duralay acrylic resin and after completion of polymerization (almost 20 minutes), an impression was taken and the other steps were carried out in a manner similar to those in group 1.

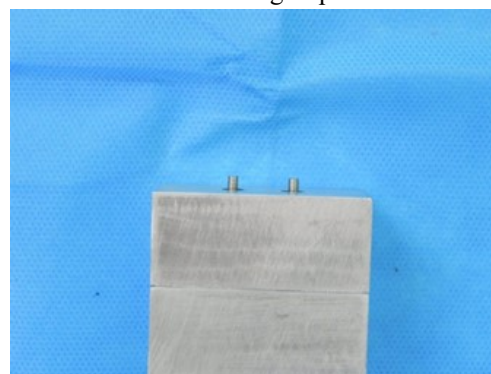


Figure 4. The closed view of index with impression copings integrated.

Group 3 procedural steps: Using the technique described above, the impression copings were splinted with a low volume of Duralay acrylic resin. The putty impression material was placed within segment B and the wash was injected around the neck of impression copings. After the complete setting of the impression material, the screws of impression copings were unscrewed and appropriate analogs were connected to them. In this technique, in order to decrease the possible errors resulting from the expansion of the stone, the analogs were splinted together. In order to standardize the dimensions of the Duralay splint around the analogs, after taking the impression using the splint technique, appropriate analogs were connected to impression copings and the impression material around the analogs was covered with Vaseline. Subsequently, the putty impression material was placed around the analogs so that 2 mm of their head was out of the material and the interface between the analogs was cut with a #13 scalpel blade and removed; this way an index was fabricated, which measured 4×20×4 mm in dimensions (figure 4). Then the Duralay splint material was poured within the index. After the

complete setting of Duralay acrylic resin, it was sectioned in the middle at a thickness of a carbon disk. Then the thickness of the disk was filled with Duralay acrylic resin and the analogs were re-attached to minimize the possible error resulting from polymerization of the acrylic resin. It should be pointed out that a new index was fabricated under the same conditions after the index was used for 5 consecutive times (10). Subsequently, the

3. RESULTS

ICC was used to assess agreement between different measurements made at different time intervals by the same observer, which yielded a coefficient of >95%. Therefore, in order to report the distances, the mean of the 4 measurements was used, and the values in each group were recorded and compared with each other and with the distance on the master model.

The man distance in the first technique (impression taking without splinting the impression copings and the analogs) was 18.44 ± 0.042 mm. One-sample t-test revealed a difference of 0.028 mm between the measurement made with this technique and the real distance (18.4 mm), which was statistically significant.

The mean distance in the second technique (impression taking with splinting of the impression copings without splinting the analogs) was 18.42 ± 0.13 mm. One-sample t-test showed a difference of 0.005 mm from the real distance (18.42 mm) with the use of this technique, which was not significant statistically.

The mean distance with the use of the third technique (impression taking with concomitant splinting of impression copings and analogs) was 18.42 ± 0.9 mm. One-sample t-test revealed a difference of 0.0025 mm from the real value (18.42) with the use of this technique, which was not significant statistically.

To compare the accuracy of impression taking between the three groups, normal distribution of data in the three groups was assessed with Kolmogorov-Smirnov test, which revealed that data were not distributed normally ($P < 0.05$). Therefore, Kruskal-Wallis test was used to compare the means between the three groups. The results of the test showed significant differences between the three groups ($P < 0.05$) (chart 1).

Mann-Whitney U test was used for two-by-two comparisons of the groups. The results of this test showed a significant difference in the mean distances between groups 1 and 2 ($P < 0.001$). In addition, there was a significant difference in the mean distances between groups 1 and 3 ($P < 0.001$). However, there was no significant difference in the mean distances between groups 2 and 3 ($P = 0.291$).

In the present *in vitro* study, 3 different techniques were used for taking implant impressions. The distance between the analogs was measured on the master model. The minimum positive differences were detected in the technique in which impression copings and analogs (0.0025 mm) and the technique in which impressions were taken after splinting the impression copings without splinting the analogs (0.0058 mm), with no significant difference between the two techniques. The maximum positive error in the distance between the analogs was detected in the technique in which the impressions were taken without splinting the impression copings and analogs (0.028 mm) and the distance measured with this technique was significantly greater than that measured with the two other techniques.

acrylic resin in segment A was removed and the stone cast was poured and measured in the same manner described for groups 1 and 2.

Data were analyzed with descriptive statistical methods (means \pm standard deviations) using SPSS 16. Kruskal-Wallis test was used to compare the means between the three study groups. Statistical significance was set at $P < 0.05$.

Ongul *et al* evaluated the accuracy of two implant impression-taking techniques and reported that splinting of the implant components increased the accuracy of the direct impression-taking technique. In addition, in that study splinting with acrylic resin resulted in greater accuracy compared to the bar fabricated with the use of light-cured composite resin [28].

Hariharan *et al* reported that splinting with acrylic resin was more accurate than the technique without splinting. In the present study, too, Duralay acrylic resin was used for splinting. The results of these two studies are consistent [29].

Assif *et al* reported that the impression-taking accuracy increased by rigid splinting of impression copings before taking impressions, which was attributed to the prevention of separate movements of impression copings during the impression-taking procedure by rigid splinting of the components together [30]. Avila *et al*, too, reported that splinting improved implant impression taking [31].



Figure 5. Putty index for splinting of analogs.

Carbal *et al* showed that open tray impression technique with splinting of the components resulted in more accuracy compared to the closed tray and open tray technique without splinting and open tray technique with splinting without sectioning, on the condition that the sectioning and re-attaching technique was used [32].

Tarib *et al* reported that the open tray technique in association with splinting, followed by cutting the splint material and filling the gap between the splinted components did not result in any considerable difference from the open tray technique with and without splinting and it was more accurate than the closed tray method [33].

In the present study, the accuracy of taking impressions with splinting of impression copings and taking impressions with concomitant splinting of impression copings and analogs was almost the same, with significantly greater accuracy compared to

taking impressions without splinting, consistent with the results of all the studies above.

However, some studies have reported results that are different from those of the present study. Kim et al reported that during the impression-taking procedure the non-splinted group exhibited the least changes in the position of implant components. Based on the results, they suggested that splinting of impression copings should be avoided in the direct technique [34]. These results are not consistent with the results of the present study. In the present study, the splinting technique was more accurate from the non-splinting technique of impression copings; such a discrepancy between the results of these two studies might be attributed to the absence of sectioning and reattachment of the splinting material to compensate polymerization shrinkage in the study above.

Del Acqua *et al* reported that splinting of impression copings resulted in inaccurate casts due to the shrinkage of acrylic resin (0.3%) used for splinting. On the other hand, they concluded that direct impression-taking techniques exhibited higher accuracy. In this study, to decrease the errors resulting from the expansion of stone, 1) the analogs were splinted by Duralay acrylic resin and the stone was poured, and 2) the analogs were placed within prefabricated tubes and pouring of the stone was

carried out in two stages [35-37]. In this study, the highest accuracy was related to the open tray impression technique without splinting the impression copings and the use of prefabricated tubes for analogs. The discrepancy between the outcomes of these two reports might be attributed to the absence of standardization of the volumes of the splinting material and the stone in the study above; in the present study, due to the fabrication of an index for the splint material, the stone and the impression material, the volumes of the materials applied in the study were standardized.

Despite the high accuracy of the operator in that study, the discrepancy between the results above and those of the present study might be attributed to lack of attention to the polymerization shrinkage of the resin used for splinting the impression copings and dimensional changes of the stone [38-43].

One of the errors in the present study, the correction of which might increase the accuracy of impression-taking procedure, was the elasticity and the putty nature of the indexes related to the splint material; in this context, an increase in the rigidity of these indexes might lead to the use of a more accurate volume of the splinting material in different samples. The putty index is shown in figure 5.

4. CONCLUSIONS

It can be concluded from the results of the present study that splinting of impression copings results in a decrease in the movement of impression copings during the impression-taking procedure. Therefore it is recommended that the impression copings be splinted before taking impressions; however, owing to

the lack of a considerable difference in the accuracy of impressions in the group in which the analogs were splinted and the group in which they were not splinted, splinting of analogs is not necessary so that the laboratory steps can be facilitated.

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