An Evaluation of the Accuracy of Multiple Implant Impression Techniques: An in Vitro Study

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Abstract

Background: Movement of impression copings inside the impression material using an open-tray impression technique during clinical and laboratory phases may cause inaccuracy in transferring the 3-dimensional spatial orientation of implants intraorally to the definitive cast. Consequently the restoration may require corrective procedures. This in vitro study evaluated the accuracy of 3 different impression techniques using polyvinylsiloxane impression material to obtain a precise definitive cast for a multi-unit implant restoration with multiple internal connection implants.

Materials and Methods: A reference acrylic resin model with 4 internal connection implants was fabricated. Fifteen impressions of this model were made with square impression copings using an open-tray technique. Three groups of 15 specimens were made with different impression techniques: in the first group, nonmodified square impression copings were used (NM group); in the second group, square impression copings were used and joined together with autopolymerizing acrylic resin before the impression procedure (S splinted group); and in the third group, sandblasted square impression copings and coated with adhesive were used (SB group). Implant analogs were screwed into the square impression copings in the impressions. Impressions were poured with ADA type III stone. A single calibrated examiner blinded to the nature of the impression technique used examined all definitive casts to evaluate the positional accuracy (mm) of the implant analogs using a profile projector (at original magnification ×10). These measurements were compared to the measurements calculated on the reference resin model which served as control. Data were analyzed with a 1-way analysis of variance.

Results: No significant difference was found among the 3 groups. Group NM and group SB variation from the acrylic resin model was greater than that of group S. The distance was 70 μm (SD ± 15.8) greater on group NM casts, 44μm (SD ±39.1) greater on group S casts, and 48μm (SD ± 32.7) greater on group SB casts. group NM and group SB variation from the acrylic resin model was greater than that of group S. The distance was 124 μm (SD ± 55.5) greater on group NM casts, 92μm (SD ± 58.9) greater on group S casts, and 124μm (SD ± 55.5) greater on group SB.

Conclusions: Within the limitations of this study, using a 4-implant model, the accuracy of casts obtained by impressions of internal connection implants, was similar for splinted and sandblasted square impression copings.

KEY WORDS: Dental implants, prosthodontics, impression techniques, impression materials

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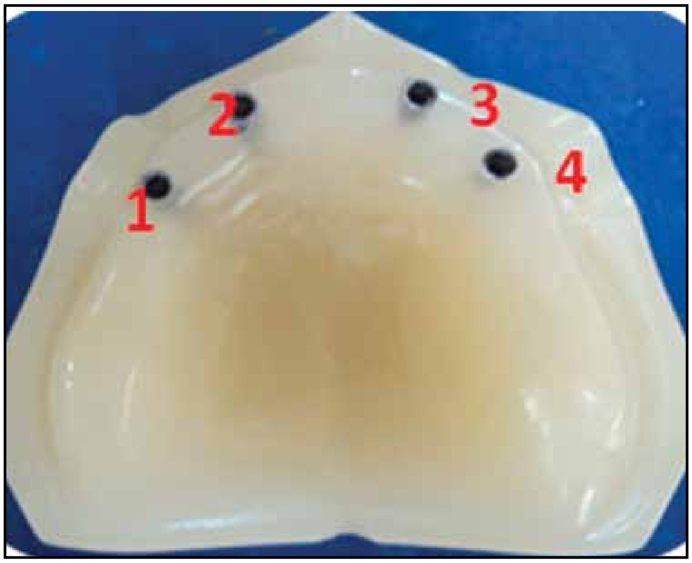


Figure 1: Reference acrylic resin model with implants numbered 1 to 4 (right to left).

Figure 2: Primary cast.

INTRODUCTION

Dental implants have become a quite successful method for restoration of fully and partially edentulous patients. An important factor for success with implant-supported restoration is the passive fit between the superstructure and the abutments. Reproducing the intraoral relationship of implants through impression procedures is the first step in achieving an accurate, passively fitting prosthesis. The critical aspect is to record the 3-dimensional orientation of the implant as it occurs intraorally, rather than reproducing fine surface detail. The accuracy of impression procedure lies in reproducing the intraoral relationship of the fixtures so that same could be transferred to the cast so that a passive framework could be fabricated.[1]

Several impression techniques have been advocated to achieve a definitive cast that will ensure the passive fit of a prosthesis on osseointegrated implants. There are two primary techniques: the indirect(closed tray) technique and the direct(open tray) technique.[2] The indirect technique may be less difficult clinically; however it has been shown to have greater instability in transferring the implant position.[3] The open tray technique allows for the impression coping to remain in the impression. This reduces the effect of implant angulation, the deformation of the impression material upon recovery from mouth, and removes the concern for replacing the coping back into its respective space in the impression.[1]

Movement of impression copings inside impression material during clinical and laboratory phases may cause inaccuracy in transferring 3-dimensional spatial orientation of implants intraorally to definitive cast. To ensure maximum accuracy, the importance of splinting transfer copings and coping modification before recording of the definitive impression has been emphasized.[2] The materials used to splint copings are composite resin, plaster, or acrylic resin.[4] Several authors advocate connecting the

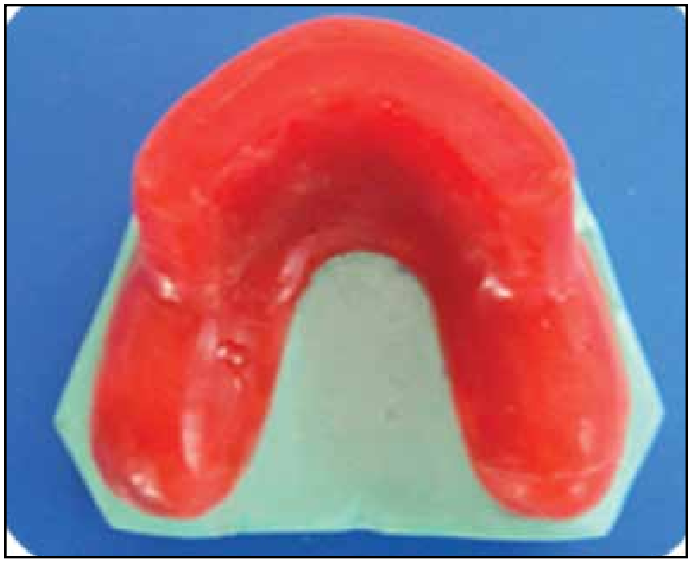


Figure 3: Base plate relief wax over the implant area.

Figure 4: Thermoplastic sheet was adapted over cast.

Figure 5: Two-part mold of silicone impression material in a dental flask.

Figure 6: Custom tray over reference model.

impression copings together prior to impression making with acrylic resin to provide the best result. Different techniques for splinting implant transfer copings with acrylic resin have been tested such as scaffold of dental floss, prefabricated acrylic resin bars, and stainless steel burs.[5] However, some authors suggested that splinted technique had inaccurate results because splinted techniques use a large amount of acrylic resin that can cause distortion due to resin shrinkage during polymerization. Therefore pattern resin has been given preference in some studies because of its low polymerisation shrinkage.[4] There is an alternative procedure in impression making for implant-supported prostheses that employ square impression copings that have been sandblasted to roughen their external surfaces at a supragingival level and then coated with adhesive. This is done to avoid the possibility of the coping rotating inside the impression at the moment of analog screwing.

The purpose of the study was to evaluate the accuracy of multiple implant impression techniques using square impression copings, splinted impression copings and sandblasted impression copings coated with adhesive so as to obtain a precise definitive cast for a multi-unit implant restoration.

MATERIALS AND METHODS

Fabrication of the Reference Cast: An acrylic resin edentulous model of maxillary arch was fabricated for the study (fig. 1). Four internal connection 3.75× 11mm implants were placed in acrylic resin model. The 4 implants in the acrylic resin model were sequentially numbered 1 through 4 from left to right. Three location marks (2 anterior marks and 1 posterior mark) were made on base of acrylic resin model to standardize tray positioning during impression making.

Fabrication of Custom Trays: A primary cast analog (fig. 2) to the reference model was poured in type III stone and utilized for the production of the custom trays. The implant area on cast was covered by 2 layers of base plate wax (fig. 3) to allow consistent thickness of impression material and palatal region acts as stop. An irreversible hydrocolloid impression of cast was made to obtain another cast on which all custom trays were molded. A thermoplastic sheet of 2 mm was adapted over this cast (fig. 4) to ensure uniform thickness of custom trays. A two-part mold was fabricated with the thermoplastic sheet and putty addition silicone impression material in a dental flask (fig. 5) to make identical 2mm thick replicate trays. The custom trays were made with autopolymerising tray resin. The trays were perforated in the region where implants were placed to provide access for the pick-up copings (fig. 6).

Impression Procedures: The impression trays were coated with manufacturer recommended impression adhesive 5 min before each impression was made. Tray adhesive was applied thinly and evenly over the inner surface of each tray and extended approximately 3 mm onto the outer surface of the tray along periphery. The adhesive was allowed to dry for 15 min before impression. The impression copings were secured on the implants using a torque wrench calibrated at 10 N-cm. Fifteen polyvinylsiloxane impressions were made according to the manufacturer's directions using one-step technique. The heavy consistency polyvinylsiloxane impression material was loaded inside the impression tray and light consistency polyvinylsiloxane impression material was meticulously syringed around the impression copings to ensure complete coverage of the copings. The impression of the reference resin model was made until the tray was fully seated on the 3 location marks and maintained in position throughout the polymerization time. Impression material was allowed to set for 12 min from the start of mixing to compensate for the delayed polymerization time at room temperature. After the impression material had set, the screws were loosened and the trays removed with the transfer copings retained in them. Five impressions with square impression copings were made for each of 3 different impression techniques represented by the 3 groups.

In the first group, impression copings as supplied by the manufacturer were used (nonmodified square impression copings: NM group). Each impression tray was seated, and the material was allowed to polymerize. The guide pins were released so that the transfer copings remained in the impression when the impression was removed.

In the second group (S group), square impression copings were splinted with dental floss and autopolymerising acrylic resin. The transfer copings were tied up with four complete loops of dental floss and splinted with autopolymerising acrylic resin (Pattern resin) and allowed to set for 3 minutes. Seventeen minutes after setting, the acrylic resin substructure and splinted transfer copings were removed from the framework and the splints were sectioned into 4 separate pieces with a handpiece diamond disk and a 0.2-mm standardized gap space was left between the single pieces. The square impression copings were then readapted to the implants in resin model and resplinted with same acrylic resin. The impression procedure was then accomplished.

In the third group, (SB) impression copings were abraded with 50 μm aluminium oxide particles at 2.5 atm pressure to roughen their external surface and coated with adhesive and the impression procedure was accomplished. Implant analogs were fastened to the impression copings in the impressions. A 100 gm Type III dental stone was mixed with 22 ml of distilled water in amounts recommended by the manufacturer and poured into each. The casts were retrieved from the impressions after 2 hour.

DIFFERENT IMPRESSION TECHNIQUE GROUPS

All casts were stored at room temperature for a minimum of 24 hours before measurements were made. All clinical and laboratory procedures were performed by the same operator. Cover screws were fastened on implant analogs and all definitive casts were evaluated for the

Figures 7a-c: GROUP S - Nonmodified square impression copings rigidly splinted with pattern resin prior to impression procedure.

Figure 8: GROUP NM - Nonmodified square impression copings.

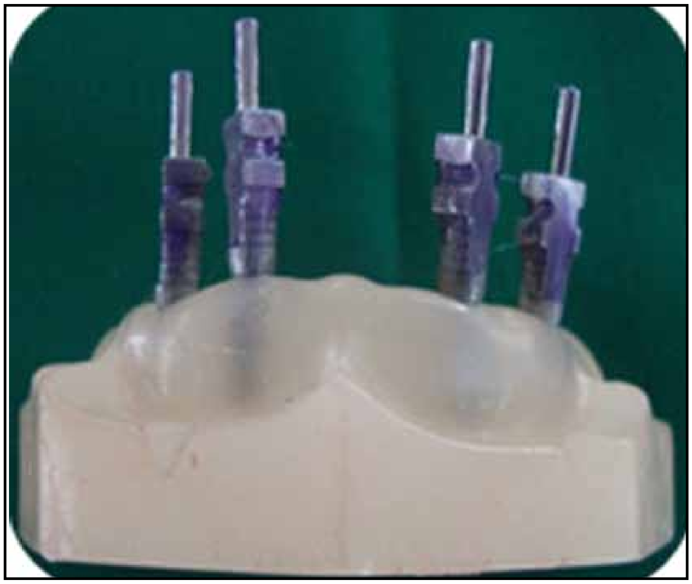


Figure 9: GROUP SB - Sandblasted square impression copings.

Figure 10: Open tray impression with pick-up.

Figure 11: I mpression with analogs in place.

positional accuracy of the implant analogs using a profile projector (Dynascan Profile Projector). The profile projector consists of a screen with horizontal and vertical reference lines and was equipped with a light source to project a magnified image of the object onto the screen in the form of a shadow (original magnification × 10). The profile projector allows measurement of linear distances with an accuracy of 2 µm. Two measurements were made per speci-

Figure 12: Cast with analogs.

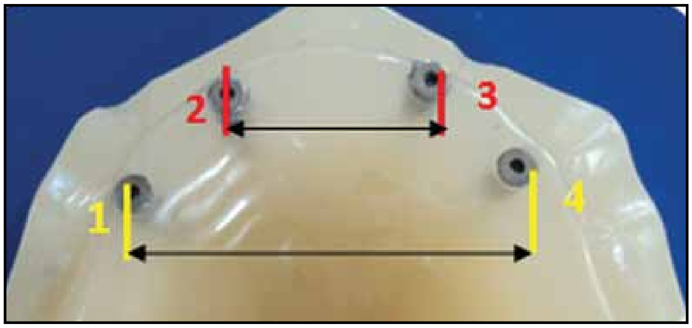


Figure 13: Measurement of distances between the analogs with profile projector.

men and measurements were performed by same operator to minimize source of error.

The following measurements were evaluated on the reference control acrylic resin model and the definitive cast replicas (fig. 13):

1. The distance between the external sharp edges of the projected silhouetted form of the cover screw of left and right posterior implants (1 and 4).
2. The distance between external sharp edges of the projected silhouetted form of the cover screw of left and right anterior implants (2 and 3).

RESULTS

1. Horizontal distances measured between posterior implants (no. 1 and 4) were obtained and then the mean was calculated for all 3 groups of impression techniques.
2. Horizontal distances measured between anterior implants (no. 2 and 3) were obtained and then the mean was calculated for all 3 groups of impression techniques.
3. A one-way statistical analysis of variance (ANOVA) was performed to analyze the difference among 3 groups.

With the use of the profile projector, numerical difference in distance between implants was evaluated. Distances between the 2 posterior implants were all different than those recorded on the resin model; group NM and group SB variation from the acrylic resin model was greater than that of group S. The distance was 70 µm (SD ± 15.8) greater on group NM casts, 44µm (SD ±39.1) greater on group S casts, and 48µm (SD ± 32.7) greater on group SB casts.

Distances between the 2 anterior implants were different than those recorded on the resin model; group NM and group SB variation from the acrylic resin model was greater than that of group S. The distance was 124 µm (SD ± 55.5) greater on group NM casts, 92µm (SD ± 58.9) greater on group S casts, and 124µm (SD ± 55.5) greater on group SB.

Results are further described in Tables 1a-b and Graphs 1a-b.

DISCUSSION

The objective of making an impression in implant dentistry is to accurately relate an analog of the

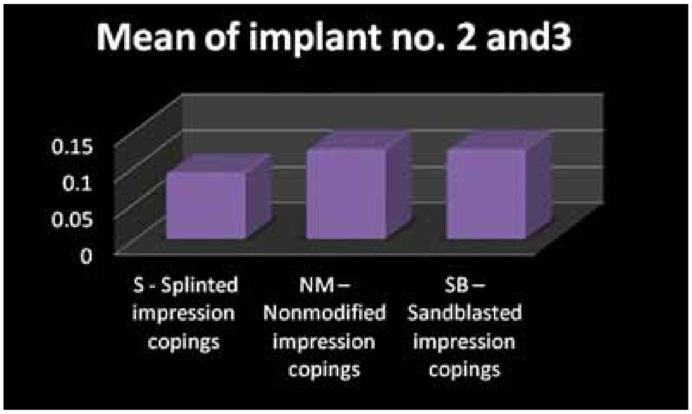


Table 1a

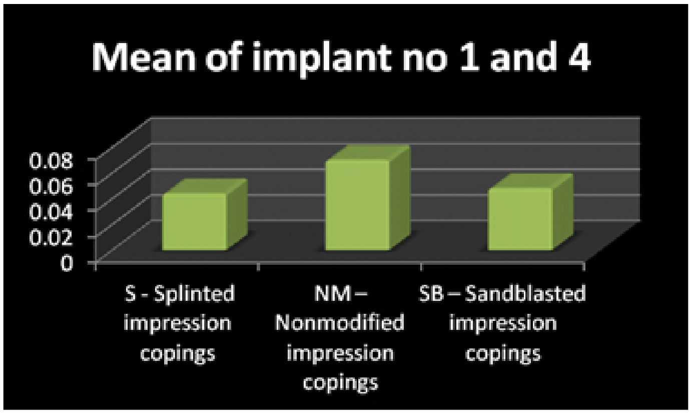


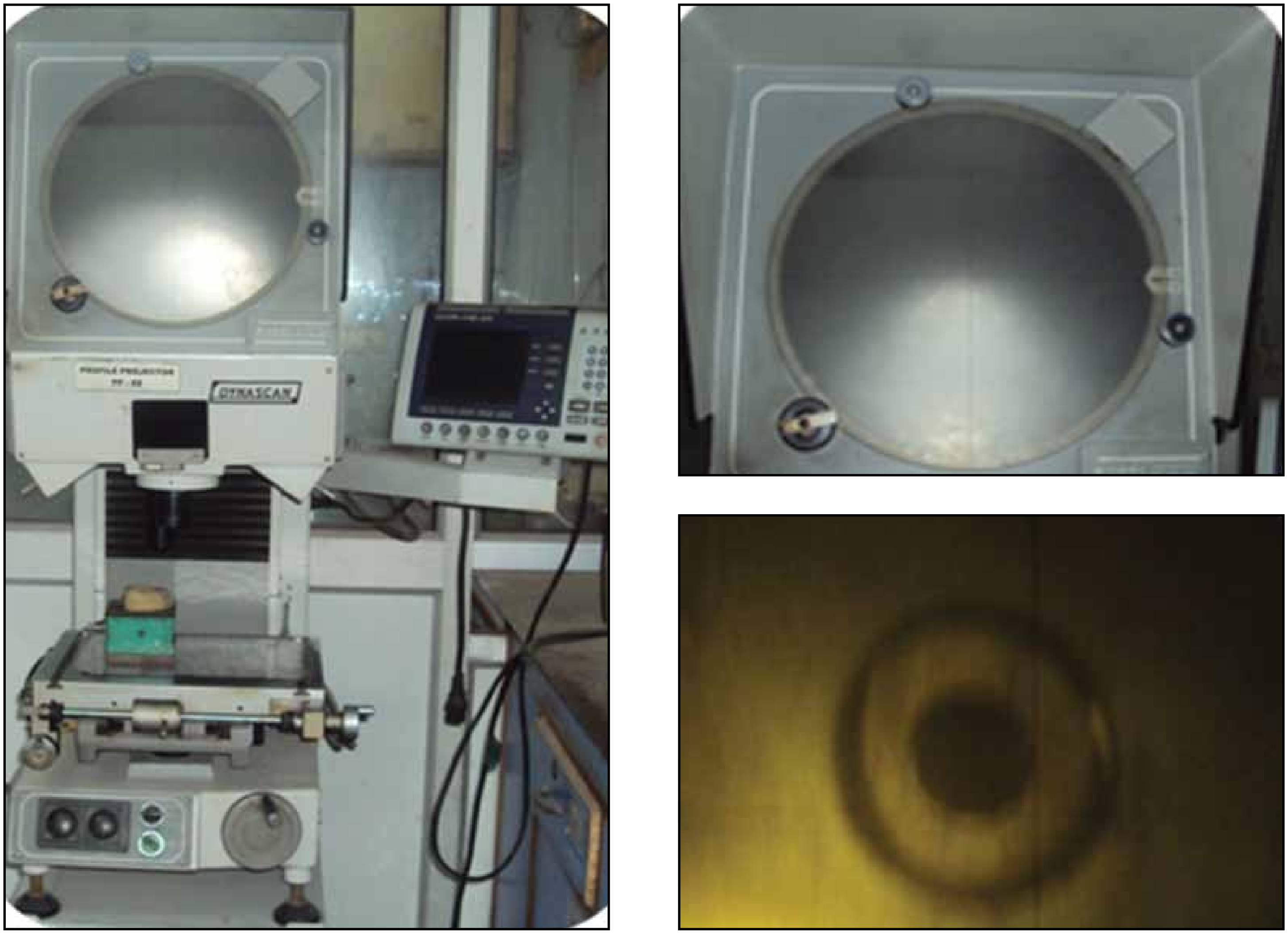
Table 1b

implant or implant abutment to the other structures in the dental arch. This is affected by use of an impression coping which is attached to the implant or implant abutment. The impression coping takes two general forms- transfer and pick up. Characteristics of transfer type impression coping are that they remain in the mouth on removal of set impression, the analog is attached to the impression coping after removal from mouth and this assembly is replaced in the indentation left on set impression. No custom tray is required for this type of impression. Characteristics of the pickup type impression coping are that they are removed from mouth together with impression. They require access to the retaining screw to allow release of the screw prior to removal of the impression coping – impression assembly; the analogs are attached to the impression copings while they are embedded in the impression tray. A custom tray with access to the impression coping screws is required.

Many articles have been written and many in vivo studies have been carried out to improve the fidelity of impressions over the use of pick up type impression copings alone. Various studies comparing accuracy of pick-up and transfer impression techniques showed more accuracy with pick-up technique,[6-9] than with transfer technique.[10,11]

Different modifications are recommended by various authors to increase impression accuracy while recording an implant impression to avoid the movement of the impression coping and transfer the three dimensional spatial orientations of the implants positions thereby ensuring accuracy of master casts. Some authors advocate connecting the impression copings together intra orally prior to impression making with acrylic resin[5,7,10,12] and others advocated treatment of impression copings with air-borne particle abrasion and impression adhesive.[13-18]

Custom autopolymerising acrylic resin trays were utilized in present study because elastomeric materials are more accurate if used in 2 to 3 mm of uniform thickness in elastomeric impression techniques. The shrinkage of impression material from the impression specimen during setting would be magnified with greater bulks of impression material, because of the impression material preferentially adhering to the tray rather than the specimen.[19] All the custom trays in the study were perforated because the bonding strength



Figures 14 a-c: Equipment used for data measurement and recording.

of adhesives used with can be improved nearly 50% by adding perforations to the tray.

In the study, addition silicone was applied by means of the one-step technique. Both heavy body and light body material were mixed simultaneously while impression making to avoid early partial polymerization of any of the material. Acc to Hung et al., accuracy of the one-step impression technique was not different from the two-step impression technique except at one of the six dimensions where one-step was more accurate than two-step.[20] There are no significant differences with regard to precision between the one- and the two-step techniques using a-silicones (Hung et al.1992;[20] Idris et al. 1995[21]) and one step technique is easier to perform, time saving clinically. According to Wenz, the 2-step VPS impression was significantly less accurate than 1-step putty and light-body VPS combination impression.[22]

Elastomeric impression materials have been found to be highly accurate without splinting impression copings. Acc to Hung et al. the precision of addition reaction silicones was more dependent on the material than on the technique.[20] Various impression materials were tested, but polyether and VPS were used most frequently. Vinyl polysiloxane impression materials have been widely accepted because of their excellent dimensional stability, superior recovery from deformation, and precise reproduction of details. There were 11 studies comparing the accuracy of polyether and VPS and 10 studies reported that the accuracy did not differ.

Many authors recommended splinting of square impression copings while recording an implant impression for accurate spatial orientation of implant positions. Different techniques for splinting impression copings with acrylic resin have been tested, such as a scaffold of dental floss, prefabricated acrylic resin bars, orthodontic wire and stainless steel burs. Distortion associated with splinted transfer techniques can be related to residual polymerization contraction of the acrylic resin used for splinting. In the present study splinting with scaffold of dental floss along with pattern resin was used because of the low polymerization shrinkage of 0.37 % of pattern resin. In the study, pattern resin splint was sectioned and resplinted in order to further minimize any discrepancies due to polymerization shrinkage. Mojon et al, have stated that the dimensional behaviour of resin, when separation and reuniting are done 17 minutes after the setting reaction, allows considerable reduction (80%) in the effects of polymerization shrinkage.

It appears from the data of present study that splinting, per se, has little or no bearing on the results obtained. With polymerization shrinkage, it is somewhat surprising to learn that it does not affect transfer impression techniques adversely under the conditions of these experiments. These observations find support in other studies where it was found that splinting had no consequence in the transfer techniques that were investigated. Many authors have reported that splinting the copings didn't significantly improved the impression accuracy. Phillips and colleagues used a patient model with 5 nonparallel implants and concluded that the amount of displacement between nonsplinted groups and the autopolymerising resin splinted groups while making impressions was not stastically significant. Inturregui et al. and Burawi et al. even reported that the splinted technique exhibited more deviation from the master model than the unsplinted technique did, and this was primarily associated with rotational discrepancies around the long axes of the implants for the splinted technique. There was a lack of significant differences between the techniques with respect to distortions during transfer procedures. However, connecting the impression copings with acrylic resin is a time consuming procedure. The results of this study suggest that displacement of the internal-connection impression copings during impression removal and replica connection in the direct nonsplinted technique can be controlled by the elastic impression material and an experienced practitioner to an extent similar to that observed with the direct splinted technique.

Vigolo et al. evaluated in vitro accuracy of definitive casts obtained from transfer impressions using square copings for replacement of one tooth. The author concluded that impression transfer accuracy increases when copings are air-borne particle abraded and adhesive coated. In the current study the results of group SB (Sandblasted and coated with adhesive) were different than expected as there is no significant difference between reference model and sandblasted technique. The present study findings are in contrast to the results of Vigolo et al. from 2000[14] and 2003[15] but are in accordance with 2004 findings of Vigolo et al.[15] It could be hypothesized that the square design of the impression copings was sufficient to stabilize the material with no need for the additional procedure of sandblasting and adhesive coating square impression coping. These obtained results could be due to the adhesive-coated layer, which may make the copings' surface less rough and could allow greater movement of the copings, so that the mechanical union between the impression material and rough surface is higher than with the adhesive layer. The results showed no difference between square impression copings and sandblasted square impression coping, therefore extra time involved should be considered unnecessary. Thus from the results it could be suggested that when using nonmodified or sandblasted square impression coping, an accurate working cast is more likely to be made. Nevertheless the clinician should choose less time consuming technique (nonmodified) since it is much easier to perform. This technique can be chosen when an immediate loading multiple implant impression has to be done, because in these cases, intraorally splinting the square impression copings with floss and acrylic resin is not the preferred option, and there is the risk of interfering with the healing process of the recently operated tissue with the contact of the resin monomer.

For the nonsplinted group displacement is more as compared to splinting because the assembly was maintained only by the impression material in the nonsplinted group. For the nonsplinted group, the distortion mainly resulted from polymerisation-related shrinkage of the impression material. The amount of the displacement of each implant replica while fabricating a definitive cast could be due to linear setting expansion of dental stone. The expansion of dental stone during setting can displace impression coping-analog assemblies. There is very little chance of displacement of impression coping-analog assemblies because of the setting expansion of dental stone with splinting.

In the present study, the use of the 2 selected measurements between the external edges of the most mesial and distal implants were dictated by the fact that this evaluation did not require positional changes of the cast during the measurements. Further assessments such as the distance between the mesial and distal implants on one side or the other involved various adjustments of the cast position were not done, which would have introduced an additional source of error to the measurements.

It is of interest that throughout this investigation, an exact reproduction of implant position was never accomplished. Interimplant distances in casts of both the groups (S and SB) always varied. Clinically, this implies that precise fit of a superstructure may be unattainable on definitive casts from any impression technique and laboratory procedure currently in use and that the terms precision and fit are relative to the clinical assessment by the operator.

Possible limitations of the present study design were that the measured distortions did not completely evaluate the actual three-dimensional distortion of the impressions and the axial rotations of the components were not detected. In present study, the discrepancies were evaluated in a horizontal plane between paired implants. Under clinical conditions and in multiple implant restorations, these differences may vary if the discrepancies are present in other spatial planes and if they occur in opposite dimensions. Moreover, the results of the present investigation were limited to a number of four implants and may not be relevant for impressions made in the presence of higher or lower numbers of implants.

CONCLUSIONS

Within the limitations of this study, the following conclusions were drawn:

1. When impressions made with nonsplinted, splinted and sandblasted impression copings were compared, the casts obtained from splinted impression technique were closest to reference model, followed by sandblasted and nonmodified impression copings.
2. The differences between test groups were stastically similar to each other. There was no statistically significant difference among the casts produced by different test groups.
3. Selection of impression technique can be based on the clinical situation and the individual clinician's preference.

Further clinical investigations will be necessary to confirm the results of the present in vitro study. Further studies are required to evaluate different impression materials and implant impression techniques related to different clinical situations.

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Disclosure
The authors report no conflicts of interest with anything mentioned in this article.

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