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An invitro study to assess the 3-dimensional positional accuracy of the definitive cast obtained using three different splinting materials in a multiple implant situation

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Abstract

Aim: This invitro study aimed to assess the 3-Dimensional positional accuracy of definitive casts obtained using three different splinting materials in a multiple implant situation. The study involved the use of self-cure pattern resin, light-cure pattern resin, and composite resin as splinting materials.

Objective: The objectives included evaluating the 3-Dimensional accuracy of implant casts obtained through splinted open tray impression techniques and comparing the implant angulation and accuracy among the three materials.

Materials and Methodology: Materials and methods detailed the fabrication of a reference mandibular edentulous model with four implants and the division into three groups based on splinting materials. The study design involved self-cure pattern resin, light-cure pattern resin, and composite resin groups. Impression procedures were carried out, and the resultant casts were evaluated for 3-Dimensional accuracy.

Result: Results showed mean deviations in distances between implant analogs in the casts compared to the reference model. Statistical analyses, including One Way ANOVA and post hoc Tukey tests, were performed to compare the three splinting materials. The outcomes highlighted specific materials that demonstrated superior accuracy in different aspects of the implant positions.

Conclusion: The study concluded that, in the context of A-B and A-C distances, self-cure pattern resin exhibited the highest accuracy. For C-D distance, light-cure pattern resin demonstrated better accuracy, and for B-D distance, composite resin displayed superior results. These findings suggested that the choice of splinting material can influence the accuracy of implant analog positions in definitive casts.

Keywords: Implant, Dimensional Accuracy, Volumetric Shrinkage

Introduction

Planning prosthodontic treatments is crucial for attaining outcomes that meet the expectations of both the patient and the dental practitioner. Various studies have observed and concluded that implant shows the highest rate of success clinically and esthetically as compared to the other prosthodontic rehabilitation option.

The introduction of dental implant was done by Branemark in 1982 in North America. Since then, various developments have been made in this field and branch of prosthodontic rehabilitation, broadening the scope and use of implant restoration in partially and completely edentulous patients. Implant in dentistry requires a multidisciplinary team of expertise and approach to achieve an esthetically pleasing and biologically acceptable final prosthesis.

Osseointegrated dental implant have become a replacement for the natural teeth. With the advancements in dentistry, dental implants have been proven as a prime treatment modality for edentulism. Patients with conventional dentures or long span FPD are being replaced with an implant supported prosthesis including single tooth, multiple implant or implant overdentures.

An implant impression serves as a detailed three-dimensional representation of the implant and the adjacent tissues. The precision of the impression is critical for the long-term success of the implant. Any inaccuracies or mistakes during the fabrication of the superstructure can result in a compromised fit among different components.

Implant impression dimensional accuracy and its angulation in a working cast is of utmost importance for the fabrication of a passively fitting framework.

The choice of impression tray, whether it's a stock tray or custom tray, significantly influences the accuracy of the impression. Additionally, factors such as the impression technique (e.g., close tray or open tray) and the type of impression material used also play a role in determining accuracy.

For the accurate impression making, transferring the precise position of the implant to the working cast, it's essential to consider that implants are stationary unlike natural teeth. Because implants lack the ability for compensatory readjustment, which is present in natural teeth due to the periodontal ligament, there can be potential complications or failures if this lack of adaptability is not properly accounted for.

Since implants are immobile compared to natural teeth, this is of utmost importance. An implant superstructure's and the implant abutments' tightly allowed metal-to-metal interaction is what is meant by the term "passive adaptation." Stresses at the implant abutment contact can be created if a passive fit is not achieved, which might cause problems and mechanical failure.

Uneven distribution of occlusal load and torque exerted on the implant can lead to stresses on the implant, which leads to increase the risk of implant failure and minor bone loss. This results in mechanical issues including screw loosening and implant component fatigue fractures.

The primary goal of modern implant prosthodontics is to develop techniques for fabricating working casts that accurately replicate the relationship of implant analogs or abutments outside the mouth in a manner consistent with their intraoral positioning. Splinting of impression copings has been a recommended technique for multiple implant impressions.

However, the procedure is cumbersome, technique sensitive, requires more than one visit as it includes volumetric shrinkage of metal casting during solidification , dimensional changes in wax , acrylic patterns, investment materials, and the expansion gypsum die product.

The initial and crucial step in accurately transferring the spatial relationships of implants and ensuring a passive fit of the implant framework from the oral cavity to the master cast involves taking an impression. Therefore, various materials and techniques have been employed to enhance the accuracy of transferring impressions of implant analogs.

Research indicates that materials such as polyether (PE) and polyvinylsiloxane (PVS) exhibit superior accuracy compared to condensation silicone, polysulfide, irreversible hydrocolloid, and plaster materials. Similar findings also exist regarding the effects of splinting, angulation, and alternative impression materials on accuracy.

Two primary methods, the direct (open tray) and indirect (closed tray) impression techniques, are commonly employed in dental implant procedures. In the open tray technique, the impression coping is placed in the impression and removed from the mouth along with the set impression. Conversely, in the closed tray approach, the impression coping remains in the mouth when the set impression is removed.

Some experts emphasize the importance of intra-orally splinting impression copings together before taking the impression to achieve optimal accuracy. Various materials, including acrylic resin, dental plaster, bite registration silicone, polyether (PE), pattern resin, composite, and light-cure pattern resin, have been utilized as splinting materials with varying levels of accuracy.

The advent of newer flowable materials has made it easier to record the impression in a single visits, but, the accuracy for the same has been in question.[5-6] Therefore, the study has been designed to assess the 3-Dimensional positional accuracy of the definitive cast obtained using three different splinting material in a multiple implant situation.

Aim

An invitro study to assess the 3-Dimensional positional accuracy of the definitive cast obtained using three different splinting materials in a multiple implant situation.

Objectives

1. To evaluate 3-Dimensional accuracy of implant cast as obtained by splinted open tray impression technique using self-cure pattern resin under vision measuring machine.
2. To evaluate 3-Dimensional accuracy of implant cast as obtained by splinted open tray impression technique using light cure pattern resin under vision measuring machine.

3. To evaluate 3-Dimensional accuracy of implant cast as obtained by splinted open tray impression using composite resin under vision measuring machine.
4. To comparatively evaluate the implant angulation of the cast obtained by using the above three materials.
5. To comparatively evaluate the 3-Dimensional accuracy of the cast as obtained by using the above three materials.

Materials and Methodology

Materials to be used for making control group

- Self-Pattern Resin.
- Light Cure Pattern Resin.
- Composite.
- Open Tray Transfer Copings
- Dental Floss

Materials to be used for duplication of master model

- Addition polyvinyl silioxane impression material Putty – Aquasil (president)
- Light body - Aquasil cartilage (president)
- Mixing Tip
- Perforated Stainless steel impression tray

Methodology

The study was conducted in the Department of Prosthodontics and Crown and Bridge, Maxillofacial Prosthesis and Oral Implantology, I.T.S Centre for Dental Sciences and Research, Greater Noida (U.P)

Fabrication of Die Model

A reference fiber mandibular edentulous jaw was fabricated with 4 TSIII SA Dummy implant,(Osstem implant system)(4.0D 11.5L) two placed anteriorly in A-B position and two placed posteriorly at D and E position at an angle at an angle of 90 degree. The reference model mimics a mandibular "All -on-4", situation.

Control Group

On the reference model , 4 TSIII SA Dummy implant,(Osstem implant system)(4.0D 11.5L) two placed anteriorly in A-B position and two placed posteriorly at D and E position at an angle at an angle of 90 degree were placed . This model was used for measurements which served as control group.

Depending on the different splinting material used for the fabrication of cast. The samples were divided into three groups:

Group 1: Implant cast (N=5) as obtained from self-pattern resin.

Group 2: Implant cast (N=5) as obtained from light cure pattern resin.

Group 3: Implant cast (N=5) as obtained from composite.

Table 1: Distribution of Samples (N=30)

Groups	Sample Size	Sample Type
Group	1	Reference model
Group	5	Implant cast obtained from self-pattern resin.
Group	5	Implant cast obtained from light pattern resin
Group	5	Implant cast obtained from composite

Measurement Protocol

VMM (Vision Measurement Machine is designed especially for large scale repeated measuring. It is with high speed, high efficiency and powerful function. It especially suits for large-amount in section which requires high speed, high efficiency and high precision. It is necessary and important equipment within a busy QC line.BJV Series uses high precision 00 class granite fixed bridged structure for the bracket, along with high precision work-table, in order to ensure the stability and precision of the machine body as long as the high precision of the measuring. Three axis adopt the Panasonic AC servo motor system, recognized by the whole industry as the most reliable system

Reference Model

Fig.1: Osteotomy on fiber edentulous reference model

Fig. 2: TS111 SA Dummy Implant

Fig. 3: Dummy Implant Placed On Reference Model

Fig. 4: Ts Fixture Pick-Up Impression Coping

Group I

Fig. 5: Open Tray Impression Copings on Dummy Implant

Fig. 6: GC Pattern Resin

Fig. 7: Impression Coping Splinted With GC Pattern Resin and Dental Floss

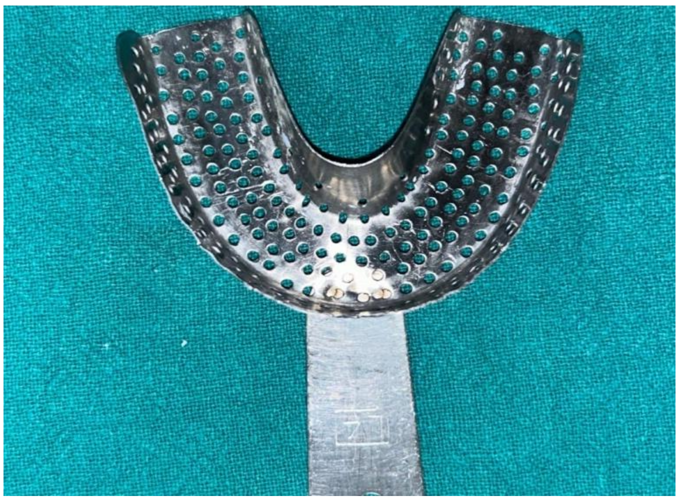


Fig. 8: Mandibular Perforated tray

Fig. 9: Light Body (President)

Fig. 10: Dental mart Light Body Gun

Fig. 11: Polyvinyl Siloxane -Putty

Fig.12: Implant Analogue

Fig. 13: Open Tray Implant Putty Light A body Impression with Implant Analogue

Fig. 14: Master Cast

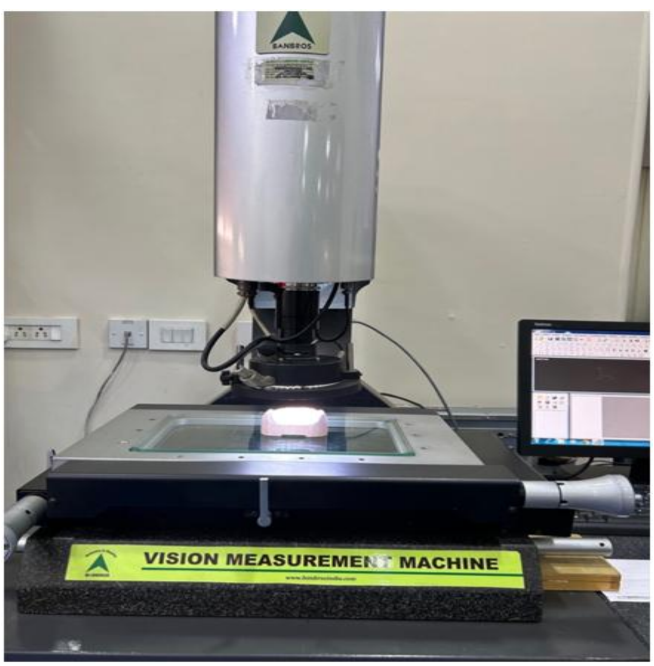


Fig.15: Measuring Device

Group II

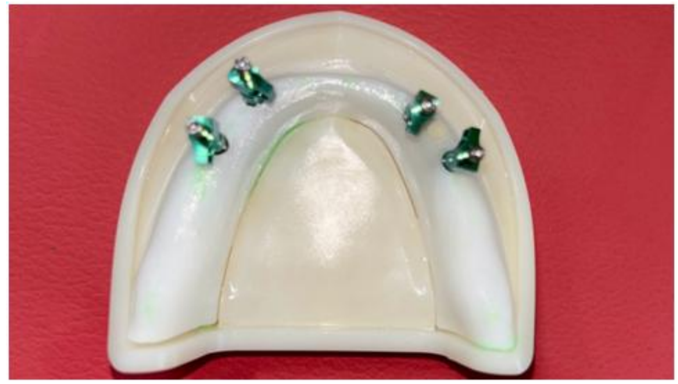


Fig.16: Open Tray Impression Copings On Dummy Implant

Fig. 17: Light Cure Pattern Resin

Fig. 18: Impression Coping Splinted With Light Cure Pattern Resin and Dental Floss

Fig. 19: Implant Analogue

Fig. 20: Open Tray Implant Putty Light Body Impression with Implant Analogue

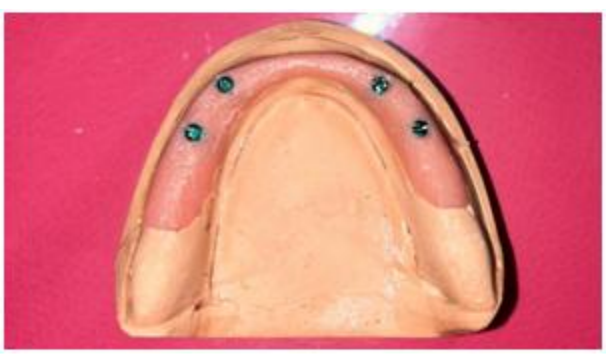


Fig. 21: Master Cast

Fig. 22: Measuring Device

Group III

Fig. 23: Open Tray Impression Copings on Dummy Implant

Fig. 24: Composite Resin

Fig. 25: Impression Coping Splinted With Composite Resin and Dental Floss

Fig. 26: Implant Analogue

Fig. 27: Open Tray Implant Putty Light Body Impression with Implant Analogue

Fig 28: Master Cast

Fig. 29: Measuring Device

Result

An invitro study was undertaken in the department of prosthodontics including Crown & Bridge, Maxillofacial Prosthesis & Oral Implantology, ITS Dental College, Hospital and Research Centre, Greater Noida, to assess the 3- dimensional positional accuracy of the definitive cast obtained using three different splinting material in a multiple implant situation. A reference die simulating mandibular edentulous jaw was fabricated with 4 Endosseous implants out of which 2 implants were placed anteriorly in A -B (canine region) position and 2 implants were placed posteriorly in C -D (molar region) position. Open tray impression copings were splinted by three different materials and all the samples were divided into three groups as under:

1. Group 1: Splinted with self cure pattern resin.
2. Group 2: Splinted with light cure pattern resin.
3. Group 3: Splinted with composite resin.

Five implant level impressions were made from each group and poured in Type - 4 Dental stone. The implant analogue was transferred to the cast and the inter implant positional accuracy (angle & distance) was checked and compared to the reference model using vision measuring machine [VMM].

Table 1: Master cast dimensions

A-B Distance	29.273mm
C-D Distance	42.674mm
A-C Distance	10.787mm
B-D Distance	11.193mm

Self Cure Pattern Resin-1.1

A-B Distance	29.198mm
C-D Distance	42.431mm
A-C Distance	10.706mm
B-D Distance	11.267mm

Self cure pattern resin -1.2

A-B Distance	29.316mm
C-D Distance	42.689mm
A-C Distance	10.959mm
B-D Distance	11.436mm

Self Cure Pattern Resin -1.3

A-B Distance	29.312mm
C-D Distance	42.435mm
A-C Distance	10.701mm
B-D Distance	11.269mm

Self Cure Pattern Resin -1.4

A-B Distance	29.398mm
C-D Distance	42.427mm
A-C Distance	10.711mm
B-D Distance	11.263mm

Self Cure Pattern Resin -1.5

A-B Distance	29.199mm
C-D Distance	42.687mm
A-C Distance	10.961mm
B-D Distance	11.435mm

Light Cure Pattern Resin-2.1

A-B Distance	29.286mm
C-D Distance	42.751mm
A-C Distance	10.948mm
B-D Distance	11.430mm

Light Cure Pattern Resin-2.2

A-B Distance	29.316mm
C-D Distance	42.711mm
A-C Distance	10.988mm
B-D Distance	11.388mm

Light Cure Pattern Resin-2.3

A-B Distance	29.288mm
C-D Distance	42.745mm
A-C Distance	10.942mm
B-D Distance	11.42mm

Light Cure Pattern Resin-2.4

A-B Distance	29.284mm
C-D Distance	42.756mm
A-C Distance	10.954mm
B-D Distance	11.44mm

Light Cure Pattern Resin-2.5

A-B Distance	29.315mm
C-D Distance	42.711mm
A-C Distance	10.99mm
B-D Distance	11.385mm

Composite-3.1

A-B Distance	29.179mm
C-D Distance	42.767mm
A-C Distance	10.911mm
B-D Distance	11.245mm

Composite-3.2

A-B Distance	29.390mm
C-D Distance	42.800mm
A-C Distance	11.015mm
B-D Distance	11.276mm

Composite-3.3

A-B Distance	29.175mm
C-D Distance	42.771mm
A-C Distance	10.912mm
B-D Distance	11.242mm

Composite-3.4

A-B Distance	29.183mm
C-D Distance	42.763mm
A-C Distance	10.909mm
B-D Distance	11.248mm

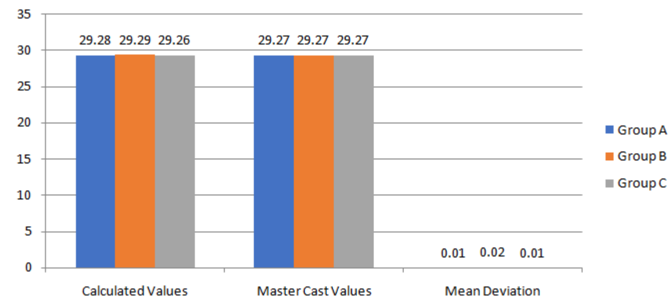
Composite-3.5

A-B Distance	29.388mm
C-D Distance	42.79mm
A-C Distance	11.01mm
B-D Distance	11.278mm

Intergroup Comparison f Mean Deviation From The Master Cast of A-B Distance In Three Groups

	Calculated Values	Master Cast Values	Mean Deviation	F value	P value
Group A	29.28±0.07mm	29.27±0.01mm	0.01±0.04mm	0.076	0.927 (Non-Significant)
Group B	29.29±0.01mm	29.27±0.01mm	0.02±0.01mm		
Group C	29.26±0.09mm	29.27±0.01mm	0.01±0.07mm		

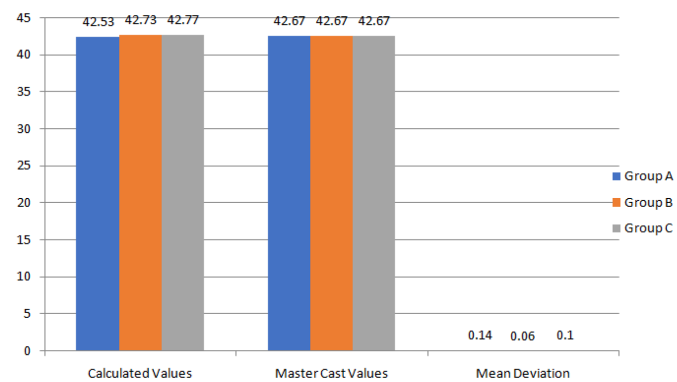
Graph 1



Intergroup comparison of mean deviation from the master cast of C-D distance in three groups

	Calculated Values	Master Cast Values	Mean Deviation	F value	P value
Group A	42.53±0.12mm	42.67±0.01mm	0.14±0.11mm	4.951	0.023 (Significant)
Group B	42.73±0.01mm	42.67±0.01mm	0.06±0.01mm		
Group C	42.77±0.01mm	42.67±0.01mm	0.10±0.01mm		

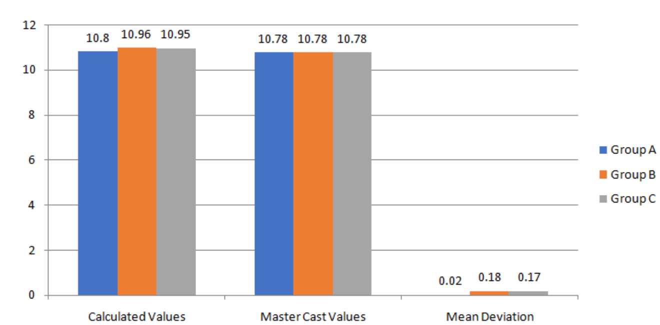
Graph 2



Intergroup comparison of mean deviation from the master cast of A-C distance in three groups

	Calculated Values	Master Cast Values	Mean Deviation	F value	P value
Group A	10.80±0.12mm	10.78±0.01mm	0.02±0.11mm	9.198	0.001 (Significant)
Group B	10.96±0.02mm	10.78±0.01mm	0.18±0.01mm		
Group C	10.95±0.04mm	10.78±0.01mm	0.17±0.03mm		

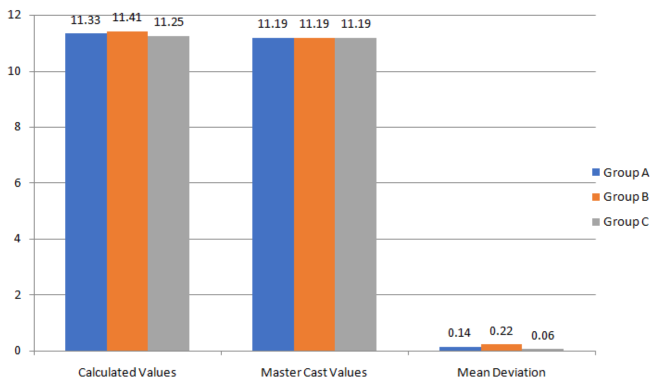
Graph 3



Intergroup comparison of mean deviation from the master cast of B-D distance in three groups

	Calculated Values	Master Cast Values	Mean Deviation	F value	P value
Group A	11.33±0.08mm	11.19±0.01mm	0.14±0.07mm	9.198	0.001 (Significant)
Group B	11.41±0.02mm	11.19±0.01mm	0.22±0.01mm		
Group C	11.25±0.01mm	11.19±0.01mm	0.06±0.01mm		

Graph 4



Statistical Analysis

The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation frequency and percentage. The level of the significance for the present study was fixed at 5%.

The intergroup comparison was done using the One Way ANOVAt followed by post Hoc Analysis depending upon the normality of the data. The The Shapiro–Wilk test was used to investigate the distribution of the data and Levene’s test to explore the homogeneity of the variables.

Discussion

Long term success for any implant prosthesis has been a key factor in determining the success of an implant. A variety of factors have been attributed to the same. These include loosening and fracture of screw, framework, abutment or chipping or fracture of the veneering material or decementation of the prosthesis. Of all the factors mentioned above, placement and angulation of the implant fixture plays a vital role in redistribution of biomechanical stresses on the implant and ensuring it’s long term success and survivability. However, recording implant position using proper impression material is equally important for fabricating right kind of passive framework for the prosthesis. [11]Branemark and colleagues suggest that for optimal outcomes, the passive fit of dental implants should ideally be within a range of 10 micrometers, enabling proper bone maturation and remodelling in response to occlusal forces.

Since implants may have different angulations and impression tends to distort while retrieval, splinting of impression copings has been recommended as a protocol especially in cases of multiple implants. According to research by Papaspyridakos, Burawi, Assuncao, Lee, and Cho, when making impressions for prostheses requiring four or more implants, it is recommended to splint impression copings. This method has been shown to yield greater accuracy compared to non-splinted techniques.

Hence, it is important to splint transfer copings and make adjustments to stop this movement [26] . The findings from Saini et al.'s study also suggested that the splinted direct approach is the most accurate and precise technique for multiple implants. This superiority is attributed to the stabilizing effect of splinting on the copings during transfer.

This result could be due similarity in polymerization shrinkage of acrylic resin and pattern resin. In our study we used three different splinting materials i.e self cure pattern resin, light cure pattern resin and composite and concluded that master cast obtained from self cure pattern resin and light cure pattern resin did not show any significant difference

Long-term success in implant dentistry depends on various factors such as screw stability, framework integrity, and proper implant positioning. Accurate recording of implant position through precise impression taking is crucial for creating a passive framework for the prosthesis. Branemark et al. highlighted the importance of achieving a passive fit within a narrow range to allow for bone maturation and remodelling. To address potential distortion during impression retrieval, splinting of impression copings, especially in cases involving multiple implants, has been recommended by several studies.

Conclusion

An impression is a negative replica that is used to create a positive model of a structure in order to fabricate a prosthesis or dental restoration. A precise impression is necessary to create prosthesis with a good fit since it influences the definitive cast's accuracy.

A satisfactory outcome in implant dentistry is only possible with the fabrication of passively fitting prostheses. The results may be compromised if screws are torque excessively when attaching the superstructure to the abutments. It is imperative that the work be done on a master cast that replicates the location of the abutments in the patient's mouth as precisely as possible in order to remove fit disparities. Impressions accuracy is a significant aspect that affects fit precision. Research indicates that number of variables, including the type of impression material, implant angulation, implant impression technique, die material accuracy, and master cast, affect how accurate the implant cast will be that is used to create a positive model of a structure to fabricate a prosthesis or dental restoration.

The impression copings were splinted using self-cure pattern resin, Light cure pattern resin, composite resin material, and Polyvinylsiloxane in putty consistency were used as an impression material. Total 15 master casts were poured, five master casts for each group. A VMM was used to measure the master casts and the reference model in order to calculate the inter-implant distances.

The findings indicated that the use of self-cure pattern resin was associated with a lower mean inter-implant distance variation from the reference model, followed by light cure pattern resin and composite resin.

The study's constraints led to the following conclusions being drawn.

1. Every splinting material produced master cast with readings that were within the clinical range and quite close to the reference model.
2. Out of the splinting techniques employed in this study self cure pattern resin (GC pattern resin) was found to be a more reliable approach for splinting impression copings than light cure pattern resin and composite resin.
3. The most recent splinting techniques employing light cure pattern resin and composite resin may yield clinically satisfactory accuracy.

With all of the factors taken into account, the current study concludes that self-cure pattern resin (GC pattern resin) can still be the material of choice for splinting in order to achieve accuracy in implant impressions. This is followed by more recent materials like light cure pattern resin and composite resin.

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