Original Article

To evaluate and compare the accuracy of definitive casts using various splinting methods on implant level impressions in All-on-Four treatment: An *in vitro* study

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Abstract

Aim: The aim of this study is to evaluate and compare the accuracy of master casts obtained by different splinting techniques for implant level impressions in All-on-Four implant treatment protocol using a coordinate measuring machine.

Settings and Design: The study design involves an *in vitro* study.

Materials and Methods: In this *in vitro* study, a reference clear acrylic resin (AR) model comprising four regular platform implant 3.6 mm × 10.0 mm (Dentium Implant India Pvt. Ltd, Bengaluru, India) which was placed following the All-on-Four implant protocol is prepared. Impressions were categorized into three different groups: Group 1 – impression copings were nonsplinted; Group 2 – impression copings were splinted using AR sectioned 17 min after setting and rewelded with the same resin; and Group 3 – impression copings were splinted by titanium bar using an intraoral welder. A total of 33 ($n = 11$ in each group) impressions were made to evaluate three different splinting techniques. Impressions were poured with Type 4 dental stone. A coordinate measuring machine was used to record the x, y, and z co-ordinates and angular displacement. The measurements were compared with those obtained from the reference model.

Statistical Analysis Used: One-way ANOVA test was used as a test of significance.

Results: There was less linear and rotational displacement for the metal-splinted group ($P < 0.001$) In the x-axis, nonsplinted group showed a statistically significant difference in straight implants (2 and 3 implants) ($P = 0.001$) of All-on-Four treatment protocol.

Conclusion: The splinting methods have a direct effect on the accuracy of definitive casts. The metal-splinted direct technique produced the most accurate casts followed by AR-splinted direct technique and nonsplinted direct technique.

Keywords: All-on-Four implant prostheses, implant level impressions, splinting technique

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INTRODUCTION

To overcome the biologic and biomechanical complications such as the presence of inferior alveolar nerve, blood vessels, sinuses, lengthy cantilever distally,[1] the "All-On-Four" treatment concept was developed to maximize the use of available bone in atrophic jaws. This allows immediate function and avoids regenerative procedures.[2]

The success of All-on-Four implant treatment depends on achieving a passive fit between the implant frameworks and underlying structures.[3] Clinically, open-tray impression is found to be more accurate in multiple implant scenario.[4,5] To achieve a passive fit, making an accurate impression is important. This is affected by the factors such as impression material, impression tray, impression technique,[6] and splint material.[7] Not much literature is available on how metal welding would influence the accuracy of impressions in a scenario of a conventional multi-implant system with different implant angulations, especially for All-On-Four implant treatment dentures.

Research hypothesis (H1)

There is a difference in the accuracy of the casts made with two different splinting methods to those without splinting the impression copings.

MATERIALS AND METHODS

Preparation of standard model

Various materials used in this study are shown in Figure 1. A reference acrylic resin (AR) replica of an edentulous maxilla was made. The proposed All-on-Four protocol was followed, and four implants 3.6 mm × 10.0 mm (Dentium Implant India Pvt. Ltd., Bengaluru, India) were inserted in canine and second premolar sites using the prescribed All-on-Four guide. Two anterior implants were inserted perpendicular to the horizontal plane and parallel to each other, whereas the posterior implants were placed at 45° to the horizontal plane. Paulo Malo guide (All-on-4 Guide: Noble Biocare, Goteborg, Sweden) was used for placing these implants [Figure 2]. A metallic index was inserted in the midline of the palate to serve as a reference for the measurement and was defined as point 0.

Sample size and grouping

To calculate the sample size, mean difference of displacement was considered.[7,8] Hence, the calculated sample size is 33. Three different groups of impression techniques were investigated (n = 11 per group).

Group 1 (N)

Nonsplinted direct impression technique is shown in Figure 3. The transfer copings were adapted to implants with uniform 10N/cm torque (Ref. 001457; GT Medical, Madrid, Spain).

Group 2 (R)

This was an AR-splinted direct impression technique. In this group, the transfer copings were adapted to implants with uniform 10 N/cm torque. The impression copings were tied up with four complete loops of dental floss and

Figure 1: List of materials used in this study

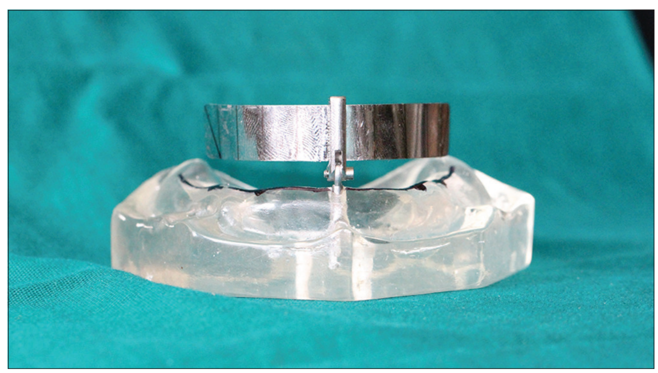


Figure 2: Paulo Malo guide used to place implants in the correct position

Figure 3: Nonsplinted group

splinted with auto-polymerizing pattern AR (GC Pattern resin, GC Corporation, Tokyo, Japan). The AR was applied around the impression copings using an incremental application technique with a brush. The amount of AR was assumed to be satisfactory when the square surfaces of the transfer copings were fully covered with a layer about 2 mm in thickness [Figure 4]. After 17 min, the splint was sectioned and readapted using the same AR using a brush. Another 17 min interval was allowed after additional splinting to reduce the effects of polymerization shrinkage.

Group 3 (M)

Impression copings were splinted by 2-mm thick round titanium bar using intraoral welder (Ennebi electronica srl, Papa Giovanni, Navedrata, Italy) [Figure 5].

Impression procedure

This standard model is duplicated with an irreversible hydrocolloid (Zelgan plus, Dentsply India Pvt Ltd., Gurgaon, India) and poured with die stone (Kalrock, Kalabhai Karson Pvt. Ltd., Mumbai, India). This duplicated model is covered by two layers of baseplate wax (Golden dental products, Hyderabad, Telangana, India) to provide a uniform thickness of impression material. The special trays were made using auto-polymerizing AR (MP Sai Enterprise Pvt. Ltd., Thane, Mumbai, Maharashtra, India) for making a final impression. The impression trays were designed with four occlusal openings to allow access for the coping screws.

Three different groups of direct impressions were made (n = 11 per group). All the impressions were made with regular-viscosity polyether impression material (Impregum Penta; 3M ESPE, USA). An automix machine (Pentamix; 3M ESPE, USA) was used to standardize all the mixtures [Figure 6]. The appropriate adhesive (Polyether adhesive; 3M ESPE, USA) was applied to the inner surface and 5 mm beyond the borders of all custom trays 15 min before impression making.

All copings were connected to the implants using a manual hex driver. The impression material was injected around the copings using a dispenser (Penta Elastomer syringe; 3M ESPE, USA) to ensure the complete coverage of the copings, and the remaining material was used to load the impression tray. The tray was seated over the reference model under the finger pressure. After the impression material had polymerized completely (10 min from the start of mixing), the guide pins were loosened with a hex screwdriver and removed. The tray was separated from the reference model, whereas the impression copings remained locked in the impression.

The guide pins were placed back into the impression copings from the top and implant analog was connected to the hex on the bottom, and the guide pins were tightened with the driver.

Impressions were inspected and repeated when any inaccuracies were found such as air voids, impression material between the implant impression coping interface, or separation from the tray. All the components were carefully oriented for complete seating [Figure 7]. The same operator attached analogs to the impression copings. The impressions were boxed and poured with Type 4 dental stone (Kalrock, Kalabhai Karson Pvt. Ltd., Mumbai, Maharashtra, India) after 1 h to form a base height of 3 cm. The casts were retrieved [Figure 8] after 2 h. Like this, a total of 11 casts were made per group.

Assessment accuracy

A coordinate measuring machine (CMM FARO edge technologies, India) with a mechanical probe of 1 mm diameter was used to record 3D (three-dimensional) coordinate centers of each implant [Figure 9] in each direction (x-axis, y-axis, and z-axis). Moreover, the same software transforms the 3D data into the distance between

Figure 4: Pattern resin sectioned and Re-welded for splinting

Figure 5: Splinting by titanium bar using intraoral welder

the implants. The center-to-center distance between four implants was measured five times for the reference model, and the values were recorded and tabulated [Figure 10]. This is repeated for 33 definitive casts.

Statistical analysis

Statistical analysis was performed using the SPSS Statistics version 20(IBM, Armonk, NY, USA). The inter-technique variability was analyzed using the ANOVA with repeated measures followed by the Bonferroni *post hoc* test. $P < 0.05$ is considered to be statistically significant.

RESULTS

The angulated implant in the first quadrant was assigned number 1; the straight implant in the first quadrant was assigned number 2; the straight implant in the second quadrant was assigned number 3; and the angulated implant in the second quadrant was assigned number 4 [Figure 3]. Three different splinting techniques were used: Group 1 (N) was the nonsplinted group; Group 2 (R) was the splinted using pattern resin, sectioned, and re-welded after 17 min; and Group 3 (M) was splinted with titanium bar [Table 1].

Each implant was evaluated for rotational discrepancy designated as (r) and discrepancy in the three-axis x, y, and z with that of the reference model.

Effect on angulated implant [implant location 1 in Figure 3]

The x-axis value for (N) nonsplinted, (R) splinted using pattern resin, and (M) splinted using titanium bar had a $P = 0.029$ which was statistically significant in relation to R-M pair with the M grou*P* value showing the least discrepancy [Table 2 and Graph 1].

Figure 6: Loading of impression tray using pentamix auto-mixing machine

Clinical significance

Along the x-axis (mesiodistally), Group 3 (metal splinted) showed the least variation compared to others.

Effect on straight implant [implant location 2 in Figure 3]

The straight implants in the first quadrant had a rotational discrepancy (r) noted with a $P = 0.024$ which was statistically significant in relation to the N-M pair with M group showing the least discrepancy [Table 3 and Graph 2].

The x-axis value for all the three nonsplinted (N) had a $P = 0.001$ which was statistically significant in relation to the R-M pair. Hence, Group N showed the least discrepancy.

Table 1: Sample groups

Group 1/Group-N	Group 2/Group-R	Group 3/Group-M
Impression copings were not splinted	Impression copings were splinted using pattern acrylic resin, sectioned after 17 min and re-welded again with the same material	Impression coping was splinted by a titanium bar using an intraoral welder

Table 2: Absolute mean values of deviation for the first (1) angulated implant in N, R, and M Groups from the reference model (X, Y, and Z axis in millimeters and "R" in degree)

	Group	Mean	SD	*F*	*P*	Significant
1r	N	-1.81355	1.855345	.540	.588	
	R	-1.27536	1.452060			
	M	-2.38209	3.627205			
1x	N	-.164364	.3007505	3.977	.029	R-M
	R	-.615364	.8978058			
	M	.078091	.3620402			
1y	N	-.565818	.5407520	.418	.662	
	R	-.570000	.5739164			
	M	-.893364	1.4718706			
1z	N	.212545	1.3176265	.129	.879	
	R	.399818	.4319229			
	M	.402727	1.0552369			

Figure 7: Impression retrieved, analogs fastened

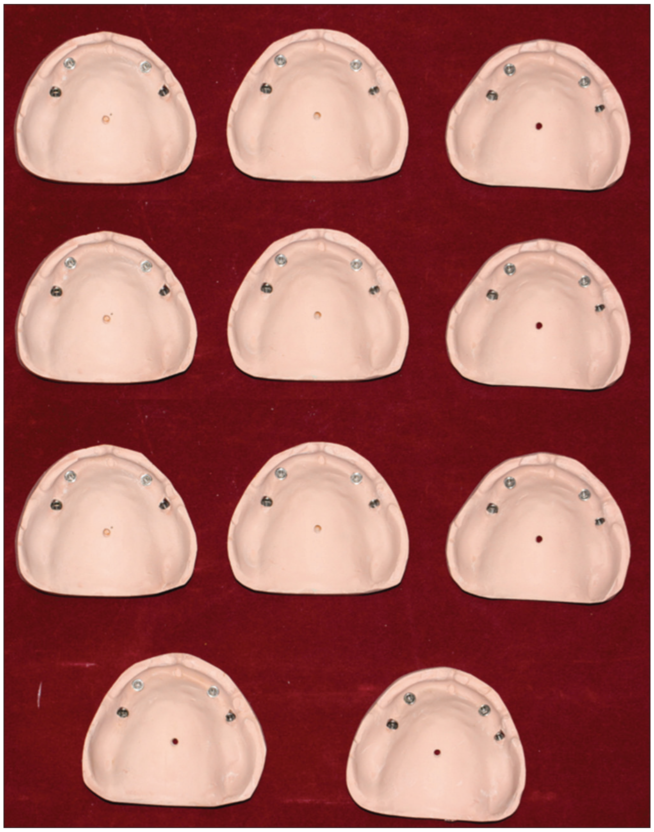


Figure 8: Replica models obtained

Clinical significance

Straight implants which were nonsplinted (N) showed a significant rotational discrepancy. Along the x-axis (mesiodistally), the Group N showed the least discrepancy.

Effect on straight implant [implant location 3 in Figure 3]

The straight implants in the second quadrant with that of the master model had a $P < 0.001$ which was statistically significant in relation to N-R, R-M, and N-M pairs. M group showed the least discrepancy [Table 4 and Graph 3].

The x-axis values for Group N showed a $P = 0.001$ which was statistically significant in relation to the R-M pair. Group N showed the least discrepancy.

The y-axis value of Group M at 95% confidence interval showed a $P < 0.001$ which was statistically significant in relation to N-R, N-M, and R-M pairs with M group showing the least discrepancy.

The z-axis value for Group R had a $P < 0.001$ which was statistically significant in relation to N-M and R-M pairs. R group showed the least discrepancy.

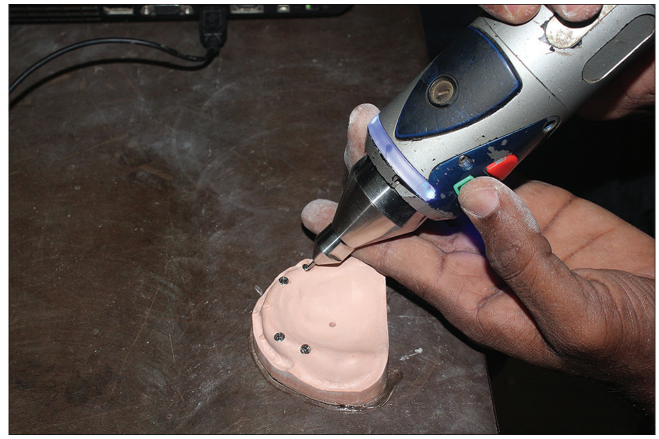


Figure 9: Displacement checked using coordinate measuring probe

Table 3: Absolute mean values of deviation for the second (2) straight implant in N, R, and M Groups from the reference model (X-axis, Y-axis, and Z-axis in millimeters and "R" in degree)

	Group	Mean	SD	*F*	*P*	Significant
2r	N	-2.533909	2.3686937	4.227	.024	N-M
	R	-1.137545	2.5158774			
	M	.099909	1.2708992			
2x	N	.112091	.5626307	8.845	.001	R-M
	R	-.773636	1.1558029			
	M	.700545	.6341723			
2y	N	-.847364	.5159580	.578	.567	
	R	-.954091	.5587106			
	M	-1.277182	1.5111371			
2z	N	.220818	1.5916634	2.380	.110	
	R	1.645545	1.0286740			
	M	1.006727	1.8629771			

Clinical significance

Rotational (r) and labiolingual displacement (y-axis) are least with Group M, whereas in z-axis (vertical displacement), Group R showed less discrepancy.

Effect on angulated implant (4)

When comparing the angulated implants in the second quadrant with that of the master model, the $P < 0.001$ for the N (nonsplinted), R (splinted using pattern resin), and M (splinted using titanium) which was statistically significant in relation to N-R, R-M, and N-M pairs. M group showed the least discrepancy [Table 5 and Graph 4].

The x-axis value showed a statistically significant P value in relation to N-R, N-M, and R-M pairs. M group showed the least discrepancy.

The y-axis value for all the three groups had $P < 0.001$ which was statistically significant in relation to N-R, R-M, and N-M pairs. M group showed the least discrepancy.

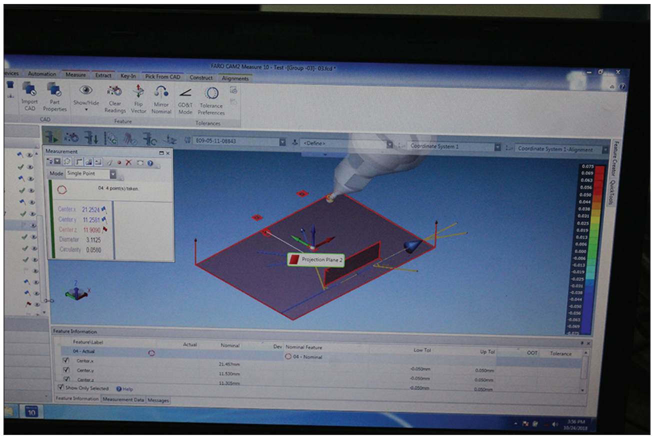
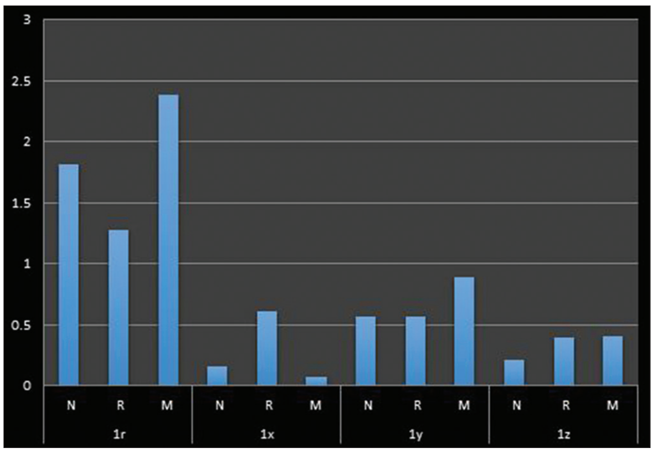
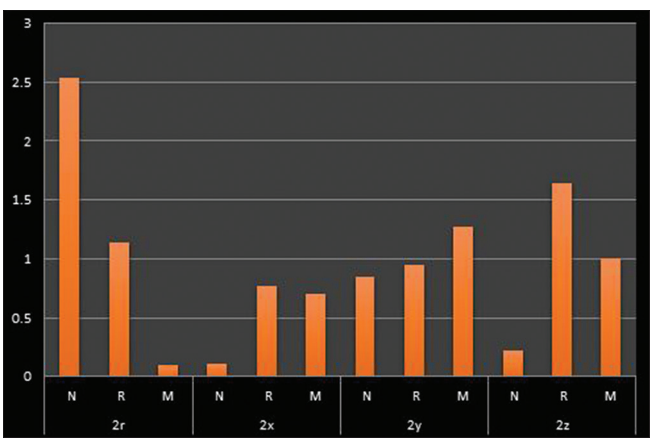


Figure 10: Data obtained by the coordinate measuring machine



Graph 1: Absolute mean values of deviation for the first (1) angulated implant in N, R and M groups from the reference model (x-axis, y-axis, and z-axis in millimeters and "r" in degree)



Graph 2: Absolute mean values of deviation for the second (2) straight implant in N, R, and M groups from the reference model (x-axis, y-axis, and z axis in millimeters and "r" in degree)

Clinical significance

Group M showed significantly best results out of the other three groups with respect to rotational as well as in x-axis, y-axis, and z-axis.

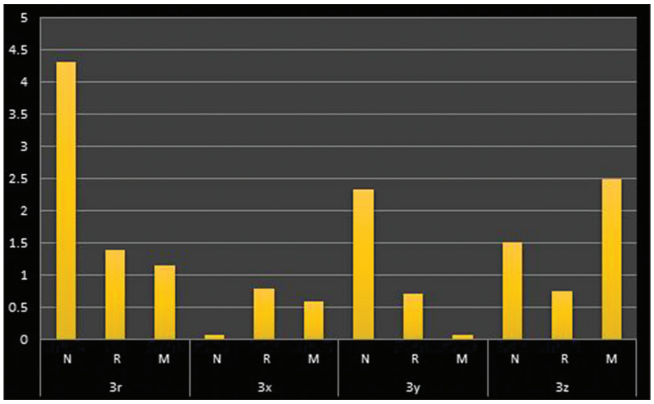
Table 4: Absolute mean values of deviation for the third (3) straight implant in N, R, and M Groups from the reference model (X-axis, Y-axis, and Z-axis in millimeters and "R" in degree)

	Group	Mean	SD	*F*	*P*	Significant
3r	N	-4.312273	1.8382838	17.572	<.001	N-R
	R	1.397818	2.8951765			N-M
	M	-1.162636	1.8975408			R-M
3x	N	-.069364	.6350454	8.796	.001	
	R	-.797545	1.0866223			R-M
	M	.605273	.5124898			
3y	N	-2.326636	.7510167	20.149	<.001	N-R
	R	-.708273	1.0824800			N-M
	M	-.070182	.6929394			R-M
3z	N	1.520636	1.0475246	12.447	<.001	N-M
	R	.750636	.4665223			
	M	2.503545	.8554079			R-M

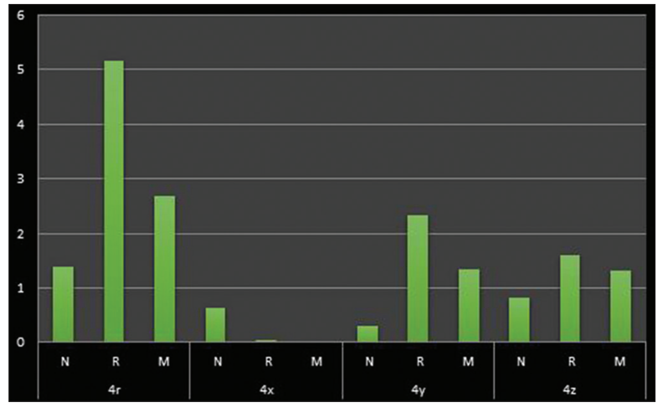
DISCUSSION

In this study, an open-tray direct impression is followed as the study showed it is better than the closed-tray impression.[5] The findings of the study clearly suggest the maximum amount of variation or discrepancy was seen in Group N (nonsplinted) in comparison with the other two groups (R and M). The rotational discrepancy was evident for both Group N and R in comparison with that of the M group. However, maximum variation was seen along the x-axis (mesiodistally) for all the groups except Group M, increasing its accuracy by the process of splinting using a metal bar. A study done by Saini *et al.* stated that during clinical and laboratory phases, inaccuracy in transferring 3D orientation of implants to the cast can be detected due to the movement of impression copings. The splinting of transfer copings and modifications are emphasized to reduce this movement. The splinted direct technique was found to be the most accurate for multiple nonparallel implants.[9]

The reason for greater accuracy with the splinted technique is that the splinting may provide stabilization of transfer copings under the torque from analog tightening and reduce rotational freedom within a resilient impression material. Pujari *et al.* have shown the importance of proper seating of all the components during the fabrication of definitive cast. Unscrewing the guide pins from the impression copings when the tray is removed or screwing the matching implant replicas in the impression may cause minor movement and thus influence cast accuracy.[10] As found in the result of this study, nonsplinted implants have shown most of the variation compared to the other stable groups (R and M). Lack of splinting will thus result in an inaccurate impression and casts thereafter.



Graph 3: Absolute mean values of deviation for the third (3) straight implant in N, R, and M groups from the reference model (x-axis, y-axis, and z-axis in millimeters and "r" in degree)



Graph 4: Absolute mean values of deviation for the fourth (4) angulated implant in N, R and M groups from the reference model (x-axis, y-axis, and z-axis in millimeters and "r" in degree)

Table 5: Absolute mean values of deviation for the fourth (4) angulated implant N N, R, and M Groups from the reference model (X-axis, Y-axis, and Z-axis in millimeters and "R" in degree)

	Group	Mean	SD	*F*	*P*	Significant
4r	N	-5.161455	2.0556773	22.236	<.001	N-R
	R	-2.681000	2.3845899			N-M
	M	1.386727	2.5116524			R-M
4x	N	-.733545	.7228216	8.927	.001	N-R
	R	.054091	.3380537			N-M
	M	.055364	.3589976			R-M
4y	N	-2.339182	.8348604	26.647	<.001	N-R
	R	-1.330000	.9547908			N-M
	M	.297909	.7641689			R-M
4z	N	.835273	.8056192	3.147	.057	
	R	1.607909	.7758250			
	M	1.327182	.5942905			

Splinting technique is one of the most important methods mentioned in the literature, gaining popularity over the years and proven to be the most accurate, even though contrary opinions still remain. However, the authors have identified potential problems with the splinted technique, such as a fracture of the connection between the splint material and the impression copings, in particular, due to shrinkage of the splint material.[11] AR is the most popular splinting material. Besides AR, impression plaster, dual-cure AR, orthodontic wire, prefabricated AR bars, light-curing composite resin, and carbon steel pins have been used to splint the impression copings. Auto-polymerizing AR yielded better results, probably because of increased stiffness and greater stability.[12] Temporization material bispenol A -glycidyl methacrylate (GMA) also showed better results compared to nonsplinted impressions.[13]

To minimize the adverse effects of polymerization shrinkage, it is recommended that the AR splint should be separated after polymerization and then reconnected with a small amount of this material. Martínez-Rus *et al.* demonstrated that 80% of the AR shrinkage occurs in the first 17 min.[14] In the present study, the separation and reconnection were performed after this time interval to relieve the shrinkage stress. Lee and Cho showed adequate polymerization time and compensation of shrinkage, which is the main reason for greater accuracy. Material shrinkage will deteriorate the fit of the final prosthesis.[15] Achieving a passive fit still remains a tricky goal for prosthodontists.[16]

The residual stress on the matrix of chemically activated AR could be released during the impression procedure, causing misfit of the abutment's position on the definite cast. The distortion increases proportionally with the volume of the AR used.[17] To avoid any sort of discrepancy in implant framework or connection, some authors evaluated metal bar for splinting the impression copings. Del Acqua *et al.* showed the increased splint rigidity of metal bars to withstand the forces of distortion. Metal bars also avoid AR polymerization, and further sectioning and rejoining are clinically advantageous.[7] Singh conducted a study to know the result of joining the sectioned implant-supported prosthesis on the peri-implant strain generated in the virtual mandibular model. This study revealed that sectioning and reuniting the long-span implant prosthesis was found to be a significant factor in influencing the peri-implant strain, irrespective of joining methods such as arc welding, laser welding, and soldering.[18] When we see the literature on the digital impression for such cases, Gherlone EF used digital impressions in "All-on-Four" implant restorations. A digital scan body can be an adjuvant to get a definitive prosthesis. The digital impression creates a precise physical model that will significantly improve efficiency and streamlining the workflow.[19] Regarding impression materials for multiple implant impressions, we could see a lot of articles comparing polyvinyl siloxanes with polyether. Polyether impression material is stiff, hydrophilic, and highest tear strength compared to polyvinyl siloxane. One such study by Pujari *et al*. on an evaluation of the accuracy of casts of multiple internal connection implant prosthesis obtained from different impression materials and techniques revealed casts obtained from polyether impression material were more accurate than the casts obtained from vinyl polysiloxane impression material.[10] Despite using the best impression material, we could see a discrepancy between inter-implant locations; hence, idea of splinting the abutment inside the mouth came into the picture.

Martínez-Rus *et al*. conducted a study comparing different splinting media for multiple implant situations and they concluded that the metal-splinted direct technique was the most accurate impression procedure for a situation of multiple internal connection implants placed with different angulations (0–30 degrees) and depths (0–3 mm), followed by AR-splinted direct and nonsplinted direct techniques,[14] which showed similar results like the present study.

CONCLUSION

Within the limitations of this prospective study and the results obtained, it can be concluded that

1. The greatest discrepancy was observed in the nonsplinted group in all the three axes (x-axis, y-axis, and z-axis) and rotational movement around the long axis
2. Although AR splinting is most commonly used clinically, the results of this study have shown significant values compared to the nonsplinted and metal-splinted group. The discrepancy observed in the resin group is less than nonsplinted and more than the metal-splinted group suggestive of resin splinting as a viable splinting material
3. The discrepancy observed in all three axes and rotational movement was least in metal-splinted group for making an impression of multiple implants.

Clinical significance

The titanium bar splinted to the impression copings using intraoral welder may be considered as an excellent splinting material to prevent the linear and rotational displacement of transfer copings and obtain accurate master casts. This, in turn, improves the passivity of the framework and longevity of the treatment in multiple implant cases.

Scope and limitations

The results of this study are limited to four implants with All-on-Four arrangements and might not apply to impressions with higher or lower numbers and different degrees of implant divergence. Furthermore, it might be assumed that tissue undercuts and different implant angulations may cause greater inaccuracy in the impression procedures that were not addressed in the present study. Although the present investigation did not simulate all clinical conditions, the techniques evaluated are expected to produce similar results in the oral environment. Future studies, particularly long-term prospective clinical trials, are needed to make further refinements to the impression and laboratory procedures to determine the amount of distortion tolerable biologically and mechanically. It will also help to analyze the clinical failures and complications in implant-supported prostheses.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Balshi TJ, Wolfinger GJ, Slauch RW, Balshi SF. A retrospective analysis of 800 Brånemark System implants following the All-on-Four™ protocol. J Prosthodont 2014;23:83-8.
2. Soto-Penaloza D, Zaragozí-Alonso R, Penarrocha-Diago M, Penarrocha-Diago M. The all-on-four treatment concept: Systematic review. J Clin Exp Dent 2017;9:e474-88.
3. Kan JY, Rungcharassaeng K, Bohsali K, Goodacre CJ, Lang BR. Clinical methods for evaluating implant framework fit. J Prosthet Dent 1999;81:7-13.
4. Siadat H, Alikhasi M, Beyabanaki E, Rahimian S. Comparison of different impression techniques when using the all-on-four implant treatment protocol. Int J Prosthodont 2016;29:265-70.
5. Balamurugan T, Manimaran P. Evaluation of the accuracy of direct transfer snap-on the impression coping closed tray impression technique and direct transfer open tray impression technique: An *in vitro* study. J Indian Prosthodont Soc 2013;13:226-32.
6. Alikhasi M, Siadat H, Beyabanaki E, Kharazifard MJ. Accuracy of implant position transfer and surface detail reproduction with different impression materials and techniques. J Dent (Tehran) 2015;12:774-83.
7. Del Acqua MA, Chavez AM, Castanharo SM, Compagnoni MA, Mollo F de A Jr. The effect of splint material rigidity in implant impression techniques. Int J Oral Maxillofac Implants 2010;25:1153-8.
8. Chow S, Shao J, Wang H. Sample Size Calculations in Clinical Research (Chapman and Hall/CRC Biostatistics Series). 2nd ed. Boca Raton: Taylor; 2008. p. 58.
9. Saini HS, Jain S, Kumar S, Aggarwal R, Choudhary S, Reddy NK. Evaluating the effect of different impression techniques and splinting methods on the dimensional accuracy of multiple implant impressions: An *in vitro* study. J Contemp Dent Pract 2018;19:1005-12.
10. Pujari M, Garg P, Prithviraj DR. Evaluation of the accuracy of casts of multiple internal connection implant prosthesis obtained from different impression materials and techniques: An *in vitro* study. J Oral Implantol 2014;40:137-45.

11. Moreira AH, Rodrigues NF, Pinho AC, Fonseca JC, Vilaça JL. Accuracy comparison of implant impression techniques: A systematic review. Clin Implant Dent Relat Res 2015;17 Suppl 2:e751-64.
12. Ongül D, Gökçen-Röhlig B, Şermet B, Keskin H. A comparative analysis of the accuracy of different direct impression techniques for multiple implants. Aust Dent J 2012;57:184-9.
13. 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.
14. Martínez-Rus F, García C, Santamaría A, Özcan M, Pradíes G. Accuracy of definitive casts using 4 implant-level impression techniques in a scenario of a multi-implant system with different implant angulations and sub-gingival alignment levels. Implant Dent 2013;22:268-76.
15. Lee SJ, Cho SB. Accuracy of five implant impression technique: Effect of splint- ing materials and methods. J Adv Prosthodont 2011;3:177-85.
16. Buzayan MM, Yunus NB. Passive fit in screw retained multi-unit implant prosthesis understanding and achieving: A review of the literature. J Indian Prosthodont Soc 2014;14:16-23.
17. Lopes-Júnior I, de Lima Lucas B, Gomide HA, Gomes VL. Impression techniques for multiple implants: A photoelastic analysis. Part I: Comparison of three direct methods. J Oral Implantol 2013;39:539-44.
18. Singh I, Nair KC, Shetty J. Effect of joining the sectioned implant-supported prosthesis on the peri-implant strain generated in simulated mandibular model. J Indian Prosthodont Soc 2017;17:388-94.
19. Gherlone EF, Ferrini F, Crespi R, Gastaldi G, Capparé P. Digital impressions for fabrication of definitive "all-on-four" restorations. Implant Dent 2015;24:125-9.