COMPARISION OF IMPLANT CAST ACCURACY EFFECTED BY DIFFERENT IMPRESSION TECHNIQUES AND IMPLANT ANGULATIONS: AN IN-VITRO STUDY

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ABSTRACT

Aim: The purpose of this study was to evaluate the accuracy of implant casts generated with splinted andnonsplinted impression techniques with multiple parallel and nonparallel implants.

Materials and Methods: In this experimental study, two edentulous maxillary stainless-steel models withseven implant analogues in the central incisor, canine, premolar, and first molar region simulating clinicalcondition were used (control groups). In one master model, implant analogs were placed parallel to eachother, whereas in another model, analogs were placed with a tilt-to-longitudinal axis. Forty stone casts weremade from each model using splined and nonsplinted technique using polyether with open-tray technique.Then, the difference in the distance between the master cast and experimental cast in three dimensionswas measured by coordinate-measuring machine. One-way ANOVA, *post hoc* Bonferroni test, and unpaired*t*-test were used for data analysis.

Results: Statistical comparisons were made using ANOVA test, *post hoc* test, and unpaired *t*-test. Splintedtechnique with parallel implants generated interimplant distance values closest to the master model,followed by nonsplinted technique with parallel implants, splinted technique with angulated implants, andnonsplinted technique with angulated implants.

Conclusions: Splinted impression technique exhibited higher accuracy than the other technique studies inboth parallel and angulated implants.

Keywords: Accuracy, master cast, splinted

INTRODUCTION

Osseointegrated implants have been established as a successful alternative to conventional prosthesis in the replacement of missing teeth. The fixed dental prosthesis, the osseointegrated implants, and the bone act as a unified structure without any resiliency.[1] In completely edentulous patients, prosthetic rehabilitation with implants is a very reliable and predictable treatment option. According to the Branemark System concept, placement of the implants should be fairly upright. An overall decrease in quantity of bone makes the ideal placement of implants more difficult in the maxilla. In severely resorbed ridges, placing angulated implants is a very suitable and appropriate alternative treatment option to bone augmentation and sinus lift procedures.[2] To record the threedimensional (3D) intraoral relationships among the implants and adjacent structures, the most critical clinical step is impression making. First step in achieving an accurate and passively fitting prosthesis is the reproduction of intraoral relationship of implants through impression procedures.[3] Laboratory errors due to inaccuracies during impression making may result in lack of precision and misfit of prosthesis in fixed and implant-supported prosthesis that can lead to mechanical and biological complications.[2] Mechanical complications resulting in prosthesis misfit such as occlusal discrepancies, screw and abutment loosening, and fracture of the prosthetic or implant components are seen. Biological complications from plaque accumulation due to marginal discrepancies may affect soft or hard tissues around the implants.[2] To obtain the maximum accuracy of the implant position, recent developments in impression techniques have been regarded more than other issues as it is a critical step to precisely transfer the spatial relationships of implants from mouth to master cast to ensure fit of implant retained prosthesis.[2]

Most of the studies evaluated the impression accuracy in ideal conditions with various methods. Although nonparallel implants are commonly encountered in clinical situations, there are only a few studies to evaluate the effect of angulated implants on the accuracy of the impression.[2] Hence, this study aims to compare the implant cast accuracy of angulated and parallel implants with splinted and nonsplinted impression techniques.

MATERIALS AND METHODS

The comparison of accuracy of the study model obtained with direct impression technique using impression copings with and without splinting utilizing impression material Polyether material (3M ESPE, Impregum, medium consistency) was used for all impressions as it shows the greatest torque values which are favourable for the manipulation of a pickup impression. Direct/open-tray/pickup impression technique was used in all groups.

Study groups

Ten models were made for each subgroup (n = 10).

Model preparation

A vertical milling machine and an implant angulation guide (InstitutStraumann AG, Switzerland) were used to placeparallel implants (BioHorizonsTM Tapered Internal, 3.5 mm × 12 mm, USA) in an acrylic resin maxillary edentulous model [Figures 1 and 2].


Figure 1: Implant master model (Group 1)**Figure 2:** Implant master model (Group 2)

3D interimplant distance of both the master models were simulated using coordinate-measuring machine (CMM), and angulation was measured and marked by analyzing through CMM [Figures 3 and 4]. Central implant was placed perpendicular to the surface in both the models, and the other implants in model with angulated implants had divergence/convergence from the central component.

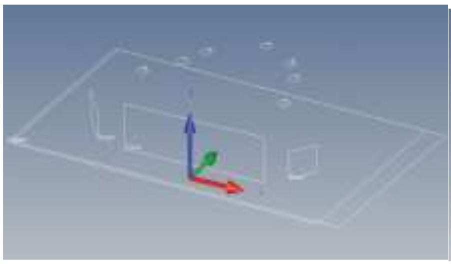
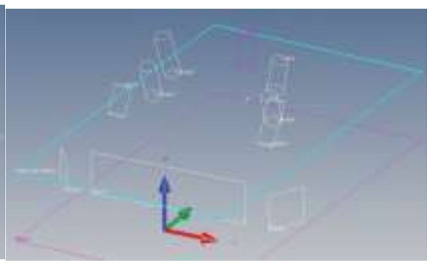



Figure 3: Implant master model (Group 1) **Figure 4:** Implant master model (Group 2) measurements on coordinate-measuring machine

Custom tray fabrication

Reference model was duplicated after adaptation of 3 mm wax spacer to accommodate open-tray impression copings. This duplicated spaced model was used to fabricate open impression custom trays of light-cure resin (Plaque Photo®, WP Dental, Willmann and Pein GmbH). Two types of custom open impression trays were prepared (Figure 5 and 6).


Figure 5 **Figure 6**

Impression procedure

A standard procedure was followed for all impressions.impression copings were tightened to the implantswith the help of a hex driver at 10 N cm torque. Trayadhesive (3M ESPE™) was painted on all the trays for15 min prior to each procedure to obtain adequate tensilebonding strength, before recording the impressions. Forsplinting, impression copings were tied with dental flossand pattern resin (GC Corporation, Japan) was appliedin 2 mm thickness [Figure7]. After 17 min, thesplint was sectioned into four pieces with a diamond diskand resplinted, to minimize polymerization shrinkage.

Figure 7: Posts retained in impression

Cast production

Once the impression material had been set, the impression copings were loosened with the aid of a hex driver and the recorded impression was retrieved with impression copings embedded within the impression material. The implant analogs were tightened onto the impression copings with a hex driver manually. Gingival mask (Gingifast Elastic, ZhermackSpA, Italy) was applied around the impression copings and analogs, and once set, the impression was poured in a vacuum-mixed Type IV dental stone (Kalrock, Kalabhai, Mumbai). The impressions wereseparated from the cast after 1 h. All the casts were stored at room temperature for 24 h.

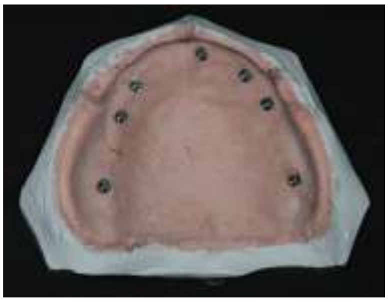


Figure 8: Cast obtained

Measurement

BioHorizonsTM (3.5 diameter, regular) standard abutmentswere screwed onto the implants in reference model to getreference measurements for each distance. In each study model also, BioHorizonsTM(3.5 diameter, regular) standard abutments were screwedonto the analogs. A single examiner measured the distancebetween abutment heads using acoordinate measuring machine (CMM) (Mitutoyo, Japan)in reference and study models [Figure 9].Differencesof mean distances in each group from respectivedistance on reference model were taken as coronaldeviation from accuracy and compared.

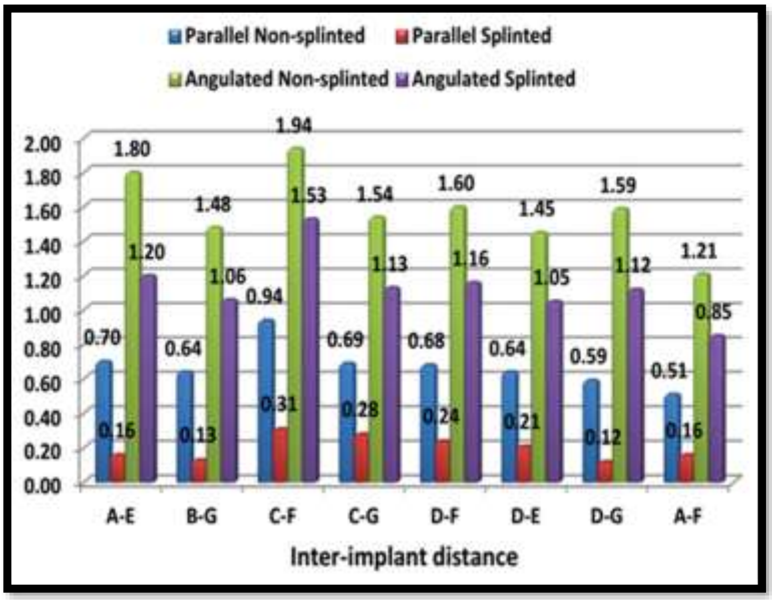
Figure 9: Stone cast being measured with standard abutments in

place on the CMM machine. CMM: Coordinate measuring machine

Statistical analysis

The measurements of the stone casts obtained with four impression techniques were compared with master model values, tabulated, and statistically analysed using one-way ANOVA test ($P < 0.001$ considered as significant difference), *post hoc* Bonferroni test for the intergroup comparisons, and unpaired *t*-test for comparison of mean differences.

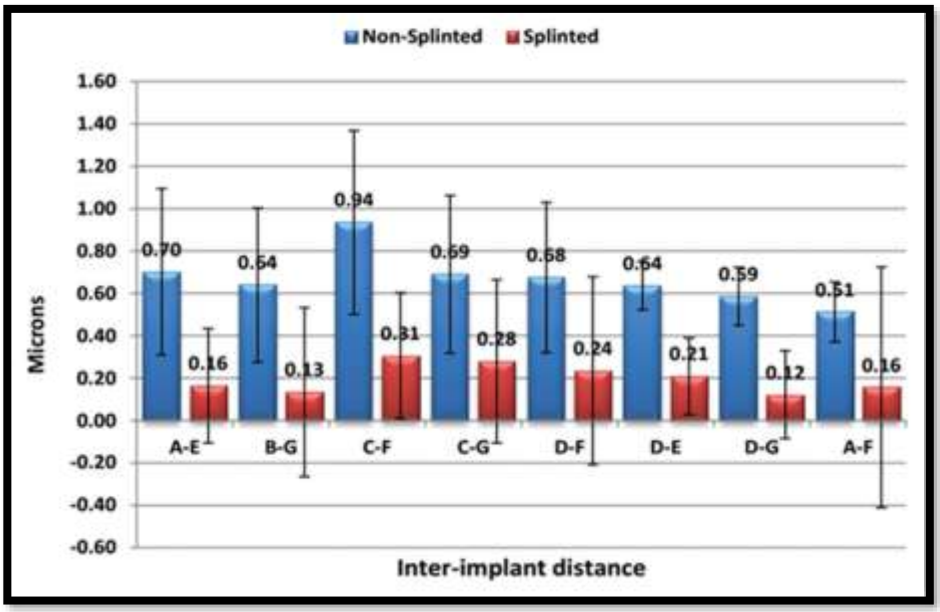
RESULT



Graph 1: Inter sub group comparison of mean difference

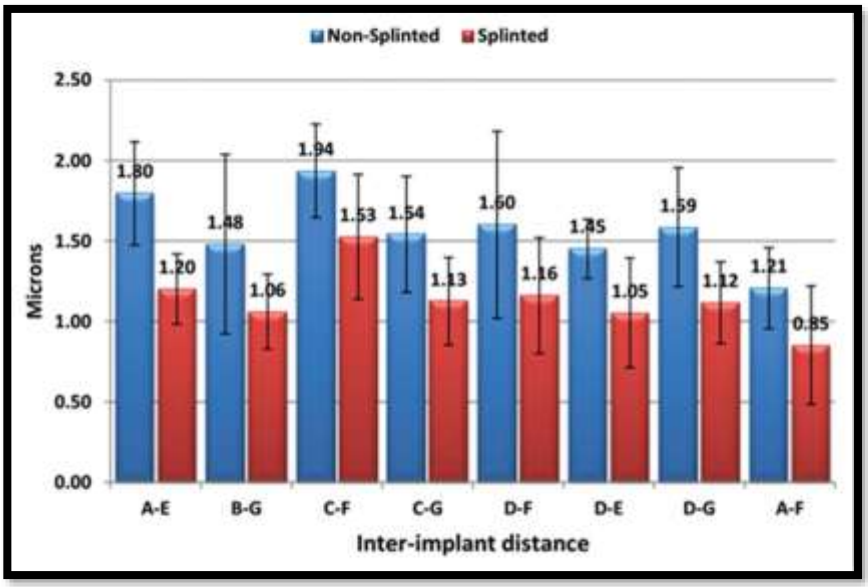
Graph 1 depicts the summarization of the mean difference and standard deviation of inter implant distances such as A–E, B–G, C–F, C–G, D–F, D–E, D–G, and A–F compared from control values on master models. A significant difference ($P <$ 0.001) was found among the four subgroups.

The mean difference was found to be maximum in angulated splinted group (Subgroup 2NS; 1.80, 1.48, 1.94, 1.54, 1.60, 1.45, 1.59, and 1.21), followed by angulated splinted (Subgroup 2S; 1.20, 1.06, 1.53, 1.13, 1.16, 1.05, 1.12, and 0.85), parallel nonsplinted (Subgroup 1NS; 0.70, 0.64, 0.94, 0.69, 0.68, 0.64, 0.59, and 0.51), and parallel splinted (Subgroup 1S; 0.16, 0.13, 0.31, 0.28, 0.24, 0.21, 0.12, and 0.16) groups.



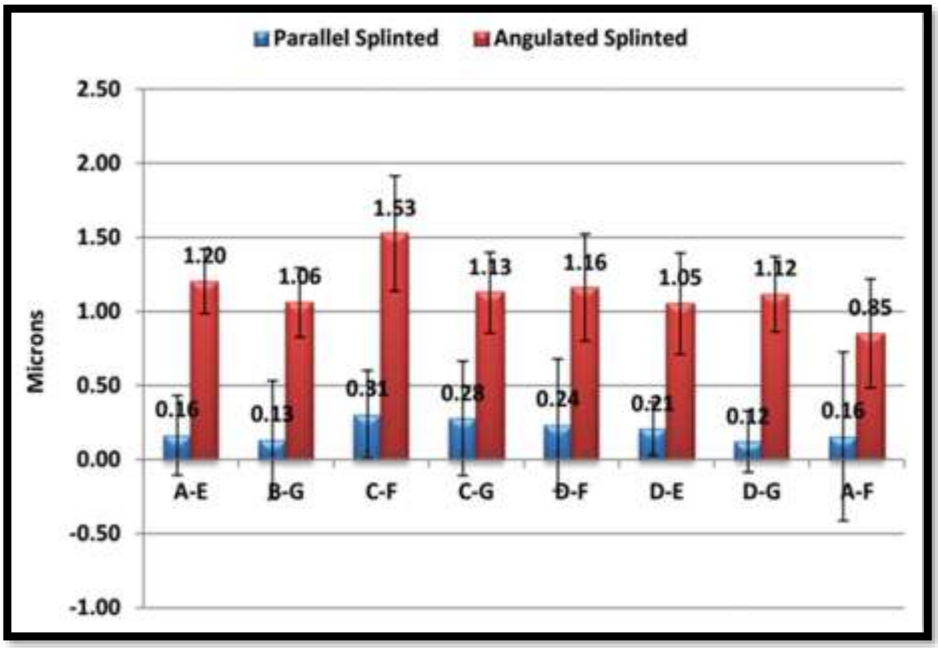
Graph 2: Intragroup comparison of mean difference with standard deviation between parallel nonsplinted (Subgroup 1NS) and parallel splinted (Subgroup 1S) groups

Graph 2, the intragroup comparison of mean difference of interimplant distances such as A–E, B–G, C–F, C–G, D–F, D–E, D–G, and A–F among parallel splinted (Subgroup 1S) and parallel nonsplinted (Subgroup 1NS) groups was done using the unpaired *t*-test. The mean difference was found to be significantly more in parallel nonsplinted (Subgroup 1NS; 0.70, 0.64, 0.94, 0.69, 0.68, 0.64, 0.59, and 0.51) in comparison to parallel splinted (Subgroup 1S) groups.



Graph 3: Intragroup comparison of mean difference with standard deviation between angulated nonsplinted (Subgroup 2NS) and angulated splinted (Subgroup 2S) groups

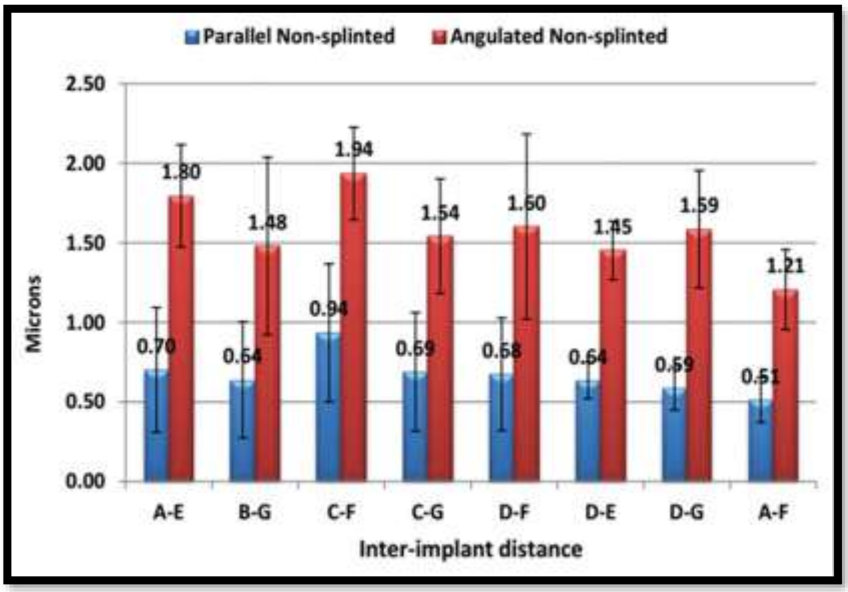
Graph 3, intragroup comparison of mean difference of interimplant distances such as A–E, B–G, C–F, C–G, D–F, D–E, D–G, and A–F among angulated nonsplinted (Subgroup 2NS) and angulated splinted (Subgroup 2S) groups was done using the unpaired *t*-test. The mean difference was found to be significantly less in angulated splinted (Subgroup 2S; 1.20, 1.06, 1.53, 1.13, 1.16, 1.05, 1.12, and 0.85) in comparison to angulated nonsplinted (Subgroup 2NS; 1.80, 1.48, 1.94, 1.54, 1.60, 1.45, 1.59, and 1.21) groups.



Graph 4: Comparison of mean difference with standard deviation for

splinted impression technique

Graph 4, depicts the comparison of mean difference of interimplant distances such as A–E, B–G, C–F, C–G, D–F, D–E, D–G, and A–F among parallel splinted (Subgroup 1S) and angulated splinted (Subgroup 2S) groups using the unpaired *t*-test. It was evaluated that the mean difference was significantly less among parallel splinted (Subgroup 1S; 0.70, 0.64, 0.94, 0.69, 0.68, 0.64, 0.59, and 0.51) in comparison to angulated splinted (Subgroup 2S; 1.80, 1.48, 1.94, 1.54, 1.60, 1.45, 1.59, and 1.21) groups.



Graph 5: Comparison of mean difference with standard deviation for

nonsplinted impression technique

Graph 5, the comparison of mean difference of interimplant distances such as A–E, B–G, C–F, C–G, D–F, D–E, D–G, and A–F among parallelnonsplinted (Subgroup 1NS) and angulated nonsplinted (Subgroup 2NS) groups was done using the unpaired *t*-test. The mean difference was found to be significantly less among parallel nonsplinted (Subgroup 1NS; 0.70, 0.64, 0.94, 0.69, 0.68, 0.64, 0.59, and 0.51) in comparison to angulated nonsplinted (Subgroup 2NS; 1.80, 1.48, 1.94, 1.54, 1.60, 1.45, 1.59, and 1.21) groups.

DISCUSSION

Accurate implant-level impression is a critical step to achieve success in multiple implant prosthesis. Variables such as impression material, impression techniques, type of impression coping, splinting/nonsplinting of impression copings, and number and angle of implants influence the accuracy of implant impression.[4,5] Very few studies havereported cumulative influence of these variables on implantimpression. The accuracy of implant cast is directly proportional to theimpression technique which ultimately leads to passive fitimplant prosthesis. There are various techniques that canbe used for impression in multiple unit implant-supportedprosthesis with advantages and disadvantages associated witheach technique. The present study was conducted to comparethe implant cast accuracy of angulated and parallel implantswith splinted and nonsplinted impression technique.

In multiple implant impressions, impression copings arealigned at different angles and there can be pronouncedrotational movement of copings leading to inaccuracy.Further, deep wide connection area (hex) in internalconnection implants is more engaging and may causemovement of impression copings and hence distortionwithin impression necessitating the use of nonhexedcopings.[6,7]The impression procedure in our study was standardizedby using light-cure custom trays of uniform thicknessfabricated on the same duplicated cast and with same-sizedstops for the accurate positioning of the tray on thereference model each time an impression was made. Thepickup impression copings were hand tightened with a hexdriver by the same operator, eliminating the difference inforce used for tightening to simulate a clinical situation.The PE impressions were separated from the cast aftermore than 6 min.

In the present study, splinted technique in angulatedimplants exhibited greater accuracy as compared tononsplinted technique in parallel implants. This resultwas in accordance with the study conducted by Assuncao*et al*.[8] and Cabral and Guedes[9] that reported lessaccurate impressions with angulated implants than parallelimplants with four or five implants in experimental cast.

Similarly, Tsagkalidis *et al*.[10] also concluded that splintedimpression technique exhibited a higher accuracy thanthe other techniques studied when increased implantangulations at 25° were involved..Some studies did not show significant result in splintingand nonsplinting technique. According to the study byLee *et al*.,[11] it was concluded that there was no significantdifference in the accuracy between the unsplinted andsplinted methods in pickup impression techniques. Thisstudy also had two implants in master model with 10°divergence angle. In clinical conditions, divergence betweenimplants may often be >8°.

However, few studies reported in literature did not favor theresult of this study and suggested nonsplinted technique.Inturregui*et al*.[12] suggested that nonsplinted techniquewas better than splinted technique. In this study, only twoabutments were placed in the master model, and rigidThis study is limited by the following factors thattemperature, humidity, moisture, and saliva in oralcavity could affect the setting of acrylic resin splinting.

In addition, because of different extent of undercut ordifference in anatomy, the force and path of impression trayremoval were considered to be different from experimentalstudies. While interpreting implant impression accuracy,the machining tolerance was not considered as it is alsoan important factor affecting accuracy.[13] Comparisonsbetween implant impressions with copings that can bedigitally scanned intraorally and superimposed may providethe foundation for future research.Therefore, the influence of the above-mentionedparameters should be considered in future research as theymay affect the precision and passive fit of the prosthesis.

CONCLUSIONS

Within the limitations of study, it was concluded that:

1. The dimensional accuracy of casts obtained from splinted technique for parallel implants was greater than the splinted technique for angulated implants with interimplant distance values closer to implant master model.

2. The dimensional accuracy of casts obtained from nonsplinted technique for parallel implants was greater than the nonsplinted technique for angulated implants with interimplant distance values closer to implant master model.

3. The implant cast dimensional accuracy obtained from splinted technique was greater than the nonsplinted technique for parallel implants with interimplant distance values closer to implant master model.

4. The dimensional accuracy of casts obtained from splinted technique was greater than the nonsplinted technique for angulated implants with interimplant distance values closer to implant master model.

5. Within the limitations of this study, it was concluded that when seven or multiple parallels or nonparallel implants are used, the splinted technique could be recommended for ensuring accuracy and passive fit of implant-retained prosthesis. Parallel implants with splinted technique showed interimplant distance values closest to implant master model, and angulated implants with nonsplinted technique showed maximum deviation from the master model values

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