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To compare the implant cast accuracy using open tray impression technique for multiple implants with different splinting materials - An In Vitro Study

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Abstract

Background: Achieving accurate implant impressions is critical to ensure a passive fit of prostheses and to minimize biological and mechanical complications. The open tray impression technique, when combined with splinting, has been shown to improve accuracy. However, the choice of splinting material significantly influences dimensional stability.

Aim: This in vitro study compared the accuracy of implant casts obtained using the open tray impression technique with three different splinting materials: Pattern Resin (PR), Flow able Composite (C), and Auto polymerizing Acrylic Resin (AR).

Materials and Methods: An edentulous maxillary acrylic master model with four parallel implants was fabricated. A total of 15 samples were prepared and divided into three groups (n=5 each) based on the splinting material used: PR, C, and AR. Impressions were made using a custom open tray and polyvinyl siloxane material. Linear inter-implant distances (A–F) were measured on the master model and study casts using a profile projector with a precision of 0.0025 mm. Data were statistically analyzed using one-way ANOVA, post hoc Tukey's test, and one-sample t-test.

Results: Significant differences were observed in inter-implant distances D (p=0.023) and F (p=0.040). Post hoc comparisons revealed that casts obtained with PR were significantly more accurate than those with C (p<0.05), while AR showed intermediate accuracy. One-sample t-tests further confirmed that PR demonstrated the least deviation from the master model, followed by AR, whereas C consistently exhibited the greatest discrepancies.

Conclusion: Splinting impression copings significantly enhances implant cast accuracy in multiple implant cases. Among the tested materials, Pattern Resin provided the most stable and precise results, followed by Auto polymerizing Acrylic Resin, while Flow Able Composite showed the highest distortion. Within the limitations of this in vitro study, Pattern Resin can be recommended as the material of choice for splinting in open tray implant impressions to achieve optimal prosthetic outcomes.

Keywords: Implant Impression, Open Tray Technique, Splinting Materials, Pattern Resin, Acrylic Resin, Composite, Cast Accuracy.

Introduction

According to GPT 10 implant prosthodontics is defined as the selection, planning, development, placement, replacement of missing teeth and/or associated structures, and maintenance of restoration (s) with dental implants. Implant is defined as any object or material, such as an alloplastic substance or other tissue, which is partially or completely inserted or grafted into the body for therapeutic, diagnostic, prosthetic, or experimental purposes; syn, Dental Implant Implant supported fixed dental prosthesis termed as a prosthesis that is fixed to and supported by more than one dental implant, where the planned placement of at least one implant has resulted in its long axis of inclination varying considerably from a parallel relationship with adjacent implants; the prosthesis cannot be removed by the patient; this term can be used with additional qualifies such as complete-arch and segmental; comp, intentionally angulated implant, angulated dental implant, angulated dental implant abutment[1]

For implant prostheses to function effectively, they must achieve a passive fit with the underlying structures. Any visible misalignment between the prosthetic framework and osseointegrated implants may generate internal stress within the framework, implants, and surrounding bone.

Therefore, accurately capturing the three-dimensional position of implants is a critical step in treatment. A well-fitting prosthesis depends on a highly precise impression, as inaccuracies can affect the final cast, laboratory procedures, and overall prosthetic fit. If an impression is flawed, it may lead to misfits in the prosthesis, which could result in mechanical complications or bio logical issues.

Since implants are directly integrated with the bone, precision in fit is essential. Unlike natural teeth, which can move up to 100 µm within the periodontal ligament, implants exhibit only a minor movement of approximately 10 µm . Implant impression techniques are generally classified into two main approaches: the direct (open-tray) and indirect (closed-tray) methods. In the open-tray technique, the impression coping remains attached to the implant fixture, and the impression is retrieved with the tray as a single unit. To improve impression accuracy, various splinting materials are commonly used.[2]

The splinting technique for implant impressions was introduced alongside the development of metal-acrylic resin implant-supported fixed complete dentures for edentulous jaws. The primary objective of this approach is to rigidly connect all impression copings, minimizing their individual movement during the impression-making process. Since the earliest studies on implant impression accuracy, splinting has remained a key area of research.[3]

In order to achieve a framework that fits accurately and passively onto the abutments. An improper fit can generate stress, potentially leading to implant failure and compromised osseo integration. Therefore, ensuring a passive fit of the framework on the abutments is highly recommended for the long-term success of an implant-supported prosthesis. To accurately transfer implant positions before prosthesis fabrication, various impression techniques have been proposed. Brånemark et al. highlighted the significance of intraorally linking transfer copings using a supportive acrylic resin matrix before making an impression, as this approach enhances accuracy and stability.[4]

To achieve the highest level of accuracy, some researchers have highlighted the significance of intraorally splinting impression copings before taking an impression. Different materials, including acrylic resin, dental plaster, bite registration silicone, and polyether (PE), have been utilized for this purpose, each demonstrating varying levels of precision in impression making.[5]

Materials and Method

Sample Preparation

An edentulous maxillary acrylic master model was selected for the study. To construct this model, a standard maxillary mold was filled with melted impression compound material, resulting in a maxillary impression compound cast. Flasking and dewaxing were performed to obtain the acrylic master model.

Four implants were drilled into the model in the region extending from the first premolar to the contra lateral first premolar. The placement of the implants was standardized using a dental surveyor to ensure parallel alignment. The analogues were sequentially numbered 1, 2, 3, and 4.

Fabrication of Custom Tray for Open Tray Impression Technique

A 4 mm thick polyethylene vacuum-formed sheet was adapted over the implant master model with impression posts screwed into the implant analogues using a vacuum forming machine. This step ensured uniform space for impression material during impression-making. An alginate impression of the master model with the adapted sheet was taken and poured in dental stone to obtain a working cast.

For the fabrication of a custom tray, two sheets of modelling wax were adapted over the cast. Sections of wax were removed over the open tray impression posts to create access points. Following the custom tray was fabricated. The finished and polished tray was then used for impression-making.

Sample Grouping and Splinting Technique

A total of 15 samples were prepared and divided into three groups based on the splinting material used:

Group A: Pattern Resin (n=5)

Group B: Composite resin (n=5)

Group C: Autopolymerising resin (n=5)

For all samples, the open tray impression copings were initially joined with dental floss in a Figure-eight shape (. Different splinting materials were then applied over the floss using a camel brush:

Pattern Resin: The monomer and polymer components were mixed and applied onto the supporting floss. After

17 minutes, the splinted pattern resin was sectioned using a disk. The impression coping screws were retightened, and the resin was then re-joined.

Autopolymerising Resin: The splinting materials were applied directly onto the floss using a camel brush without sectioning.

Composite Resin: The splinting materials were applied directly onto the floss using a camel brush without sectioning.

Implant analogues were attached to the impression posts before pouring the impressions with Type IV dental stone to fabricate the final casts.

Measurement Protocol

To assess the accuracy of implant positioning, a linear inter-implant distance analysis was conducted using a profile projector with a precision uncertainty of 0.0025 mm. A profile projector was employed to record the linear distances between implant analogues. The pouring carrier was securely mounted in the device holder, with its posterior edge aligned parallel to the machine's axis of movement. Each cast was then positioned on the platform and stabilized with three stoppers, ensuring repeatability. To maintain accuracy, the projector's screen incorporated horizontal and vertical reference lines, allowing standardized placement of all casts so that the implant copings remained at a consistent level during measurement. The instrument projected a 10× magnified shadow image of the casts onto the screen, facilitating precise measurement of inter-implant distances. The integrated digital display counter, calibrated with an uncertainty of 0.0025 mm, further ensured measurement reliability.

Linear distances were measured on both the control acrylic resin model and the experimental casts at defined reference points. To avoid inconsistencies associated with the sharp edges of transfer copings, measurements were standardized from the center of each analogue, considering its 2.5 mm diameter and 1.25 mm radius.

The following distances were assessed:

- A– Distance from point 1 to 2
- B – Distance from point 2 to 3
- C – Distance from point 3 to 4
- D – Distance from point 4 to 1
- E – Diagonal distance from point 2 to 4
- F – Diagonal distance from point 1 to 3

Using the analogue centres as reference points minimized edge-related discrepancies and ensured standardized, reproducible measurements across all casts.

Statistical Analysis

Each measurement was recorded three times by the same operator, and the mean value was calculated. The results from the master model and stone casts, obtained using the three different impression techniques, were statistically analysed using the ANOVA test, Tukey Post Hoc Test and one sample t test.

Table 1 shows the comparison of various inter-implant distances as measured with various splinting materials. The statistical analysis was carried out using one-way analysis of variance (ANOVA) which showed that:

- There was a statistically significant difference in distance D among various splinting
- Materials (p=0.023) and statistically significant difference in distance F among various splinting materials (p=0.040).

Since statistically significant differences were observed in inter-implant distances D and F, Tukey's post-hoc test was conducted to assess the pairwise comparisons among splinting materials. The statistical analysis showed that:

Inter-implant Distance D (Table 2 and Graph 1)

- There was a statistically significant difference in inter-implant distance measured using Pattern Resin and measured using Composite (p=0.018). It was observed that the mean inter-implant distance as measured with Composite was significantly higher than that with Pattern Resin.

Inter-implant Distance F (Table 2 and Graph 1)

- There was a statistically significant difference in inter-implant distance measured using Pattern Resin and measured using Composite (p=0.046). It was observed that the mean inter-implant distance as measured with Composite was significantly higher than that with Pattern Resin.

One-sample t-tests was further used to confirm which splinting material demonstrated the least deviation from the master model Pattern Resin (PR):

- Showed no significant difference from the master model in most distances (A p=0.059, F p=0.529), and when significant, the mean deviation was very small (e.g., C p=0.048, D p=0.030).
- Interpretation → PR was closest to the master model, i.e., least deviation. Acrylic Resin (AR):
- Significant deviations were noted in some distances (A p=0.020, B p=0.010, D p=0.039), but in other measurements it was not significantly different (C p= 0.239, F p=0.324).
- Interpretation → AR showed intermediate accuracy.

Composite (C):

- Frequently showed significant differences from the master model with higher deviations (A p=0.008, D p<0.001, F p<0.001).
- Interpretation → Composite consistently exhibited the greatest discrepancies.

Discussion

The impression which allows replication must be accurate so that the resulting master cast precisely duplicates the clinical situation. Most research indicates that direct techniques produce less distortion than indirect techniques. From investigations in this study, Composite material consistently resulted in larger inter-implant distances compared to Pattern Resin. Acrylic Resin and Pattern Resin showed some variations but were generally closer to the master model in most cases.

The accuracy of implant cast reproduction varied depending on the inter-implant distance and splinting material used. The choice of splinting material can in fluenceinter-implant distances, with Composite leading to greater discrepancies. Pattern Resin and Acrylic Resin may provide more accurate reproductions for inter-implant distances. Future research with larger sample sizes should further explore these differences to optimize material selection for clinical applications.

Saini et al. (2018) [7] conducted a study comparing different impression techniques and splinting methods for multiple implant impressions to determine the most accurate approach. The results showed that the closed tray technique had the highest deviation**,** making it the least accurate. The open tray technique was more precise, with further improvement when splinting was used. Among the splinting materials, light cure splinting showed the least deviation, making it the most accurate, followed by acrylic splinting. The findings suggest that using an open tray impression technique with light cure splinting provides the best dimensional accuracy, ensuring a well-fitting prosthesis for edentulous patients.

Selvaraj et al. (2016)[8] evaluated the accuracy of implant master casts using the open tray impression technique with two different splinting materials: GC pattern resin (auto polymerizing acrylic resin) and Pro-temp TM 4 (bis-GMA). The results showed no significant difference in dimensional accuracy between the two groups, as statistical analysis (ANOVA and post-hoc tests) indicated similar deviation values for both materials. This suggests that bis-GMA, despite being a newer material, performs comparably to conventional acrylic resin in maintaining implant position accuracy. The study highlights the advantages of bis-GMA, including its ease of handling, reduced technique sensitivity, and time efficiency, making it a practical alternative for splinting in implant impressions without compromising accuracy.

Stimmelmayr et al. (2012)[9] conducted a clinical study comparing the accuracy of two different impression techniques for four implants in edentulous jaws. The study evaluated transfer (closed tray) impressions and splinted pick-up (open tray) impressions**,** analyzing discrepancies in implant positioning through digital scans.

The results showed that the splinted pick-up technique produced significantly more accurate casts with less deviation compared to the transfer technique. Clinically, prostheses fabricated on casts from the splinted pick-up technique had a superior fit, reinforcing the recommendation that splinted open tray impressions should be preferred for multi-implant cases to ensure better prosthetic accuracy.

A janpeni et al. (2023) [10] conducted an in vitro study to evaluate the effect of splinting with two different material son the accuracy of impressions in an All-on-Four implant scenario using the open tray impression technique. The study compared non-splinted impressions, splinting with pattern resin, and splinting with flow able composite.

The results indicated that splinting significantly improved accuracy compared to the non-splinted group. However, there was no significant difference between pattern resin and flow able composite, suggesting that both materials provide similar levels of accuracy. Based on these findings, either pattern resin or flow able composite can be recommended for splinting implant impression copings in an All-on-Four scenario to achieve precise prosthetic outcomes.

Conclusion

This study compared the accuracy of implant casts obtained using the open tray impression technique with different splinting materials: Pattern Resin (PR), Flow able Composite (C), and Auto polymerizing Acrylic Resin (AR). The findings indicate that Pattern Resin (PR) provides the most stable and accurate results, followed by Auto polymerizing Acrylic Resin (AR), while Flow able Composite (C) showed the highest distortion.

Splinting enhances stability, reduces the likelihood of positional discrepancies, and improves the overall precision of the impression.

The differences observed among the splinting materials highlight the importance of selecting an appropriate material to minimize dimensional changes.

Within limitation of the study it reinforced that splinting is a critical step in achieving accurate implant casts, particularly in multiple implant cases where misalignment can compromise prosthetic fit.

Legends Figures, Graphs and Tables

Fig. 1: Master model.

Fig. 2: Impression compound model, Flasking Unit.

Fig. 3: Flasking and dew axing.

Fig. 4: Master model with implants placed.

Fig. 5: Open tray copings in place and vaccuform sheet adapted.

Fig. 6: Alginate impression for the open tray technique with the cast obtained.

Fig. 7: Impression copings splinted with Dental Floss in Figure of 8 shape.

Fig. 8: Pattern resin used as splinting Material.

Fig. 9: Pattern Resin splinted after 17 Minutes.

Fig. 10: Pattern resin rejoined again after splitting.

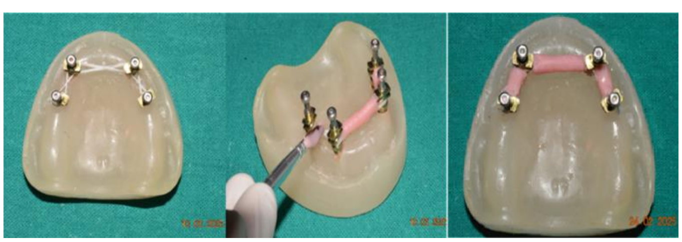


Fig. 11: Impression copings splinted with Dental floss in Figure of 8 shape, Application of Auto polymerizing resin as splinting Material with brush, Impression copings splinted with Auto polymerizing resin as splinting Material.

Fig. 12: Impression copings splinted with Dental Floss in Figure of 8 shape, Application of flow able composite as splinting Material.

Fig. 13: Light curing of the Flow able composite Material, Impression copings splinted with light cured flow able composite as splinting Material.

Fig.14: Master casts obtained by splinting the open tray impression copings with Pattern resin.

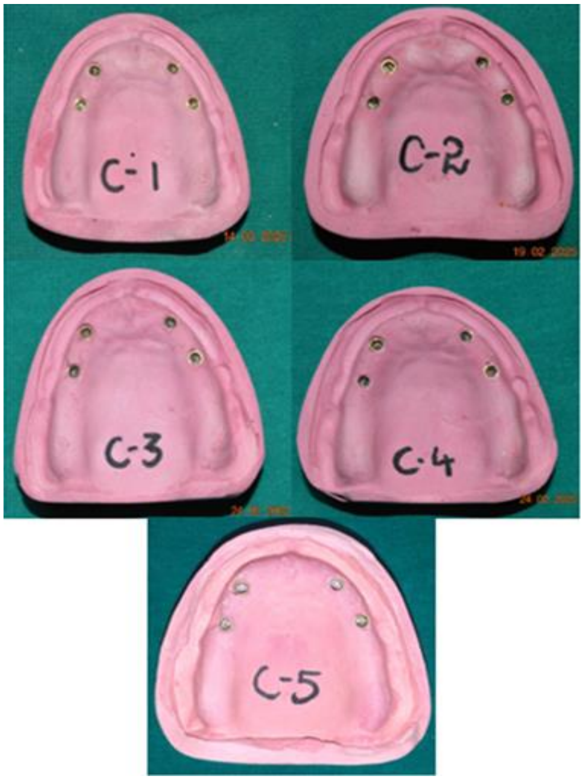


Fig. 15: Master casts obtained by splinting the open tray impression copings with Light Cured Flow able Composite.

Fig.16: Master casts obtained by splinting the open tray impression copings with Autopolymerising Resin.

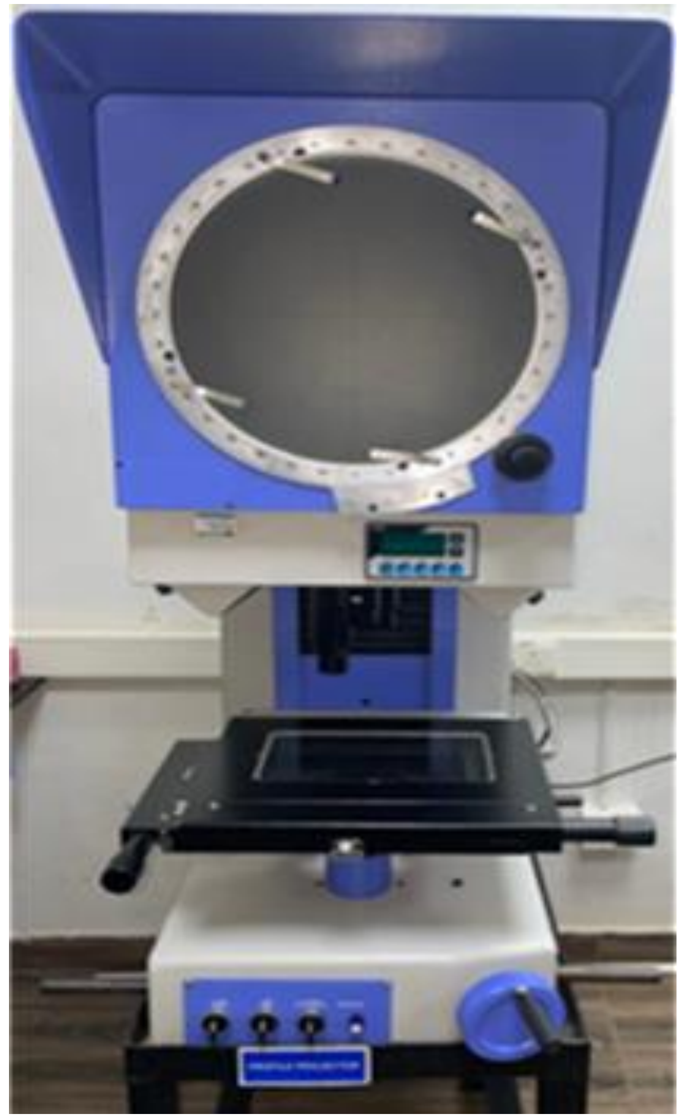
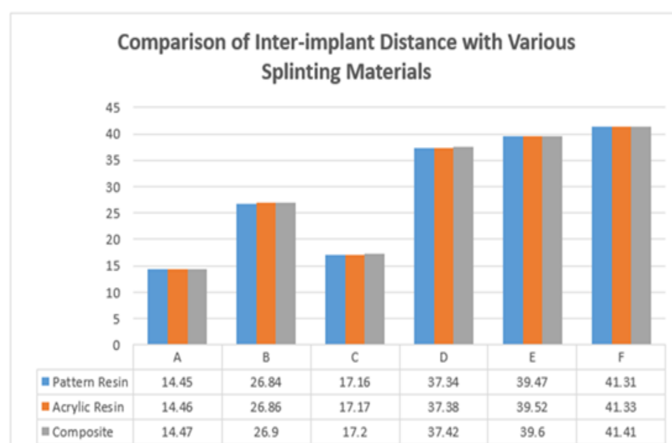


Fig. 17: Profile Projector.

Graph



Graph 1: Comparison of inter implant distance with various splinting material.

Table 1: Comparison of various inter-implant distances among splinting materials

		N	Mean	Std. Deviation	95% Confidence Interval for Mean		p-value
					Lower Bound	Upper Bound	
A	PR	5	14.4518	.01951	14.4276	14.4760	0.337
	AR	5	14.4654	.02179	14.4383	14.4925	
	C	5	14.4708	.01871	14.4476	14.4940	
	Total	15	14.4627	.02032	14.4514	14.4739	
B	PR	5	26.8462	.03490	26.8029	26.8895	0.340
	AR	5	26.8674	.03228	26.8273	26.9075	
	C	5	26.9010	.08628	26.7939	27.0081	
	Total	15	26.8715	.05760	26.8396	26.9034	
C	PR	5	17.1698	.01972	17.1453	17.1943	0.691
	AR	5	17.1798	.05625	17.1100	17.2496	
	C	5	17.2022	.08534	17.0962	17.3082	
	Total	15	17.1839	.05738	17.1522	17.2157	
D	PR	5	37.3430	.03045	37.3052	37.3808	0.023*
	AR	5	37.3824	.06237	37.3050	37.4598	
	C	5	37.4286	.02096	37.4026	37.4546	
	Total	15	37.3847	.05304	37.3553	37.4140	
E	PR	5	39.4706	.04248	39.4179	39.5233	0.389
	AR	5	39.5280	.15006	39.3417	39.7143	
	C	5	39.6062	.20876	39.3470	39.8654	
	Total	15	39.5349	.15070	39.4515	39.6184	
F	PR	5	41.3170	.06503	41.2363	41.3977	0.040*
	AR	5	41.3316	.06888	41.2461	41.4171	
	C	5	41.4126	.01894	41.3891	41.4361	
	Total	15	41.3537	.06753	41.3163	41.3911	

Table 2: Multiple comparisons.

Dependent Variable	Group	Group	Mean Difference	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
A	PR	AR-2	-.01360	.548	-.0474	.0202
	PR	C	-.01900	.326	-.0528	.0148
	AR	C	-.00540	.906	-.0392	.0284
B	PR	AR-2	-.02120	.828	-.1172	.0748
	PR	C	-.05480	.315	-.1508	.0412
	AR	C	-.03360	.630	-.1296	.0624
C	PR	AR-2	-.01000	.963	-.1114	.0914
	PR	C	-.03240	.679	-.1338	.0690
	AR	C	-.02240	.828	-.1238	.0790
D	PR	AR-2	-.03940	.331	-.1100	.0312
	PR	C	-.08560*	.018*	-.1562	-.0150
	AR	C	-.04620	.229	-.1168	.0244
E	PR	AR-2	-.05740	.821	-.3113	.1965
	PR	C	-.13560	.360	-.3895	.1183
	AR	C	-.07820	.697	-.3321	.1757
F	PR	AR-2	-.01460	.911	-.1087	.0795
	PR	C	-.09560*	.046*	-.1897	-.0015
	AR	C	-.08100	.095	-.1751	.0131

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