Comparison of Positional Accuracy of Multiple Implants Using Pattern Resin, Flowable Composite, Acrylic Resin and Protemp 4 as Splinting Material: An In Vitro Study

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Abstract

Introduction: The purpose of this study was to evaluate and compare the positional accuracy of multiple implants using different splinting materials. Samples were scanned and analysed for discrepancy.

Materials and Method Maxilllary model was made with acrylic resin with four parallel analougues placed. Model was scanned with guide pins attached to them as a control. Model was splinted with different materials, impression was made and casts were poured. 20 samples were made (n=5) using four splinting materials i.e. pattern resin, flowable composite, acrylic resin and protemp 4 named as group 1, 2, 3, 4 respectively.

Results: A post-hoc analysis by tukey's test revealed a statistically significant relationship between Group 1 and Group 2, Group 1 vs Group 2, Group1 vs Group 4, Group 2 vs Group 3 and Group 2 vs Group 4. The significance levels of these four comparisons were the major contributors towards the statistical significance noticed with respect to the ANOVA test.

Conclusion: The splinting methods have affected the accuracy of definitive casts. The flowable composite splinted cast produced the most accurate casts followed by protemp 4, autopolymerizing acrylic resin and pattern resin splinted casts.

Keywords: Implant, splinting material, pattern resin, flowable composite, acrylic resin, protemp 4.

INTRODUCTION

Osseointegrated dental implant has been proven successful in the treatment of complete and partial edentulism. Oral rehabilitation with implants is multifactorial with aesthetics and passive fit being the prime concern. With predictable integration of implants, the emphasis is shifted towards precise prosthesis. The connection of prosthesis to osseointegrated implants produces a unified structure in which the prosthesis, implant and the bone act as a unit. Any misalignment of the prosthesis may jeopardize the implants, bone matrix and or the prosthesis.[1]

Inaccurate superstructure results in mechanical and biological consequences that disrupt the function of dental implants. Mechanical complications include loosening, bending and fracture of the prosthetic or implant components. Biological complications from loading above the physiologic tolerance level often result in the breakdown of an osseointegrated interface between the implant and the surrounding bone.[2,3]

An accurate master cast is a pre requisite for the avoidance of any future misalignment with respect to fabrication of passive prosthesis. Accuracy of the master cast is critical and dependent on the clinical and laboratory variables intrinsic to restorative treatment, such as the type of impression material and technique. The success of implant prosthesis therefore depends directly on the accuracy of impression, in order to obtain the original position of the implants in the master cast.[4]

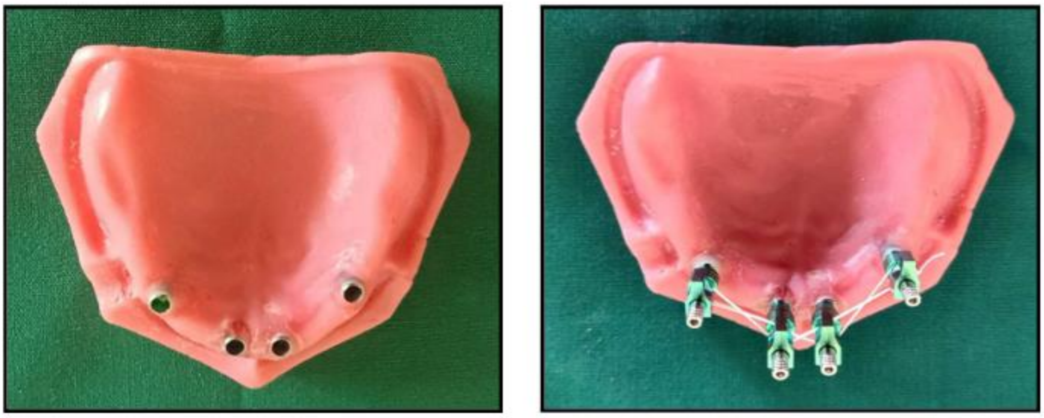
The first and foremost is the complexity surrounding the attainment of passive fit of the implant prosthesis, which is directly related to the accurate three dimensional transfer of the implant positions to the working cast. Other challenging factors are impression technique, impression materials, splinting materials, splinting techniques, implant angulations and implant depth. The primary goal of an implant impression is to obtain an accurate working cast to improve the chances of production of passively fitting implant prosthesis.[4]

Connecting all the impression copings together with rigid material is the underlying principle of splinting to prevent the movement of impression coping.[10] The splinting technique has gained popularity with consistent results of higher accuracy as compared to non-splinting technique.

Hence, the purpose of this study is to evaluate and compare the positional accuracy of implants using different splinting materials.

METHOD

An acrylic resin model was fabricated with heat cure acrylic using a prefabricated rubber mold. Using pilot drill with surveyor, four parallel holes were drilled at A, B, C, D positions. Four 4mm diameter implant analogs with internal hex were placed in the acrylic model. The implant analogues were fixed at these sites and will be numbered as 1, 2, 3, and4. Open tray impression copings were then attached to the implant analogs. The impression copings were secured with 10-mm flat head guide pins will be used to secure the impression copings on to the implants using a hex drive by applying a torque of 15 N. Cm.



Splinting materials used were Pattern resin, Flowable composite, Autopolymerizing acrylic resin and, Protemp4.

Onto the open tray impression copings, dental floss was looped around tight on each of the copings and firmly secured. Autopolymerizing acrylic resin was adapted around on the dental floss and the copings were allowed to set. This splints were then sectioned using a diamond disk in the center of each section so that a 0.2 mm standardized space was created between each of the splinted sections. The sectioned pieces were reconnected just before the impression procedure with an incremental application autopolymerizing acrylic resin and attached to the splints. In the preformed tray windows were cut corresponding to the position of implant analogs. Putty consistency polyvinylsiloxane impression material was loaded onto the tray, and seated over the resin model. The impression tray was loaded with light body impression material and a wash impression was made. This position was maintained throughout the polymerization time. The impression copings were then loosened with a hex driver and the tray was separated from the die, with the impression copings along with guide pin remaining locked in the impression. The implant analog were then connected to the hex at the bottom of the impression coping and the guide pins were tightened with the hex driver and cast was poured. Total 20 samples (n=5) were made using four different splinting materials.

In the same manner impression will be obtained by using remaining 3 splinting materials.

An ADA Type IV die stone was used to pour the cast. The casts were retrieved from the impressions after 24 h. All the casts were stored at room temperature for a minimum of 24 h before taking measurements. The implant model was scanner using a blue light scanner. The positional accuracy was measured digitally. The obtained data was analyzed by using appropriate biostatic tests. Data was evaluated with a significance level of $p<0.05$.

Fig. 12: Impression coping splinted with acrylic resin

Fig. 13: Impression coping splinted with protemp

Fig. 14: Impression coping splinted with pattern resin

Fig. 15: Impression coping splinted with flowable composite

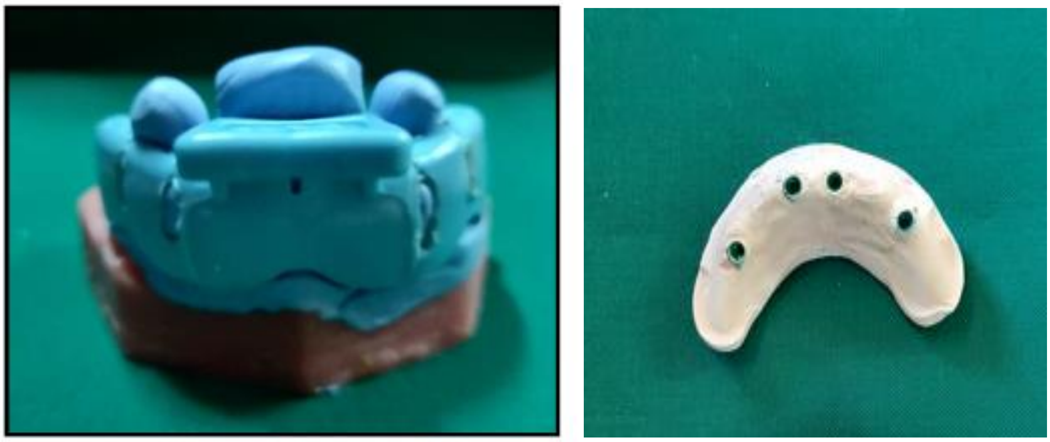


Fig. 20: Impression made

Fig. 25: Model with parallel pin being scanned

Fig. 26: Specimen with parallel pin being scanned

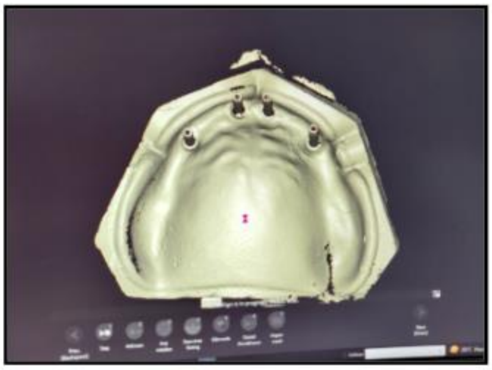


Fig. 27: Image obtained of scanned model

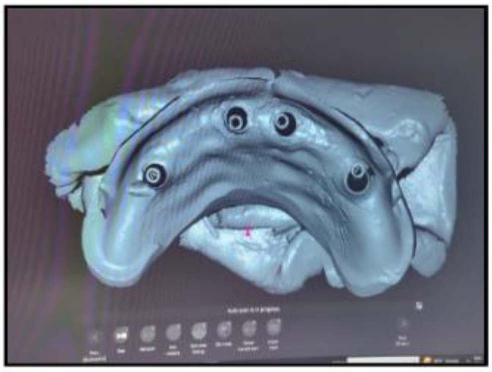


Fig. 28: Image obtained of scanned specimen

RESULTS

One way ANOVA test was done to check the significance between the four groups and the master model. Post hoc Tukey's test was done for comparison between the four different methods of splinting to identify the significant pairs. The significance level was kept at $p \leq 0.05$.

Software analysis for statistics was done using IBM SPSS V.25.0

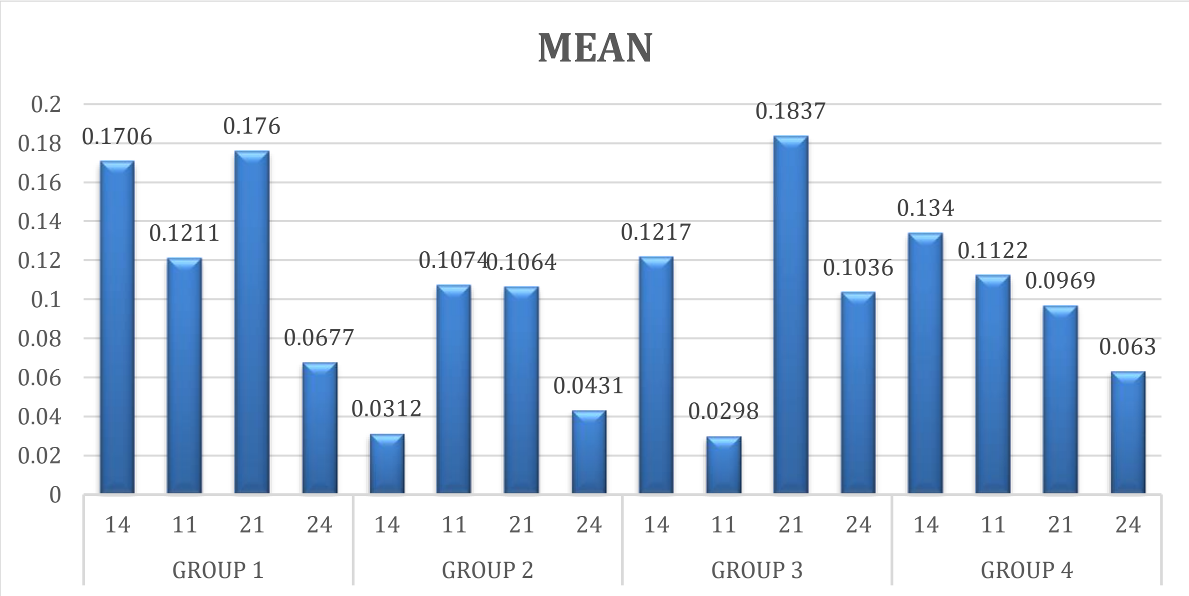


CHART 5: Mean value for all tooth of each group

Chart 5 represent the mean for the change in position in x and y axis for each tooth region when the model was splinted with all the four Groups i.e. Group 1 (Pattern resin), Group 2 (Flowable composite), Group 3 (Autopolymerizing acrylic resin) and Group 4 (Protemp).

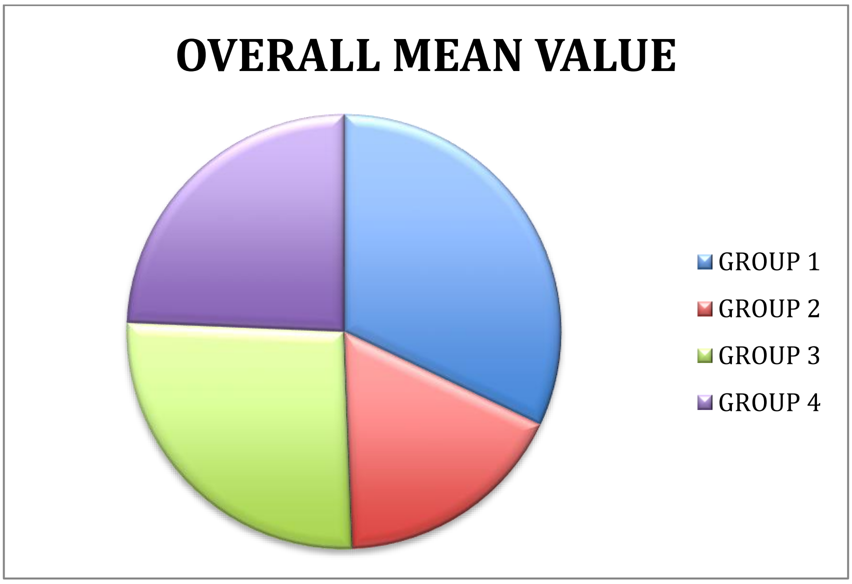


CHART 6: Overall mean of all groups

The overall mean value for Group 1 (Pattern resin) was 0.133mm.

The overall mean value for Group 2 (Flowable composite) was 0.072mm.

The overall mean value for Group 3 (Autopolymerizing acrylic resin) was 0.109mm.

The overall mean value for Group 4 (Protemp) was 0.101mm.

OVERALL COMPARISON BETWEEN FOUR GROUPS USING ONE-WAY ANOVA FOLLOWED BY POST-HOC TUKEY TEST

	Mean square	F-value		p- value
Group 1 **Group 2** **Group 3** **Group 4**	0.026	11.190		0.000*
1st group	**2nd group**	**Mean difference**	**Std. error**	**p- value**
Group 1	**Group 2**	0.061	0.010	0.000*
	Group 3	0.024	0.010	0.117
	Group 4	0.032	0.010	0.017*
Group 2	**Group 3**	0.037	0.010	0.003*
	Group 4	0.029	0.010	0.035*
Group 3	**Group 4**	0.008	0.010	0.873

*p<0.05= statistically significant

The overall comparison between the four groups was conducted using One-Way ANOVA statistical test. The mean difference between the four groups was found to be statistically significant. A post-hoc analysis of the result to compare two individual groups in order to ascertain the contributors of significance of ANOVA was done using Tukey's test. It revealed a statistically significant relationship between Group 1 and Group 2, Group 1 vs Group 2, Group1 vs Group 4, Group 2 vs Group 3 and Group 2 vs Group 4. The significance levels of these four comparisons were the major contributors towards the statistical significance noticed with respect to the ANOVA test.

DISCUSSION

Since dental implants are routinely used to have a long term successful result with implant prosthesis, a precise and passive fit of the implant superstructure to an implant abutment is recommended. The making of accurate impressions and obtaining a definitive cast is critical to achieve passively fitting implant retained prosthesis.[35]

An inaccurate impression may result in improper fit of prosthesis which may lead to biological as well as mechanical complication leading to failure of implant. Mechanical complication may include screw loosening, screw fracture, and occlusal inaccuracy;[38-43] biologically marginal discrepancy from misfit may cause unfavorable soft and/ or hard tissue reactions due to increased plaque accumulation.[44-46] Even though obtaining absolute passive fit is practically impossible, minimizing the misfit to prevent the complications is a generally acceptable goal of prosthodontic implant procedures.[47]

To create an accurate definitive cast, it is critically important to obtain an intraoral impression that accurately captures the 3-dimensional (3-D) spatial orientation of a patient's implants. Factors affecting the accuracy of such impressions include: splinting or not splinting impression copings; different splinting materials; implant angulation; the number of implants; polymerization shrinkage of the impression material; the setting expansion of stone; and the design and rigidity of the impression tray. Among all these, splinting or not splinting the impression copings is among the most significant.[56]

Studies evaluating the relationship between different types of splinting materials and their accuracy have yielded conflicting results. Rhyu et al. used VPS bite registration material for splinting. It was seen that impressions with VPS bite registration material splinted square impression copings were more accurate than those splinted with acrylic resins. Assif et al. used impression plaster, autopolymerizing acrylic resin, and dual-cured acrylic resin as a splinting material and concluded that splinting with autopolymerizing polymethylmethacrylate was more accurate. Pattern resin is also one of the most popular splinting materials. Besides pattern resin, impression plaster, dental floss, polyether-based bite registration material, dual-cure acrylic resin, orthodontic wire, prefabricated acrylic resin bars, light-curing composite resin, and carbon steel pins have been used to splint the impression copings. Auto-polymerizing acrylic resin yielded better results, probably because of increased stiffness and greater stability. Temporization material bispenol A-glycidyl methacrylate also showed better results compared to nonsplinted impressions.[34]

In this vitro study, total 20 stone casts were made constituting 5 casts made with each splinting material. Four groups were made of each splinting materials, Group 1- Pattern resin, Group 2 - Flowable composite, Group 3 - Autopolymerizing acrylic resin and Group 4 - Protemp 4.

The study revealed that Group 2 showed superior positional accuracy followed by Protemp4, Autopolymerizing acrylic resin and Pattern resin.

The splinted impression technique has been shown to be a primary factor in increasing the fitting precision of the restorative complex.[57] Branemark[58] et al originally described the splint technique and emphasized the importance of splinting transfer copings intraorally with acrylic resin over the floss scaffold before making an impression. The acrylic resin splinting effectively resists translation and rotation of the transfer copings within an impression when the impression is detached from the implants followed by placement of the implant analogs.

Splinting material should thus be selected based upon their property to resist any dimensional changes. Some authors section the splint material connection to minimize the shrinkage. Some authors connected all copings with splint material and waited for complete polymerization of the material.[59] According to Lee et al, in edentulous situations involving 4 or more implants, most in vitro studies advocated splinted impression techniques. A majority of studies published after 2003 advocate the use of splinting to improve impression fidelity.[45] In recent years, metal splinting and composite-based bis acrylics have gained popularity as a splinting material in lieu of the conventionally used materials.

Selection of a specific splinting materials depends on the clinical situation present. The findings of this study will contribute to the evidence of material-related aspects of implant prosthesis fabrication for best clinical practices of implant prosthodontic rehabilitation. Future studies should be conducted to compare the materials under simulated clinical conditions; both intra study environmental differences and operator variability will provide information to translate laboratory findings to the dental office setting.

CONCLUSION

Within the limitations of this in vitro study, the following conclusions were drawn:1. The combined effect of impression material, impression technique, implant angulations and splinting materials had effect on the accuracy of the duplicate casts compared to the definitive casts (p = 0.001).2. Casts retrieved from flowable composite splinting were statistically more accurate than casts obtained from protemp 4, autopolymerizing resin and pattern resin splinting.

Hence, it can be concluded that the splinting methods have affected the accuracy of definitive casts. The flowable composite splinted cast produced the most accurate casts followed by protemp 4, autopolymerizing acrylic resin and pattern resin splinted casts.

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