# EVALUATION AND COMPARISON OF TWO DIFFERENT ABUTMENT LEVEL IMPRESSION TECHNIQUES FOR ALL-ON-FOUR IMPLANT TREATMENT PROTOCOL – AN INVITRO STUDY'

**Dr. S. Ashna MDS[1]*, Dr. N. Vidhyasankari MDS[2], Dr. Chalakuzhiyil Abraham Mathew MDS[3], Dr.Divya Krishnamoorthi MDS[4], Dr. Sheela Kannan MDS[5], Dr . S. Saravanaram MDS[6]**

**Abstract** :
To achieve a precise passive fit of an implant prosthesis, it is important to reproduce three dimensional relationship of implants and abutments by an accurate impression procedure. ***Aim*:** The accuracy of closed and non-splinted open tray abutment level impression techniques for the All-On-Four implant protocol was compared.
***Methods and Material***: Four implants were inserted into an acrylic edentulous maxillary reference model in accordance with the All-On-Four technique. Two straight transmucosal abutments were used for two straight anterior implants, and two 30° angled transmucosal abutments were used for two distal positioned posterior implants. With the use of polyether impression material, closed (n = 10) and unsplinted open tray (n = 10) impressions were made. The casts made from closed and unsplinted open tray groups as well as the reference acrylic model were measured linearly and angularly using a coordinate measuring machine.
***Statistical analysis used***: The difference in inter-implant distance in the X-axis and Y-axis between the reference, Group A, and Group B was analysed using the Kruskal-Wallis test. The implant angulation to the horizontal plane in the z-axis of the two groups was compared using the Mann Whitney U test.
**Results:** The linear and rotational differences between the casts made from the closed and unsplinted open tray and those made from the reference acrylic model did not differ significantly.
**Conclusions:** When a suitable multi-unit abutment is utilised to correct the implant angulation, either non-splint open or closed tray impressions can be made, within the scope of our study's constraints.

**Keywords** : All-On-Four, Multi unit abutment, open tray impression, closed tray impression

[1*]Assistant professor, Department of Prosthodontics and Crown & Bridge, Vinayaka Mission's Sankarachariyar Dental College, Vinayaka Missions's Research Foundation (Deemed to be University), Ariyanoor, Salem, Tamil Nadu 636308.email Id: ashnasoundararaj26@gmail.com, phone no: 9843693385.
[2]Professor, Department of Prosthodontics and Crown & Bridge, KSR Institute of Dental Science and Research, KSR Kalvi Nagar, Thokkavadi, Tiruchengode, Tamil Nadu 637215,
email Id: vidyasankari244@gmail.com , phone no: 9443940244.
[3]Dr. Chalakuzhiyil Abraham Mathew MDS, HOD & Professor, Department of Prosthodontics, KSR institute of Dental science and Research, KSR Kalvi Nagar, Thokkavadi, Tiruchengode, Tamil Nadu 637215
[4]Assossiate professor, Department of Prosthodontics and Crown & Bridge, Vinayaka Mission's Sankarachariyar Dental College, Vinayaka Missions's Research Foundation (Deemed to be University), Ariyanoor, Salem, Tamil Nadu 636308
[5]Senior lecturer, Department of Prosthodontics and Crown & Bridge, Sri Ramakrishna Dental College and Hospital, Coimbatore, Tamil Nadu
[6] Department of Orthodontics and Dentofacial Orthopedics, Tamil Nadu.

***Corresponding Author:-** Dr. Ashna
*Dr. S. Ashna MDS, Assistant professor, Department of Prosthodontics, Vinayaka Mission's Sankarachariyar Dental College, Vinayaka Missions's Research Foundation (Deemed to be University), Ariyanoor, Salem, Tamil Nadu 636308. Phone numbers: 9843693385.Facsimile numbers: 8778093313 E-mail address: ashnasoundararaj26@gmail.com

**DOI: -** 10.48047/ecb/2023.12.si10.0073

**Introduction:**

An adequate dentition is very importance for well-being. Despite improvements in preventative dentistry, edentulism continues to be a significant global public health issue. Resorption of the residual alveolar ridge leads to the reduction in the alveolar bone and the size of the denture bearing area.

The All-On-Four treatment concept was developed by Dr. Paulo Malo in 1990's. This concept maximized the use of available remnant bone in the atrophic jaws, allowing immediate function and avoiding regenerative procedures.[1]

Dr. Paulo Malo in 1990's developed the All-On-Four treatment concept which maximized the use of available remnant bone in the atrophic jaws, allowing immediate function and avoiding regenerative procedures.[1] Tilting the distal implants avoids bone augmentation, avoids anatomical structures, allows for the placement of longer implants, provides better anteroposterior spread, favours better load distribution, improves the prosthetic support with shorter cantilever arm, improves the inter implant distance and provides good anchorage in the bone.[2] Babbush CA et al stated that the cumulative success rate on the All-On-Four concept was between 92.2% and 100%.[3]

The osseointegration and passive fit of the prosthesis are crucial for the implants' success. The absence of a passive fit between the prosthesis and the implant may put tension on these parts, which could lead to failure, fracture of the implant or a microfracture of the surrounding bone, and bone loss.[4]

The prosthesis misfit should be smaller than 150 m to achieve passive fit.[5] Making an appropriate impression is one of the most crucial factors in the All-On-Four concept to produce an accurate passive fit between the fixture and the superstructure.[6] Mechanical and biological complications originates from lack of passive fit. The precision of the definitive cast is directly impacted by the impression's accuracy.

The implant impression technique, whether direct (open tray, pick up) or indirect (closed tray, transfer), type of impression material, type of impression tray used, type and surface treatment of impression copings, splinting or non-splinting, and the angulation of implants are all factors that affect the accuracy of implant impressions.[7] Implant impression technique largely influences the accuracy of the working casts because the implant impression technique aims to record the three dimensional implant position and to copy the details as deepness, angulation and position in relation to other implants, adjacent teeth and antagonist arch.

In our study, the accuracy of the casts obtained from non-splinted open tray and closed tray abutment level impression techniques were compared with the reference acrylic model. The null hypothesis was that there are no significant differences in the accuracy of the casts obtained from closed and non- splinted open tray impression techniques with that of the reference acrylic model. An in- vitro study was conducted because the reference acrylic model in this study simulated the ideal intra oral maxillary arch.

**Subjects and Methods:**

**A. Fabrication of edentulous maxillary acrylic reference model**

In the edentulous maxillary silicone mould, modelling wax (Maarc Dental, Shiva goods, Vasai district, Palghar) was melted and poured. A metal dental flask was used to invest, flask, and dewax the maxillary edentulous wax model. The mould space was filled with heat-curable acrylic resin (DPI pink, Dental Products of India, Wallance Street, Fort, Mumbai, India). After acrylization, a heat-cure acrylic resin edentulous model was fabricated.

**B. Placement of Implant and abutments in the acrylic maxillary edentulous reference model**

The All-On-Four guide was used to place two implants, each measuring 4.2 mm in diameter and 13 mm in length, perpendicular to the horizontal plane in the canine and at a 45-degree angle in the second premolar areas (Figure 1). Two straight anterior implants were supported by straight transmucosal abutments (Adin dental implant system Ldt, Industrial Zone Alon Tavor, POB 1128, Afula, Israel) with a 2 mm collar height. Two distally slanted posterior implants were supported by 30° angled transmucosal abutments (Adin dental implant system Ldt, Industrial Zone Alon Tavor, POB 1128, Afula, Israel) with a 4 mm collar height (Figure 2).The abutments in the acrylic model were numbered from 1 to 4 starting from the right posterior abutment to the left posterior abutment.

To ensure proper orientation of custom impression trays, four notches of 4×4 mm were made on the land area of the acrylic model, two in the anterior

and two in the posterior region (Figure 2). Metallic circular index of 8 mm diameter by 3 mm thickness was embedded at the center of the acrylic model and secured using autopolymerizing resin. The index was inserted such that it was made to protrude 3 mm from the surface of the acrylic model. This index was taken as the reference point for measurements using coordinate measuring machine.

**C. Evaluation of reference acrylic model using coordinate measuring machine**

The acrylic model was assessed using a Coordinate Measuring Machine (CMM) in the x, y, and z axes with an accuracy of 1 m. To determine the reference values, the acrylic model was measured in the x, y, and z planes. Using a coordinate measuring equipment, the inter-abutment distance in the x and y axes and the angle between the abutments were measured.

**D. Spaced casts fabrication**

Four closed tray impression copings were fastened to the transmucosal abutments for spaced cast creation in the acrylic model (Figure 3). Over the acrylic model, modelling wax in a two layer thickness was adapted. In and around the closed impression copings, modelling wax was placed. On the acrylic model, three rectangular tissue stops were made, one in the anterior (incisive papilla region) and two in the posterior region (second molar region). An alginate (Vignette, Dentsply India Pvt, IMT Manesar, Gurgaon, Haryana) impression of spaced acrylic model was made and cast was poured using die stone (Jai Krishna industrial estate, Veraval, Rajkot) and a spaced cast was obtained (Figure 4).

**E. Custom trays fabrication and impression making**

To standardize the spacer thickness, 10 custom trays for closed tray impressions and 10 custom trays with windows for open tray impressions were fabricated using autopolymerizing acrylic resin on the spaced cast. On the anterior portion of the custom trays handles were fabricated.

For retention of the impression material, vent holes were drilled on the custom tray. The trays were left undisturbed for 24 hours to achieve dimensional stability.

Custom trays were coated with polyether tray adhesive (Polyether adhesive, 3M, Deutschland GMbH, 41453 Neuss, Germany) and allowed to dry for 15 minutes. Impressions were divided into two groups based on the impression techniques.

**Group 1: Closed tray impressions (n=10)**

Using the torque wrench and hex driver closed tray impression copings were screwed on to the multiunit abutments at 10Ncm torque. Closed tray impressions were made using medium body polyether impression material. The abutment replicas (Adin dental implant system Ldt, Industrial Zone Alon Tavor, POB 1128, Afula, Israel) were attached to the impression copings. The four impression copings and the abutment replica units were inserted into their respective indentations in the impression to their full depth by firmly pushing them into it (Figure 5).

**Group 2: Non splinted open tray impressions (n=10)**

The open tray impression copings were screwed on to the multiunit abutments (Figure 6) at 10Ncm of torque using the torque wrench and hex driver. Non- splinted open tray impressions were made using medium body polyether impression material.

**F. Fabrication and evaluation of master cast**

Master casts were made using type IV dental stone (Jai Krishna industrial estate, Veraval, Rajkot) 60 minutes after the impression procedure. The master casts obtained from each group were numbered from 1 to 10. All the work was done by the same operator.

Similar to how the reference acrylic model was measured, all 20 master casts were measured using the coordinate measuring machine. Mean, median and standard deviation values were tabulated and subjected to statistical analysis.

**Statistical analysis:**

The non-parametric Kruskal-Wallis test was used to analyse the variation in inter-implant distance in the X-axis and Y-axis between the reference, Group A, and Group B based on the distribution of the data. As Post hoc testing is not offered in the Non parametric procedure, the further post-hoc analysis was performed with a series of Mann-Whitney tests to ascertain which pairs of groups differ significantly from one another. The implant angulation to the horizontal plane in the z-axis of the two groups was compared using the Mann Whitney U test. $p \leq 0.05$ was considered for statistical significance.

**Figure 1:** All-On-Four guide positioned on the acrylic model

**Figure 2:** Placement of 30˚ angled transmucosal abutments, four notches in land area and index in the midline

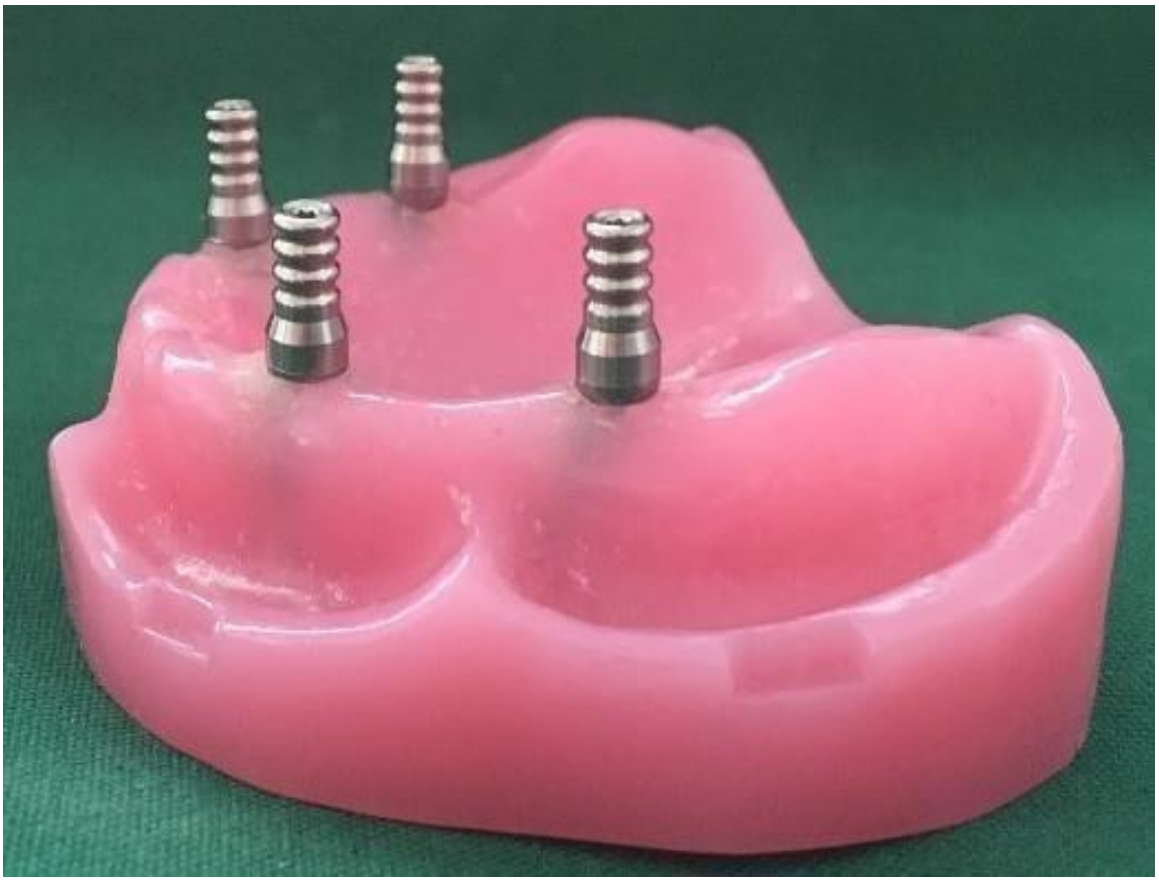

**Figure 3:** Closed tray impression copings secured on the respective abutments

**Figure 4:** Spaced cast

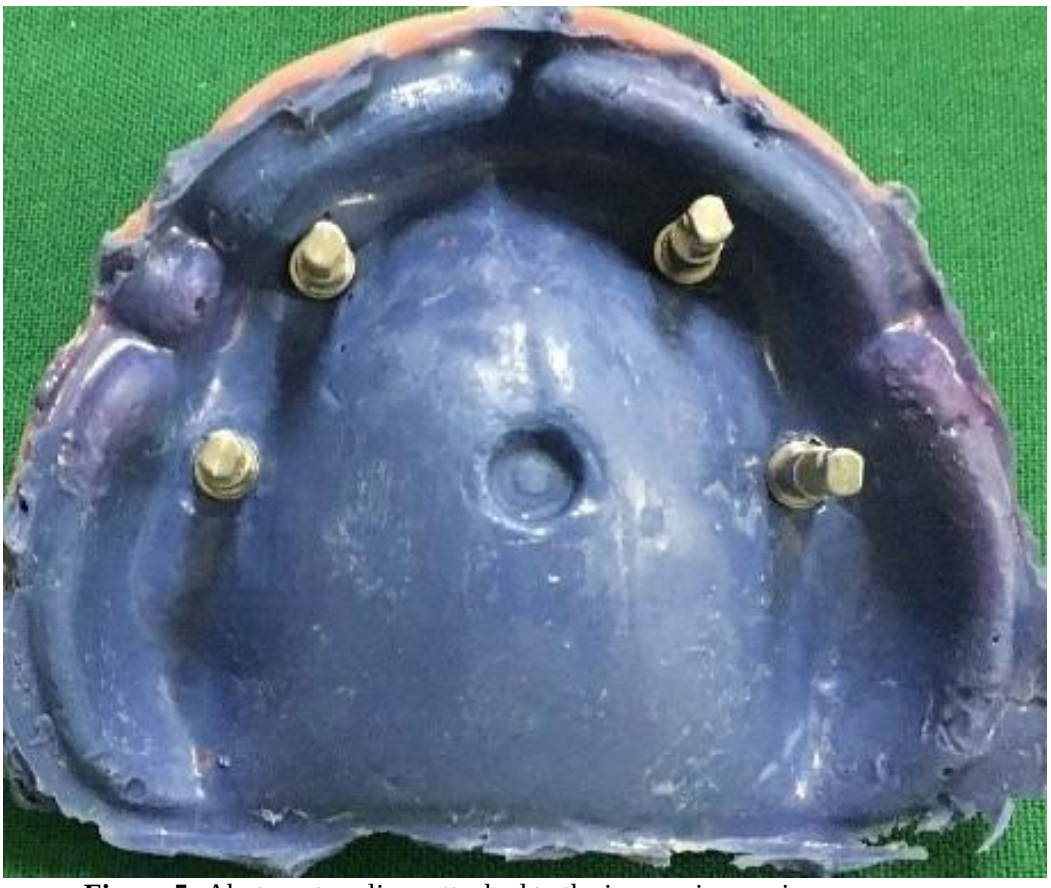

**Figure 5:** Abutment replicas attached to the impression copings

**Figure 6:** Open tray impression copings secured on the respective abutments

**Results:**

There were no statistically significant differences on comparison of the distance from the reference point to the abutments in x axis between the reference model, group A and group B (Table 1). On comparison of the distance from the reference point to the abutments in y axis between the reference model, group A and group B there was no statistical difference in D1Y, D2Y and D3Y. On comparison of the distance between the reference point and the abutment 4 (D4Y) in y axis, there was no statistically significant difference (p=0.874) between the reference model and group A. There was no statistically significant difference (p=0.114) between the reference model and group B. There was statistically significant difference (p=0.019) between the group A and group B (Table 2, 3). The values obtained from the closed tray and non-splinted open tray were 140 µm and 540 µm lesser than the values obtained from the reference acrylic model. There was no significant difference on comparison of abutment angulation to horizontal plane in z-axis between the reference model and closed tray technique (group A). Comparison of abutment angulation to horizontal plane in z-axis between the reference model and open tray technique (group B) there was no significant difference (Table 4,5).

**TABLE 1:** Comparison of the distance from the reference point to the abutments in x axis between the reference model, group A and group B

| | Reference | | | Group A (Closed tray technique) | | | Group B (Open tray technique) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Std. Deviation** | **Median** | **Mean** | **Std. Deviation** | **Median** | **Mean** | **Std. Deviation** | **Median** | **p value** |
| **D1X** | 20.04 | 0.00 | 20.04 | 19.98 | 0.26 | 19.94 | 19.94 | 0.18 | 19.94 | 0.857 |
| **D2X** | 13.60 | 0.00 | 13.60 | 12.63 | 0.90 | 12.96 | 13.26 | 0.32 | 13.31 | 0.06 |
| **D3X** | 15.56 | 0.00 | 15.56 | 15.16 | 0.65 | 15.16 | 15.51 | 0.19 | 15.55 | 0.123 |
| **D4X** | 22.34 | 0.00 | 22.34 | 22.37 | 0.49 | 22.33 | 22.31 | 0.36 | 22.18 | 0.976 |

*Kruskal-Wallis Test; shows * (p<0.05)*

**TABLE 2** Comparison of the distance from the reference point to the abutments in y axis between the reference model, group A and group B.

| | Reference | | | Group A (Closed tray technique) | | | Group B (Open tray technique) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Std. Deviation** | **Median** | **Mean** | **Std. Deviation** | **Median** | **Mean** | **Std. Deviation** | **Median** | **p value** |
| **D1Y** | 1.45 | 0.00 | 1.45 | 1.24 | 0.22 | 1.30 | 1.33 | 0.12 | 1.33 | 0.363 |
| **D2Y** | 17.73 | 0.00 | 17.73 | 17.04 | 0.43 | 17.03 | 17.35 | 0.33 | 17.31 | 0.094 |
| **D3Y** | 17.38 | 0.00 | 17.38 | 16.60 | 0.75 | 16.85 | 17.09 | 0.24 | 17.17 | 0.125 |
| **D4Y** | 2.71 | 0.00 | 2.71 | 2.57 | 0.42 | 2.74 | 2.17 | 0.21 | 2.16 | 0.039* |

*Kruskal-Wallis Test; shows * (p<0.05)*

**TABLE 3** Post hoc pairwise comparison of the distance from the reference point to the abutment 4 (D4Y) between the groups.

| Pair wise comparison | p value |
|---|---|
| *Reference* | |
| **Group A (Closed traytechnique)** | 0.874 |
| **Group B (Open tray technique)** | 0.114 |
| *Group A (Closed tray technique)* | |
| **Group B (Open tray technique)** | 0.019* |

*Mann-Whitney Test; shows *(p<0.05)*

**TABLE 4** Comparison of abutment angulation to horizontal plane in z-axis between the reference model and closed tray technique (group A)

| **Groups** | **Reference** | | | **Group A (Closed tray technique)** | | | |
|---|---|---|---|---|---|---|---|
| | **Mean** | **Std. Deviation** | **Median** | **Mean** | **Std. Deviation** | **Median** | **p value** |
| **Angle 1** | 2.61 | 0.00 | 2.61 | 2.60 | 0.08 | 2.61 | 1.00 |
| **Angle 2** | 1.19 | 0.00 | 1.19 | 1.17 | 0.05 | 1.17 | 0.526 |
| **Angle 3** | 1.03 | 0.00 | 1.03 | 0.99 | 0.14 | 1.06 | 0.751 |
| **Angle 4** | 2.49 | 0.00 | 2.49 | 2.38 | 0.13 | 2.39 | 0.428 |

*Mann-Whitney Test; Not significant*

**TABLE 5** Comparison of abutment angulation to horizontal plane in z-axis between the reference model and open tray technique (group B).

| Groups | Reference | | | Group B (Open tray technique) | | | |
|---|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Median | Mean | Std. Deviation | Median | p value |
| **Angle 1** | 2.65 | 0.00 | 2.65 | 2.64 | 0.11 | 2.65 | 1.00 |
| **Angle 2** | 1.16 | 0.00 | 1.16 | 1.18 | 0.06 | 1.20 | 0.75 |
| **Angle 3** | 1.04 | 0.00 | 1.04 | 1.01 | 0.12 | 1.04 | 1.00 |
| **Angle 4** | 2.46 | 0.00 | 2.46 | 2.45 | 0.10 | 2.43 | 0.75 |

*Mann-Whitney Test; Not significant ($p<0.05$)*

**Discussion:**

One of the most important requirements for the long-term success of any implant prosthesis is the passive fit of the implant repair. Making an implant prosthesis that passively fits requires a precise working cast. Accurate implant impressions play an important role and serves as a starting point for fabricating a precise working cast.[7] For an accurate implant impression there should be a precise transfer of the three dimensional position and intraoral relationship of the implant to a working cast.

The reference models used were block shaped with flat impression surface in many in vitro studies. These models did not simulate the deformation that occurred upon removal of the impression.[4,8] Hence, a model resembling edentulous maxilla was used in this study to simulate a curved arch .

Depending on the point of reference from which the distortion is measured, distortion can either be absolute or relative.[9] In an absolute distortion analysis, the reference point taken is an external point and not the impression coping or the implant replica. In relative distortion analysis, any one impression coping or abutment replica is used as reference point to which the distortion of the other impression copings or replicas are measured. The aim of the present study was to evaluate the resultant translational distortion of the abutment and not to evaluate the abutment to framework relationship, so an external reference point was used similar to the studies conducted by many investigators.[6,10,11] Measurements made from the indexed placed in the middle of the model and the casts were taken as the reference point.[11]

In the reference acrylic model, modelling wax of two layer thickness was adapted to provide uniform space for the impression material.[6,11,12] To provide uniform thickness of the impression material and to ensure proper orientation of the impression trays, three tissue stops were given one in the anterior region (incisive papilla) and two in the posterior region (second molar).[12] By providing uniform thickness of impression material, there is uniform polymerization shrinkage throughout the impression.

Sufficient adhesion between the impression material and the custom tray is crucial to withstand the forces generated during the removal of the set impression. This can be achieved by perforating or roughening the custom tray surface or the combination of these methods.[13] according to Patil et al, uniform thickness and an even bulk of the impression material in a custom tray leads to even contraction of the impression material away from the specimen and not to the specimen.[14] Hence, polyether tray adhesive was coated on the internal surface and 5mm beyond the borders of the custom impression trays.[8,11]

To manage angled multiple implants, multi-unit abutments and abutment level impressions can be used. These abutments eliminates the increased contact area between the internal connection of the implant and the impression coping which in turn reduces the deformation of the impression material and the movement of the impression coping during removal and transfer.[15] Recent studies that compared implant level impressions with abutment level impressions for internal and exterior connections were evaluated by Kim et al.[16] In the impression at abutment level, the displacement of the impression copings was less.[16] According to Sorrentino and Kim, the angulated implant's short connection length between the internal hex and the impression coping compensated for the increased stress during impression removal.[16,17] As a result, abutment level impressions were made in this study.

Numerous researchers have assessed the precision of various implant impression materials. There are reports that polyether, addition silicone, and polyvinyl siloxane are more accurate than condensation silicone, polysulfide, and irreversible hydrocolloid.[4,9,10] The accuracy of impression materials made of polyether and polyvinyl siloxane did not significantly differ, according to the researchers.[4,9] Due to its low strain in compression and advantageous hardness, polyether had been suggested as an impression material for edentulous

multiple implant restoration by numerous investigators.[4,8] Polyether's stiffness avoids unintentional displacement of the impression coping. Wee studied the torque resistance of impression materials and found that polyether provided the highest torque resistance value.[9] Therefore, medium body polyether was chosen as an impression material.

Spector et al examined the accuracy of the abutment level impressions and concluded that there was no statistically significant difference between the direct technique with or without splinting and the indirect technique,[15] which is consistent with the findings of our investigation. The findings from Lorenzoni and Akca were consistent with those of the current investigation, but they assessed the impression accuracy for implants with internal connections.[10,12]

The accuracy of multi-unit implant impression using open and closed impression trays were reviewed by Baig.[15] Out of the 25 studies, 12 found that the open tray impression technique were more accurate than the closed tray technique.[15] The closed tray impression may have been deformed and the cast accuracy may have been affected by the displacement of the transfer copings or counterparts during manual placement. Using parallel impression copings, 11 studies found no discernible difference between the two impression procedures.[15] Due to the shrinkage or fracture of the splinted material utilised, two investigations demonstrated that the closed tray technique was more accurate than the open tray technique.[15]

Any impression technique can be employed when the impression copings are parallel, according to Ozan et al.[19] In their study, Kempler and Akalin et al. measured the accuracy of implant impressions using open tray and closed tray techniques with internal and external connection implants and came to the conclusion that it is best to have the implants as parallel to one another as possible when dealing with full arch implant restorations.[20]

Studies concluded that in multiple angled implants, implant level splinted open tray impressions were more accurate than implant level closed tray or non-splinted open tray impression procedures.[15,19] However, in this study, multi-unit abutments were used to rectify the implant angulations, negating the need to splint the impression copings.

When employing multi-unit abutments, Rashidan and Herbst discovered no discernible difference between open and closed tray impression processes.[21,22] Because multi-unit abutments help to reduce the increased contact area between the internal connection of the implant and the impression coping, which in turn lessens the deformation of the impression material and the movement of the impression coping during removal and transfer, using them is thought to be advantageous.[15] In the implant impression at the abutment level, the displacement of the impression copings was less.[16]

Assuncao stated that, there is a possibility of finding a discrepancy of 50µm in any axis in a good impression.[4] No implant impression procedure, according to Vigolo et al. and Spector et al., generated an accurate cast.[8, 23] The casts made using the open tray and closed tray impression processes did not precisely duplicate the location of the abutments as in the reference acrylic model, according to the findings of our study. Both impression methods showed slight angular and linear deformations. This study showed significant difference in the y axis (D4Y) between open and closed tray impression techniques, but the overall results showed no statistical significant difference in both impression groups.

Due to a few deciding factors, there were no statistically significant differences between the two groups in our study. The use of multi-unit abutments for correcting implant angulations, fabrication of all custom trays using single spaced cast, which provided uniform thickness of the impression material and reduced polymerization shrinkage and the use of polyether that as stiff enough to keep the impression copings inside the imprints of the impression were important factors that helped these results.

The minimal deviation of the cast from the reference model in our study might be due to slight rotation of the impression copings within the impression, or due to the stresses caused during removal of the impression, machining tolerance of the implant components, shrinkage of the impression material, manipulation errors during impression making, angulation of distal abutments, operator's error, the material property of gypsum product and the errors made by the measuring instrument.[6,11]

In our study, there was no discernible difference between the accuracy of the casts made using the closed tray impression technique and the non-splinted open tray impression approach. Therefore, it is possible to correctly transfer the implant

abutment position from the patient's mouth to the cast using either open tray or non-splinted closed tray impression procedures. The prosthesis can eventually be passively fitted.

Limitation of this study:

This study was limited to the measurements of linear (x and y axis) and rotational discrepancy (z axis) of the abutment level impression. This in vitro study did not exactly simulate the oral condition like presence of saliva, bony and soft tissue undercut and non-uniform ridge crest. In this study the accuracy of open non splint and closed tray impression techniques was evaluated. Various factors affecting the impression accuracies like splinting the impression coping, rotational resistance of the impression material, amount of shrinkage of the impression material, number of implants, angulation of implants and digital impression technique can be taken into consideration and can be evaluated in the future. More in vivo studies are to be evaluated considering the intra oral factors. Patient's systemic conditions, angulation of the available bone, standardization in implant angulation, multi-unit abutment selection, presences of the soft tissue and bony undercuts are the factors to be considered if in vivo studies are to be carried out.

**Clinical implication:**

In this present study no significant difference was found between closed and non-splinted open tray groups because the angulation of the implants were corrected using multi-unit abutments and thus the impression copings were made almost parallel. When All-On-Four implant protocol is used as a treatment, if all the four abutment level impression copings are made parallel, errors in transferring the implant positions to the cast can be reduced. Therefore, either non splint open or closed tray impressions can be made when a suitable multi-unit abutment is used to correct the implant angulation.

**Conclusion:**

Within the limitations of this study, there was no significant difference in the accuracy of the casts obtained from the closed tray and non-splinted open tray impression techniques with that of the reference acrylic model using All-On-Four protocol.

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24. This manuscript is part of the MDS thesis available at the repository-tnmgrmu.ac.in repository.