"A Comparative Evaluation of the Positional Accuracy of Multiple Implants by Open Tray Impression Technique using Three Different Splinting Materials: An in vitro study"

Abstract:

Aim: To comparatively evaluate the positional accuracy of multiple implants by open tray impression technique using three different splinting materials namely self-cure acrylic resin, pattern resin and flowable composite.

Materials and Methods: An edentulous maxillary model was fabricated with heat-cure acrylic resin. Four dummy implants were placed bilaterally at canine and second premolar positions in the acrylic model, perpendicular to the horizontal plane and parallel to each other. Open tray impression copings were attached to dummy implants. The copings were splinted with dental floss onto which self-cure acrylic resin was added, which was sectioned and rejoined (for Group A). Similarly, pattern resin and flowable composite were used as splinting materials for Group B and Group C respectively. Open tray impressions were made using polyvinylsiloxane impression material to obtain 10 casts for each group categorized according to the splinting material used. Interimplant distances were measured between implants on the master model and between the implant analogs in the retrieved casts in three different groups using a Coordinate measuring machine and a comparative evaluation of positional accuracy was done.

Results: Splinting with materials of all three Groups showed minimal variation in positions of multiple implants and within clinical limits. Group B (pattern resin) had more accurate values similar to master model compared to Group A (self-cure acrylic resin) and Group C (flowable composite), although statistically insignificant. The results with Groups A and C were similar. No statistically significant difference was derived between the three different groups.

Conclusion: It was concluded that all the three splinting materials evaluated in the study can be recommended as splinting material of choice for multiple implants using open tray impression technique.

Keywords: Dental implants, open tray impression technique, splinting material, self-cure acrylic resin, pattern resin, flowable composite

Introduction:

Dental implants have become increasingly popular and are being successfully used for oral rehabilitation of partially and completely edentulous patients. Precise impression of the implant position is imperative in fabrication of accurately fitted implant-supported prostheses.[1] This is essential to decrease stress in the implant components and bone adjacent to the implants.[2]

Recording the intraoral relationship of implants through impression procedures is an important parameter for an accurate, passively fitting prosthesis. The critical aspect is to reproduce the 3-dimensional orientation of the implant as placed in the patient apart from recording accurate surface details.[3,4,5] The impression techniques are mainly abutment level as well as implant level with closed-tray or open-tray techniques. The open-tray technique may use either splinted or non-splinted implant impression copings.

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During clinical and laboratory phases, inaccuracy in transferring three-dimensional orientation of implants to the cast can be detected due to the movement of impression copings.[6] Splinting refers to connecting the transfer copings with a material. This attempts to prevent rotational movement of the impression copings within the impression material during analog fastening, thus maintaining the relationship between implants in a rigid fashion.[4,7,8,9,10]

Some of the commonly used splinting materials include impression plaster, dental floss, pattern resin, self-cure acrylic resin, addition silicone, or polyether-based bite registration material. Studies analyzing different types of splinting materials and their accuracy have shown conflicting results.[11,12] Some authors have suggested the use of splinting, while some have proposed that splinting does not produce superior results especially if the splinting material such as acrylic is associated with some inevitable shrinkage.[13]

The present study was undertaken to evaluate the positional accuracy of multiple implants by open tray impression technique using three different splinting materials namely self-cure acrylic resin, pattern resin and flowable composite, to determine which splinting material is most effective for the accurate reproduction of implant positions.

Materials and Methods:

An edentulous maxillary model was fabricated with heat cure acrylic resin. Four dummy implants were placed bilaterally at canine positions and second premolar positions in the acrylic model, perpendicular to the horizontal plane and parallel to each other with the help of a dental surveyor. The dummy implants placed in the model were sequentially numbered as 1, 2, 3, and 4 from left to right. Open tray impression copings were attached to the dummy implants and tightened with guide pins using a hex driver by applying a torque of 15 Ncm. A metal tray was customized to occupy the master model and windows were prepared in the metal tray coinciding with the position of the impression copings. Stoppers were added onto the borders of master model to ensure even distribution of impression material.

For Group A – Dental floss was looped tightly around each of the open tray impression copings and firmly fastened. Self-cure acrylic resin was mixed and subsequently adapted onto the dental floss and around the copings and allowed to set (Fig.1).

Fig.1: Open tray impression copings splinted with self-cure acrylic resin

The splints were then sectioned in the centre using a diamond disk to create a 0.2 mm standardized space between each of the splinted sections. The sectioned pieces were then rejoined prior to the impression procedure with an incremental application of self-cure acrylic resin. This technique of sectioning and rejoining helps to minimize the polymerization shrinkage of the resin.

A double layer wax spacer was adapted on the master model. The custom metal tray was coated with tray adhesive and allowed to dry. Soft putty consistency polyvinylsiloxane impression material was mixed and loaded onto the tray. The tray was seated over the master model with finger pressure. The wax spacer was then removed and the impression tray was loaded with light body impression material and a wash impression was made. Any excess material from the tray windows was removed with a finger swipe to expose the guide pins. This position was maintained throughout the setting time of the impression material. The guide pins were then loosened with the hex driver and the tray was removed from the master model, with the impression copings along with guide pins remaining locked in the impression (Fig.2).

Fig.2: Impression with polyvinyl siloxane impression material

The implant analogs were then connected to the impression copings and the guide pins were tightened with the hex driver. Ten impressions were thus made for Group A and casts were poured using Type IV die stone.

For Group B – Dental floss was looped around the impression copings and splinting was done with pattern resin (Fig.3).The impression procedure was carried out in a similar manner as for Group A to obtain ten impressions and casts were poured.

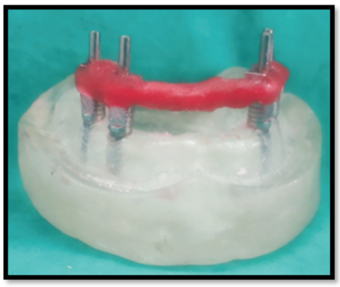

Fig.3: Open tray impression copings splinted with pattern resin

For Group C – Splinting was done with flowable composite (Fig.4) .Ten impressions were made as previously described and casts were obtained.

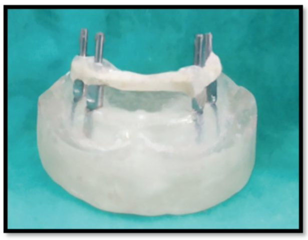

Fig.4: Open tray impression copings splinted with flowable composite

All clinical and laboratory procedures were carried out by the same operator. Interimplant distances were measured in millimeters in horizontal plane between implants no.1 and 2, 1 and 3, 1 and 4, 2 and 3, 2 and 4, 3 and 4 on the master model and between the implant analogs in all the casts in the three different groups using a Coordinate Measuring Machine and a comparative evaluation of positional accuracy was done.

Results:

The present in vitro study evaluated and compared the positional accuracy of multiple implants by open tray impression technique using three different splinting materials namely acrylic resin (for Group A), pattern resin (for Group B) and flowable composite (for Group C). Ten open tray impressions were made for each group and casts were obtained. Interimplant distances between the dummy implants in the master model and between the implant analogs in all the casts in three different groups were measured in millimeters using a Coordinate Measuring Machine.

Data was summarized as Mean ± SD (standard deviation). Groups were compared by one factor analysis of variance (ANOVA) and the significance of mean difference between the groups was done by Tukey's HSD (honestly significant difference) post hoc test after ascertaining normality by Shapiro-Wilk's test and homogeneity of variance between groups by Levene's test. A two-tailed (α=2) p<0.05 was considered statistically significant. Analysis was performed on SPSS software {Windows version 22.0} (Tables 1-12).

Table 1: Interimplant distance (mm) between implant analogs 1 and 2 of three groups

Groups	n	Mean ± SD	F value	p value
Group A	10	9.847 ± 0.046	0.34	0.712
Group B	10	9.854 ± 0.029		
Group C	10	9.839 ± 0.044		

The interimplant distance (mm) between implant analogs 1 and 2 of three groups were summarized in Mean ± SD and compared by ANOVA(F value).

Table 2: Comparison of difference in mean inter-implant distance between implant analogs 1 and 2 among three groups by Tukey test

Comparison	Mean diff. (mm)	q value	Significant? p<0.05?	Summary
Group A vs. Group B	0.007	0.52	No	ns
Group A vs. Group C	0.008	0.66	No	ns
Group B vs. Group C	0.015	1.17	No	ns

diff: difference, q value: Tukey test value, ns: not significant

Table 3: Interimplant distance (mm) between implant analogs 1 and 3 of three groups

Groups	n	Mean ± SD	F value	p value
Group A	10	32.103 ± 0.019	0.55	0.583
Group B	10	32.108 ± 0.016		
Group C	10	32.099 ± 0.022		

Table 4: Comparison of difference in mean inter-implant distance between implant analogs 1 and 3 among three groups by Tukey test

Comparison	Mean diff. (mm)	q value	Significant? p<0.05?	Summary
Group A vs. Group B	0.005	0.79	No	ns
Group A vs. Group C	0.004	0.69	No	ns
Group B vs. Group C	0.009	1.48	No	ns

diff: difference, q value: Tukey test value, ns: not significant

Table 5: Interimplant distance (mm) between implant analogs 1 and 4 of three groups

Groups	n	Mean ± SD	F value	p value
Group A	10	35.510 ± 0.023	1.16	0.327
Group B	10	35.524 ± 0.022		
Group C	10	35.507 ± 0.032		

Table 6: Comparison of difference in mean inter-implant distance between implant analogs 1 and 4 among three groups by Tukey test

Comparison	Mean diff. (mm)	q value	Significant? $p<0.05$?	Summary
Group A vs. Group B	0.014	1.67	No	ns
Group A vs. Group C	0.003	0.36	No	ns
Group B vs. Group C	0.017	2.02	No	ns

diff: difference, q value: Tukey test value, ns: not significant

Table 7: Interimplant distance (mm) between implant analogs 2 and 3 of three groups

Groups	n	Mean ± SD	F value	p value
Group A	10	25.961 ± 0.036	0.09	0.910
Group B	10	25.955 ± 0.049		
Group C	10	25.952 ± 0.044		

Table 8: Comparison of difference in mean inter-implant distance between implant analogs 2 and 3 among three groups by Tukey test

Comparison	Mean diff. (mm)	q value	Significant? $p<0.05$?	Summary
Group A vs. Group B	0.006	0.42	No	ns
Group A vs. Group C	0.008	0.60	No	ns
Group B vs. Group C	0.002	0.18	No	ns

diff: difference, q value: Tukey test value, ns: not significant

Table 9: Interimplant distance (mm) between implant analogs 2 and 4 of three groups

Groups	n	Mean ± SD	F value	p value
Group A	10	31.888 ± 0.014	0.18	0.840
Group B	10	31.891 ± 0.012		
Group C	10	31.892 ± 0.016		

Table 10: Comparison of difference in mean inter-implant distance between implant analogs 2 and 4 among three groups by Tukey test

Comparison	Mean diff. (mm)	q value	Significant? $p<0.05$?	Summary
Group A vs. Group B	0.003	0.60	No	ns
Group A vs. Group C	0.004	0.81	No	ns
Group B vs. Group C	0.001	0.20	No	ns

diff: difference, q value: Tukey test value, ns: not significant

Table 11: Interimplant distance (mm) between implant analogs 3 and 4 of three groups

Groups	n	Mean ± SD	F value	p value
Group A	10	10.217 ± 0.040	0.05	0.951
Group B	10	10.215 ± 0.045		
Group C	10	10.211 ± 0.032		

Table 12: Comparison of difference in mean inter-implant distance between implant analogs 3 and 4 among three groups by Tukey test

Comparison	Mean diff. (mm)	q value	Significant? $p<0.05$?	Summary
Group A vs. Group B	0.002	0.15	No	ns
Group A vs. Group C	0.006	0.44	No	ns
Group B vs. Group C	0.004	0.29	No	ns

diff: difference, q value: Tukey test value, ns: not significant

Discussion:

Accurate implant impressions play a vital role and serve as an initial step in obtaining a precise working cast. Accurate working casts are necessary for fabrication of passively fitting implant restorations.[12] Prosthesis misfit can cause mechanical as well as biological complications.[14]

The basic impression techniques for implants are abutment level impression technique and implant level impression technique (closed tray or open tray techniques). In the closed tray technique, the impression copings remain in the patient's mouth when the set impression is removed, and then, these copings are unscrewed from the mouth and attached to the implant analogs. This coping-implant analog assembly is placed back into the impression in its respective position.[15] In the open tray technique, the impression coping is retained within the impression and is removed from the mouth along with the set impression.[12] To ascertain maximum accuracy, some authors emphasized the significance of splinting impression copings together intraorally prior to impression making and some authors suggested sectioning the splint material leaving a thin space and then reconnecting with an appropriate amount of the same material to minimize polymerization shrinkage.[16,17]

In the literature, there have been differences in opinions regarding the accuracy of different impression techniques and splinting materials used in multiple implant cases. Considering the conflicting results reported by several authors, this study was carried out to investigate the positional accuracy of multiple implants by open tray impression technique using three different splinting materials namely self-cure acrylic resin, pattern resin and flowable composite. Since the flowable composite has attained popularity in recent years, its use as an alternative for conventionally used splinting materials such as acrylic resin and pattern resin has been evaluated in the present study.

Several researchers claimed achieving greater accuracy and improved fit with open-tray impression copings. The open-tray technique allows the impression copings to be retained in the impression. The closed-tray technique can create discrepancies in the axial rotation and inclination of the analogs; therefore, many authors have advocated superior results with the open-tray method.[18,19,20] However, some authors have reported potential problems related with the splinting technique, such as distortion of the splinting materials and fracture of the connection between the splinting material and the impression copings.[21-25] Considering errors in positional accuracy due to shrinkage of splinting materials, sectioning and rejoining of splinting materials was done for all the groups in this study prior to impression making.

Mojon et al[26] and other authors have advocated [27,28-30] that separation and rejoining of acrylic splint when done 17 minutes after the setting reaction results in 80% reduction in the effects of polymerization shrinkage. To standardize the dimensions of the acrylic resin splints for each sample, a silicone index was used.[27,31] It has been reported that the total shrinkage of acrylic resin is between 6.5% and 7.9% in the first 24 hours, with 80% of the shrinkage occurring in the first 17 minutes after mixing.[26]

Herman et al described a method of intraoral splinting of implant transfer copings for the final impression procedure. The purpose of this technique was to reduce the effects of acrylic resin polymerization shrinkage by prefabricating acrylic resin bars that were utilized for splinting implant transfer copings. The benefits of this procedure included ease of fabrication of the resin bars and ease of intraoral application for splinting transfer copings. Intraoral splinting of transfer copings was done without requiring excessive amount of acrylic resin at the time of final impression, thus reducing the effects of acrylic resin polymerization shrinkage.[32]

In order to obtain appropriate and well-fitting superstructures, it is necessary to maintain fidelity with the impression procedures.[33] A precise master cast requires an impression technique that replicates the intraoral position between implants accurately in all dimensions. Achieving a rigid connection between transfer copings enables accurate reproduction of implant spatial relationships independent of impression material considerations.[32]

During the comparative evaluation of the results of the present study, it was found that all the three splinting materials used in this study showed minimal variation in the reproduction of the spatial relationship of implant analogs in the retrieved casts. However, the measurements recorded by Coordinate measuring machine for Group B splinted with pattern resin were closer to the master model compared to Group A and Group C, though statistically insignificant.

Coordinate measuring machine was used in this study for recording measurements which provides a three-dimensional analysis. However, the measurements in this study were recorded only in horizontal plane. Considering possibilities of discrepancies in other spatial planes, further comprehensive studies are required.

The results of the present study were in support of the findings by Joseph TM et al[34] in their study on evaluation of positional accuracy in multiple implants using four different splinting materials. They concluded that flowable composite can be recommended as splinting material of choice for multiple implant cases, as it exhibited similar results like other groups (pattern resin and acrylic resin) which are conventionally used.

Ibrahim and Ghuneim[35] reported no significant differences on comparing composite resin and acrylic resin. In contrary, Farshid Akbari Kamrani and Amir Namazi in their study on comparison of accuracy of an open-tray implant impression technique with three splinting materials using pattern resin, acrylic resin and a dual-cured composite resin found that the composite resin demonstrated better accuracy than the other tested splinting materials.[36]

Conclusion:

On the basis of results, observations and statistical analysis, the following conclusions were drawn:

1. Splinting of open tray impression copings with three different splinting materials used in Groups A, B and C respectively exhibited minimal alteration in positions of implant analogs.

2. The measurements recorded by Coordinate measuring machine were closer to the master model and within acceptable clinical limits.
3. Group B splinted with pattern resin had more accurate values similar to master model as compared to Groups A and C splinted with acrylic resin and flowable composite respectively. However, no statistically significant difference was found between the three Groups.

Thus, the study concluded that the three splinting materials namely acrylic resin, pattern resin and flowable composite evaluated in the study can be recommended as splinting material of choice for multiple implants using open tray impression technique. It was observed that the splinting materials were statistically similar to each other. Some variations in results might be observed if the study was performed under in vivo conditions or with more sample size.

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