

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

Dr. Manoj Kumar<sup>1</sup>, Dr. Ajay kumar dubey<sup>2</sup>, Dr. Bushra Vasim<sup>3</sup>, Dr. Hemakshe Srivastava<sup>4</sup>,

Dr. Manshi Sharma<sup>4</sup>, Dr. Abhidvita Tripathi<sup>5</sup>, Dr. Tanya Agarwal<sup>6</sup>

### **Author**

Dr. Manoj Kumar

Reader

Department of Prosthodontics, Crown & Bridge,

Rama Dental College, Kanpur

Dr. Ajay Kumar Dubey

PG Student

Department of Prosthodontics, Crown & Bridge,

Rama Dental College, Kanpur

Dr. Bushra Vasim

PG Student

Department of Prosthodontics, Crown & Bridge,

Rama Dental College, Kanpur

Dr. Hemakshe Srivastava

PG Student

Department of Prosthodontics, Crown & Bridge,

Rama Dental College, Kanpur

Dr. Manshi Sharma

PG Student

Department of Prosthodontics, Crown & Bridge,

Rama Dental College, Kanpur

Dr. Abhidvita Tripathi

PG Student

Department of Prosthodontics, Crown & Bridge,

Rama Dental College, Kanpur

Dr. Tanya Agarwal

PG Student

Department of Prosthodontics, Crown & Bridge,

Rama Dental College, Kanpur

### **Corresponding Author**

Dr Manoj Kumar

Department of Prosthodontics

Rama Dental College, Hospital & Research Center, Mandhana, Kanpur- 209217

Email id: man.mk003@gmail.com

Mobile no. +91 9198082474

## **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.<sup>1</sup> 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.<sup>2</sup> To record the three-dimensional (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.<sup>3</sup> 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.<sup>2</sup> 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.<sup>2</sup> 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.<sup>2</sup>

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.<sup>2</sup> 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 subsubgroup ( $n = 10$ ).

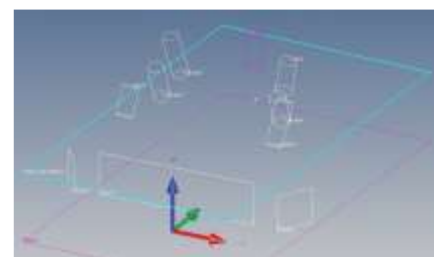
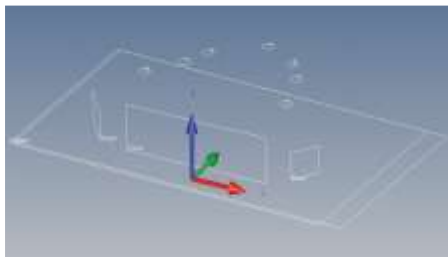
### ***Model preparation***

A vertical milling machine and an implant angulation guide (Institut Straumann AG, Switzerland) were used to place parallel implants (BioHorizons™ 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***

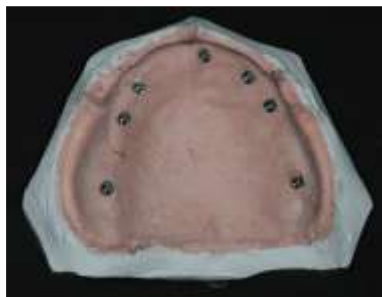
A standard procedure was followed for all impressions. impression copings were tightened to the implants with the help of a hex driver at 10 N cm torque. Tray adhesive (3M ESPE™) was painted on all the trays for 15 min prior to each procedure to obtain adequate tensile bonding strength, before recording the impressions. For splinting, impression copings were tied with dental floss and pattern resin (GC Corporation, Japan) was applied in 2 mm thickness [Figure 7]. After 17 min, the splint was sectioned into four pieces with a diamond disk and 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, Zhermack SpA, 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 were separated from the cast after 1 h. All the casts were stored at room temperature for 24 h.



**Figure 8: Cast obtained**

### ***Measurement***

BioHorizons™ (3.5 diameter, regular) standard abutments were screwed onto the implants in reference model to get reference measurements for each distance. In each study model also, BioHorizons™ (3.5 diameter, regular) standard abutments were screwed onto the analogs. A single examiner measured the distance between abutment heads using a coordinate measuring machine (CMM) (Mitutoyo, Japan) in reference and study models [Figure 9]. Differences of mean distances in each group from respective distance on reference model were taken as coronal deviation from accuracy and compared.

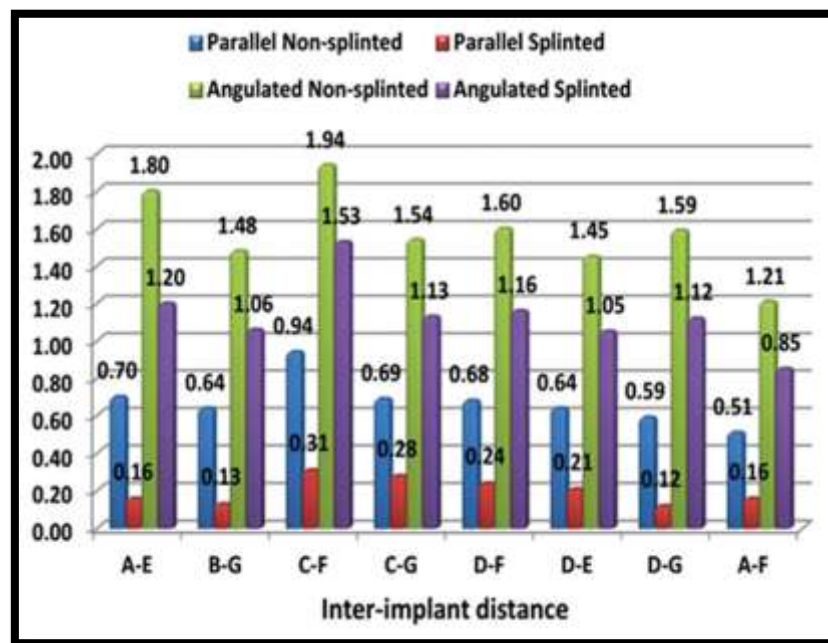


**Figure 9: Stone cast being measured with standard abutments in place on the CMM machine. CMM: Coordinate measuring machine**

## 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.

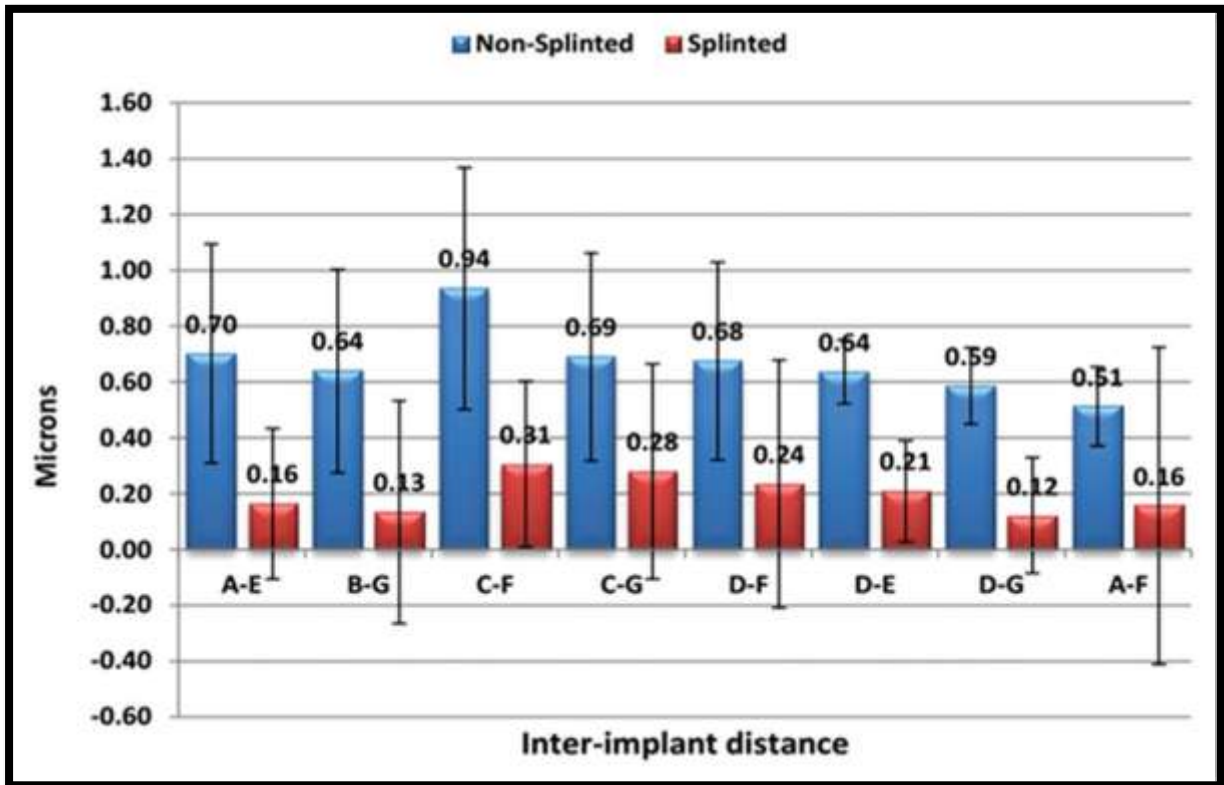
## RESULT



**Graph 1:** Inter sub group comparison of mean difference

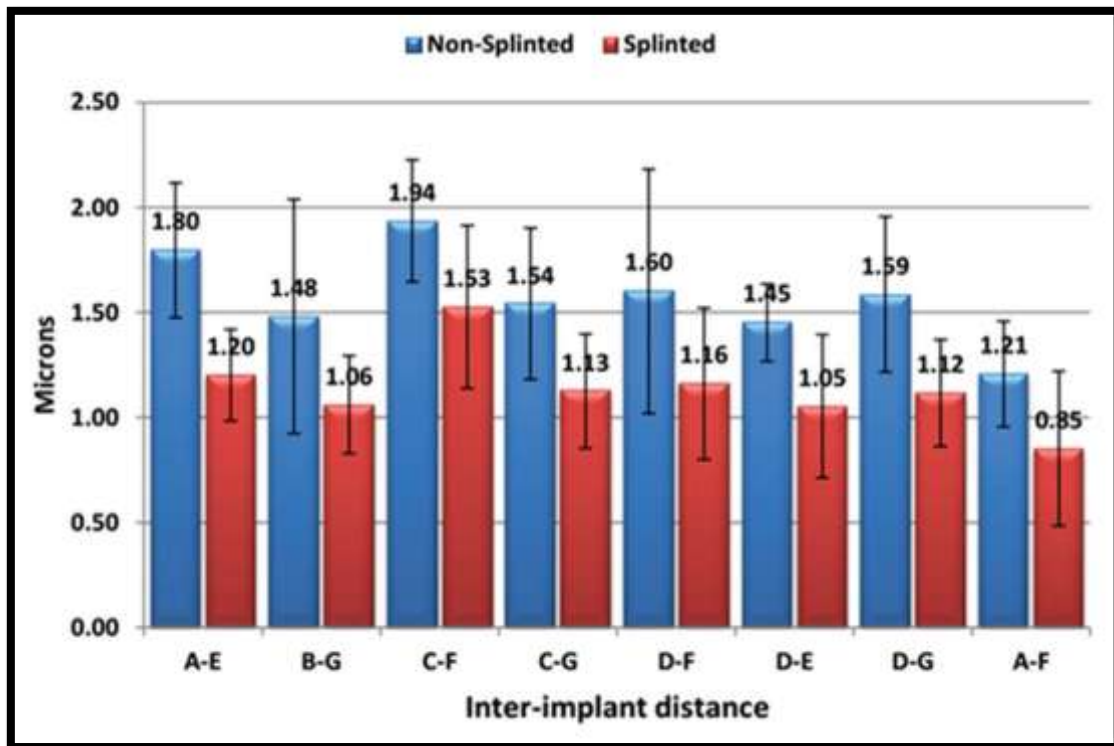
Graph 1 depicts the summarization of the mean difference and standard deviation of inter implant distances such as A–E, B–G, C–F, C–G, D–F, D–E, D–G, and A–F compared from control values on master models. A significant difference ( $P < 0.001$ ) was found among the four subgroups.

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.



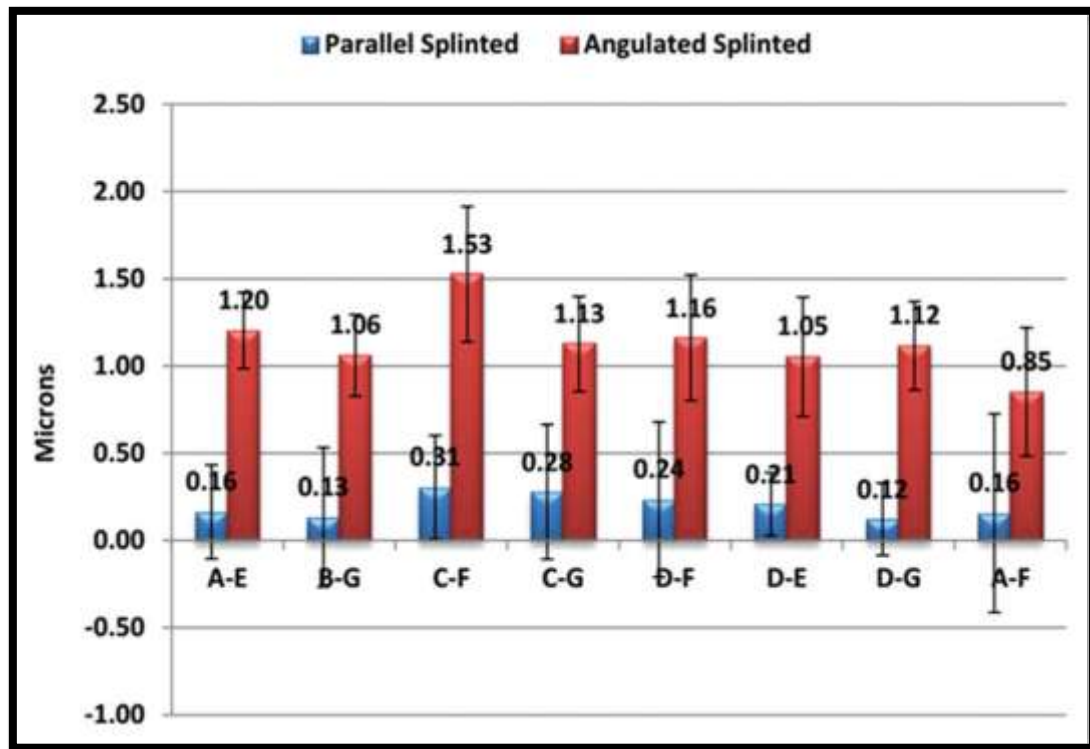
**Graph 2:** Intragroup comparison of mean difference with standard deviation between parallel nonsplinted (Subgroup 1NS) and parallel splinted (Subgroup 1S) groups

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.



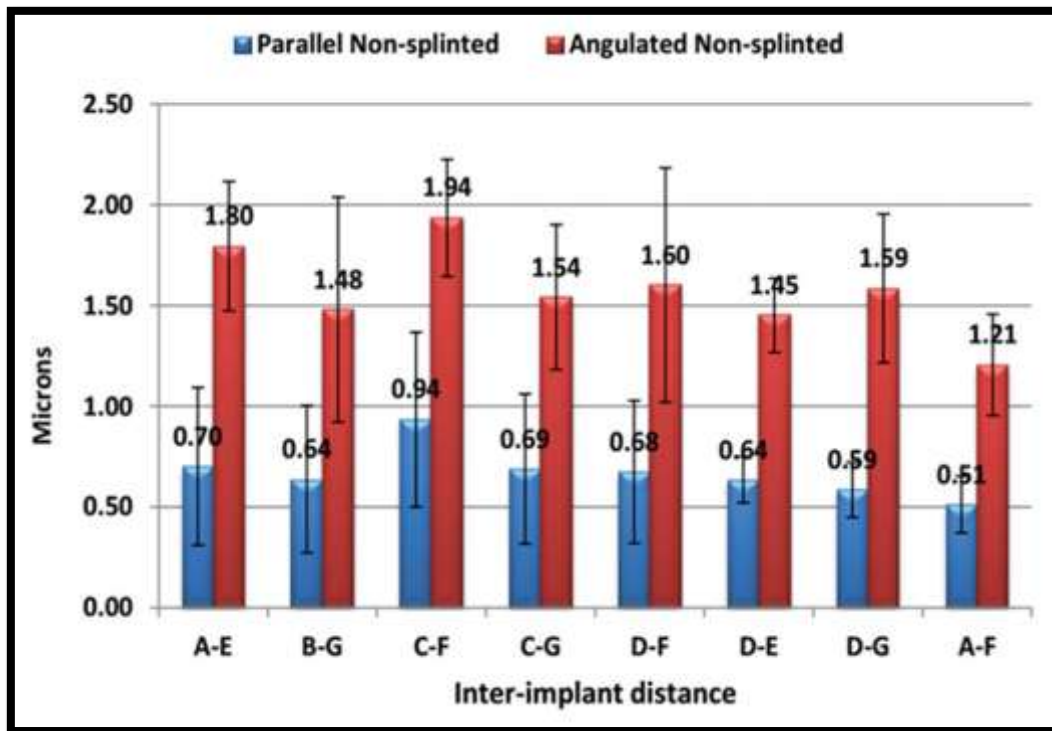
**Graph 3:** Intragroup comparison of mean difference with standard deviation between angulated nonsplinted (Subgroup 2NS) and angulated splinted (Subgroup 2S) groups

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 parallel nonsplinted (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.<sup>4,5</sup> Very few studies have reported cumulative influence of these variables on implant impression. The accuracy of implant cast is directly proportional to the impression technique which ultimately leads to passive fit implant prosthesis. There are various techniques that can be used for impression in multiple unit implant-supported prosthesis with advantages and disadvantages associated with each

technique. The present study was conducted to compare the implant cast accuracy of angulated and parallel implants with splinted and nonsplinted impression technique.

In multiple implant impressions, impression copings are aligned at different angles and there can be pronounced rotational movement of copings leading to inaccuracy. Further, deep wide connection area (hex) in internal connection implants is more engaging and may cause movement of impression copings and hence distortion within impression necessitating the use of nonhexed copings.<sup>6,7</sup> The impression procedure in our study was standardized by using light-cure custom trays of uniform thickness fabricated on the same duplicated cast and with same-sized stops for the accurate positioning of the tray on the reference model each time an impression was made. The pickup impression copings were hand tightened with a hex driver by the same operator, eliminating the difference in force used for tightening to simulate a clinical situation.

The PE impressions were separated from the cast after more than 6 min.

In the present study, splinted technique in angulated implants exhibited greater accuracy as compared to nonsplinted technique in parallel implants. This result was in accordance with the study conducted by Assuncao *et al.*<sup>8</sup> and Cabral and Guedes<sup>9</sup> that reported less accurate impressions with angulated implants than parallel implants with four or five implants in experimental cast.

Similarly, Tsagkalidis *et al.*<sup>10</sup> also concluded that splinted impression technique exhibited a higher accuracy than the other techniques studied when increased implant angulations at 25° were involved.

Some studies did not show significant result in splinting and nonsplinting technique. According to the study by Lee *et al.*,<sup>11</sup> it was concluded that there was no significant difference in the accuracy between the unsplinted and splinted methods in pickup impression techniques. This study also had two implants in master model with 10° divergence angle. In clinical conditions, divergence between implants may often be >8°.

However, few studies reported in literature did not favor the result of this study and suggested nonsplinted technique. Inturregui *et al.*<sup>12</sup> suggested that nonsplinted technique was better than splinted technique. In this study, only two abutments were placed in the master model, and rigid This study is limited by the following factors that temperature, humidity, moisture, and saliva in oral cavity could affect the setting of acrylic resin splinting.

In addition, because of different extent of undercut or difference in anatomy, the force and path of impression tray removal were considered to be different from experimental studies. While interpreting implant impression accuracy, the machining tolerance was not considered as it is also an important factor affecting accuracy.<sup>13</sup> Comparisons between implant impressions with copings that can be digitally scanned intraorally and superimposed may provide the foundation for future research. Therefore, the influence of the above-mentioned parameters should be considered in future research as they may 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.

## REFERENCES

1. Kaur T, Singla S, Kumar L. Comparison of accuracy of hexed and nonhexed pickup impression copings in a multiple variable impression setup for recording multiple

straight and angulated implant positions: An *in vitro* study. J Indian Prosthodont Soc 2023;23:21-9.

2. Arora A, Upadhyaya V, Parashar KR, Malik D. Evaluation of the effect of implant angulations and impression techniques on implant cast accuracy – An *in vitro* study. J Indian Prosthodont Soc 2019;19:149-58.
3. Selvaraj S, Dorairaj J, Mohan J, Simon P. Comparison of implant cast accuracy of multiple implant impression technique with different splinting materials: An *in vitro* study. J Indian Prosthodont Soc 2016;16:167-75.
4. Wee AG. Comparison of impression materials for direct multi-implant impressions. J Prosthet Dent 2000;83:323-31.
5. Ma T, Nicholls JI, Rubenstein JE. Tolerance measurements of various implant components. Int J Oral Maxillofac Implants 1997;12:371-5.
6. Rashidan N, Alikhasi M, Samadzadeh S, Beyabanaki E, Kharazifard MJ. Accuracy of implant impressions with different impression coping types and shapes. Clin Implant Dent Relat Res 2012;14:218-25.
7. Richi MW, Kurtulmus-Yilmaz S, Ozan O. Comparison of the accuracy of different impression procedures in case of multiple and angulated implants: Accuracy of impressions in multiple and angulated implants. Head Face Med 2020;16:9.
8. Assuncao WG, Filho HG, Zaniquelli O. Evaluation of transfer impressions for osseointegrated implants at various angulations. Implant Dent 2004;13:358-66.
9. Cabral LM, Guedes CG. Comparative analysis of 4 impression techniques for implants. Implant Dent 2007;16:187-94.
10. Tsagkalidis G, Tortopidis D, Mpikos P, Kaisarlis G, Koidis P. Accuracy of three different impression techniques for internal connection angulated implants. J Prosthet Dent 2015;1-7.
11. Lee H, So JS, Hochstedler JL, Ercoli C. The accuracy of implant impressions: A systematic review. J Prosthet Dent 2008;100:285-91.
12. Inturregui JA, Aquilino SA, Ryther JS, Lund PS. Evaluation of three impression techniques for osseointegrated oral implants. J Prosthet Dent 1993;69:503-9.
13. Ma T, Nichollas JI, Rubenstein JE. Tolerance measurements of various implant components. Int J Oral Maxillofac Implants 1997;12:371-5.