EVALUATION OF ACCURACY OF CASTS OBTAINED FROM VARIOUS IMPLANT IMPRESSION TECHNIQUES: AN INVITRO STUDY

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ABSTRACT

This study aimed to evaluate the accuracy of casts obtained from open tray and closed tray impression techniques using two different evaluation methods. A master model with two endosseous root form implants was constructed, serving as the control. Test samples were divided into closed tray and open tray groups, each containing 10 samples. Impressions were made using addition polymerizing silicone, and casts were poured with dental stone. The accuracy of the casts was assessed using electrical resistance strain gauge and coordinate measuring machine. Results indicated that the open tray technique produced casts closer to the master model values in terms of x-axis distance, y-axis values at 35 and 45 positions, and angularity. Significant differences were observed between the two impression techniques, with the direct transfer open tray technique demonstrating higher accuracy in transferring implant positions from the master model to the sample casts.

Keywords: Prosthodontics, Implant, Impression, Edentulous**,** Coordinate measuring machine (C.M.M)

INTRODUCTION:

Modern dentistry aims to restore normal contour, function, comfort, esthetics, speech, and health of the stomatognathic system, irrespective of atrophy, disease, or injury. However, traditional prosthodontics faces challenges in achieving these goals, particularly with increased tooth loss in patients. The evolving demands of patients necessitate innovative treatment techniques. One such successful advancement is dental implants, introduced by Per-Ingvar Branemark, which have revolutionized dental practice by overcoming limitations of conventional prosthetic treatments and addressing both functional and psychological needs [1, 2].

Replacing missing teeth with artificial substitutes has long been a goal in prosthodontics, and dental implants represent an exciting breakthrough in this field. They enable prosthodontists to rehabilitate patients to levels of form and function previously unimaginable. Dental implants serve various purposes, including tooth replacement, craniofacial skeleton rebuilding, orthodontic anchorage, and

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bone formation through distraction osteogenesis [3, 4].

The availability of diverse implant types for various clinical scenarios has garnered interest from all dental professions, especially prosthodontics. Advances in implant designs, materials, and techniques have enhanced their success rates, making implant prosthodontics a predictable treatment modality [5, 6]. The term "dental implant" refers to a prosthetic device implanted into oral tissues or bone to provide support for fixed or removable prostheses [7].

While early attempts at using dental implants for edentulism and partial edentulism faced challenges, the ability to place titanium implants directly into the jawbone has been a significant development in modern prosthodontics [8]. Implant dentistry offers successful alternatives for restoring one tooth to entire dental arches or stabilizing dentures. The fixed restorations provided by implants offer security, comfort, and natural functionality, enhancing patient satisfaction [9].

The success of dental implants hinges on various factors, with the impression procedure playing a crucial role in prosthesis fabrication. Impressions must provide support, retention, and stability while accurately recording all potential prosthesis-bearing surfaces. Impression techniques have evolved over time, with the closed tray and open tray techniques being commonly employed. This study aims to compare the accuracy of these two techniques in implant-supported prosthesis fabrication [10, 11].

Understanding the evolution of oral implantology is essential for appreciating current successes and future directions in dental implant treatments. By investigating the accuracy of impression techniques, this study contributes to advancing implant prosthodontics and improving patient outcomes [12].

So, our study aims to evaluate the accuracy of casts obtained from closed tray and open tray impression techniques using two methods: electrical resistance strain gage and coordinate measuring machine. This investigation is crucial as it directly addresses the aforementioned challenges and seeks to contribute valuable insights into the field of implant-supported prosthesis fabrication.

MATERIALS AND METHODS:

Study Design and Sample Selection: This comparative study enrolled 50 participants requiring implant-supported prostheses, meeting inclusion criteria of adults aged 18-65 years with good general health, and needing a single implant-supported prosthesis in the posterior region of the maxilla or mandible.

Impression Techniques: Participants were randomly assigned to closed tray or open tray impression groups. Impressions were made with polyvinyl siloxane material following manufacturer guidelines.

Measurement Methods: Casts were poured using Type IV dental stone. Accuracy assessment was conducted using electrical resistance strain gage and coordinate measuring machine methods.

Electrical Resistance Strain Gage Method: Strain gages were affixed to implant analog reference points. Casts were scanned with a laser scanner, measuring discrepancies between reference points on casts and implant analogs.

Coordinate Measuring Machine Method: Casts were scanned using a coordinate measuring machine, comparing three-dimensional coordinates of reference points on casts with those on implant analogs.

Data Analysis: Statistical analysis was performed on data collected from both methods to determine the accuracy of casts obtained from each impression technique. Results will provide valuable insights into the accuracy of casts from closed tray and open tray impression techniques, aiding in the advancement of implant-supported prosthesis fabrication.

Ethical Considerations: This study adhered to the principles of the Declaration of Helsinki and obtained ethical approval from the Institutional Review Board. Informed consent was obtained from all participants.

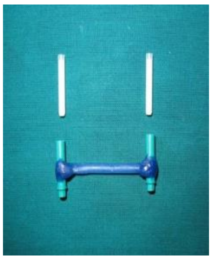
Limitations: Limitations included a small sample size and the use of only one type of impression material. Operator technique variations may have influenced impression accuracy.

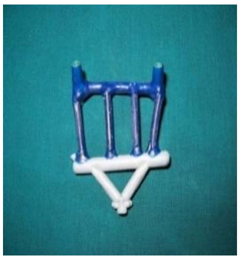
Fabrication of Master Model: Master model was prepared by making 2 parallel vents of 3.75mm size on either premolar region of Columbia dentoform V50 L brass model (Columbia dentoform Corp, New York - Fig 1,2) so that the vent can accommodate an endosseous root form implant of 3.75mm size – MIS, Israel, (Fig 3) . Implants were positioned in the holes and fixed in position with molten lead poured from the base side of the model. Implant platforms were placed such that they were at the crestal level of the ridge of the model imitating two implants placed intraorally (Fig. 4).

1 **2** **3** **4**

Fig. 1: Edentulous Mandibular brass mode (Columbia Dentoform V50L), **2**:Edentulous Mandibular brass Model (Columbia Dentoform V50L), **3**:Dental Implant (MIS), **4**:Implants placed at the crest of the ridge.

Bar Fabrication: A cobalt chromium bar was constructed with two castable UCLA abutments for 3.5mm diameter internal hex implants (Fig. 5). The UCLA castable attachments were placed inside the implants and secured with fixation screws. Waxing the bar joined the abutments, and the complex was sprued at four points (Fig. 6, 7). After unscrewing the complex, it was sprayed with surfactant spray (Debubbliser) and invested with phosphate bonded investment (Kavovest). The wax pattern was positioned in a crucible former with a silicone casting ring (Fig. 8). The investment was mixed under vacuum (Vacuumyx) and poured over the pattern (Fig. 9). After setting, the investment was removed, and wax elimination was performed (Fig. 10). Casting with molten cobalt chromium alloy followed (Fig. 11). The bar was cleaned, trimmed, and fixed onto the implants, ensuring a strain-free fit (Fig. 12, 13, 14). Passivity was confirmed with a strain gauge attached at the bar's middle.





(5) **(6)** **(7)** **(8)** **(9)**





(10) **(11)** **(12)** **(15)** **(14)**

Fig.: (5) Hex UCLA castable abutment for Internal hex Implant, **(6)** Wax pattern of bar assembly, **(7)** Sprued wax pattern for casting, **(8)** Sprue former attached to pattern, **(9)** Phosphate bonded investment with solvent, **(10)** Invested pattern, **(11)** Cast bar retrieved from investment, **(12)** Finished Bar, **(13)** BEGO Laser welding Machine.

Preparation of Sample casts: The sample size for the study was 20 casts i.e., with closed tray impression technique (with pickup posts) 10 casts and open tray impression technique 10 casts.

Closed tray impression technique: Closed tray impressions were made using dentulous perforated stainless steel stock trays - Size L 3 (GDC) (Fig. 15, 16) and Vinyl polysiloxane impression material (Express STD, Putty and Light body, regular set, hydrophilic impression material, 3M ESPE, U.S.A – Fig. 19, 20). Manufacturer's recommendations were followed for material manipulation. Closed tray direct impression transfers (MIS – for internal hex implants) were screwed into position over the implant fixtures on the master model using a hex driver with finger pressure (Fig. 17). Care was taken to ensure the flat surface of the closed tray impression transfers faced the buccal side (Fig. 18). Pickup transfer copings were then inserted with firm finger pressure over the closed tray transfers, aligning their flat internal facet with the flat buccal surface of the closed tray transfers (Fig. 22). Tray adhesive (3M ESPE) was applied to the inside surface and borders of the selected tray and allowed to dry for 5 minutes. The double mix double take technique was followed for making the impression. The base and catalyst of putty consistency material (ISO 4823 – Elastomeric impression material, Type 0 consistency) were hand mixed, loaded onto the stock tray, and pressed over the model (Fig. 21, 23). After setting, the impression was removed along with the pickup transfer. The pickup transfer coping was then removed from the impression, and light body material (ISO 4823 – Elastomeric impression material, Type 3 consistency) was injected around the closed tray impression transfers and the space previously occupied by the transfer coping in the impression tray (Fig. 24, 25). The tray was inverted over the master model, pressed into position, and allowed to set before removal (Fig. 26). The closed tray transfers were unscrewed from the fixtures using a hex driver and joined with implant analogues (MIS – 3.5mm analogues for internal hex) by screwing them with finger pressure and hex driver. The closed tray transfer analogue assembly was placed inside the pickup transfer coping in the impression and visually checked for complete seating (Fig. 27, 28, 29). The impression surface was sprayed with surfactant spray (Debubbliser, Prime Dental Products – Fig 30, 31), and poured with Type IV (Kalrock, Pink, Kalabhai Karson Pvt. Ltd, Mumbai, India. high strength, low expansion) die stone. The die stone was allowed to set for 40 minutes before retrieving the cast with the closed tray transfer. Then, the closed tray transfer was unscrewed from the analogue with a hex screw, and the base was poured and finished. Each sample was numbered as CT (closed tray) followed by the impression number (i.e., CT - 1, CT - 2, CT - 3, CT - 4, CT - 5, CT - 6, CT - 7, CT - 8, CT - 9, CT - 10) (Fig. 32).





15 16 17 18 19





20 21 22 23 24





25 26 27 28 29


30 31 32

Open tray impression technique: For open tray impressions, custom trays were fabricated with light polymerizing resin trays (Delta, India) and a spacer made of uniform thickness heat cure acrylic resin (Trevalon denture base material- Clear) template (Fig. 33). The spacer with three tissue stops was constructed by adapting wax sheets (Hindustan Modelling Wax Medium) over the cast obtained from the master model impression and heat processed. The light cure resin tray was adapted over this spacer and polymerized in the light cure chamber (Blu Lux, Delta, India) (Fig. 35). Trays were equipped with handles in the anterior and posterior regions (8× 8 × 3 mm dimensions) and vents were cut over each implant for open tray impression posts exposure before light polymerization (Fig. 36). Tray adhesive for Vinyl polysiloxane impression material was applied and allowed to dry for 5 mins (Fig. 39). Open tray impression transfers were screwed into the implant fixtures in the master model using a hex driver. Impressions were made with a double mix double take technique using a modified needle cap spacer to prevent adherence or locking of putty material to the transfer coping (Fig. 37). Putty material was loaded in the impression tray, pressed into position over the model, and excess material around the spacer was removed before setting (Fig. 40, 41). Adequate pressure was applied to expose all three tissue stops in the impression. Once set, the impression was removed. Relief was given using a putty knife to create space for light body material (Fig. 42), which was then loaded into the tray and around the open tray impression transfers. The impression tray was pressed into position over the master model (Fig. 43), and excess material was removed from the vent to expose the open tray transfer fixation screws (Fig. 44). After setting, the open tray impression transfer was unscrewed from the implant fixture, and the impression was removed with the transfers intact. Implant analogues were connected to the transfers by screwing them in position with a hex driver (Fig. 45). The impression surface was sprayed with surfactant spray (Debubbliser) (Fig. 46, 47), and poured with Type IV die stone (Fig. 48). After unscrewing the fixation screws of the open tray transfers, casts were retrieved, finished, and polished. Casts were coded for the technique and impression number (OT - 1 to OT - 10) (Fig. 49).






33 34 35 36 37 38





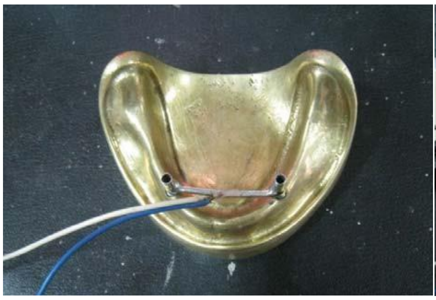

39 40 41 42 43 44





45 46 47 48 49

Procedure for analysis of accuracy using Strain gage: The casts were analyzed for accuracy by comparing them with the master model. This was done by screwing the bar constructed in the master cast, with a hand wrench at 10 Ncm, onto each cast. An electrical resistance strain gauge (Digital strain indicator SI 30, SYSCON company – Fig. 51) was attached to the horizontal portion of the bar at the middle (Fig. 50). The readings obtained were tabulated for each cast and subjected to statistical analysis.

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Procedure for analysis of accuracy using Coordinate Measuring machine: Accuracy was also assessed by measuring the change in the coordinates of the abutments using a coordinate measuring machine (C.M.M – TESA Microhite 3D, TESA Technologies - Fig. 54). Standard abutments (MIS Dental Implant systems, Israel – for 3.75mm diameter internal hex implants were screwed into the master model implants with a hex driver under finger pressure. The model was then placed in the coordinate measuring machine, and the coordinates of the abutments (screwed with a torque of 10 Ncm – Fig. 52) were recorded from their central axis (Fig. 56). Subsequently, the abutments were unscrewed and fixed onto the sample casts obtained from closed tray and open tray impression techniques (Fig. 58, 59) with fixation screws (torque of 10 Ncm). These casts were then placed in the coordinate measuring machine, and the x, y coordinates, and angularity of the abutments were measured and recorded. The difference in the coordinates of the abutments between the master model and the cast was calculated and tabulated for individual casts from CT – 1 to CT – 10 and OT – 1 to OT - 10. Statistical analysis was performed on the measurements to determine the accuracy of the casts and the impression techniques employed. The lower the amount of strain produced in the bar and the lesser the difference in the x, y axis, and angularity from the master model after statistical analysis, the more accurate the cast and the employed technique for making the implant impressions.


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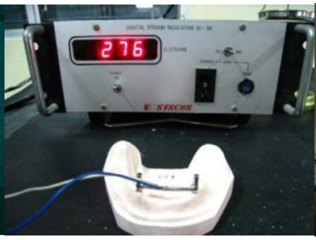

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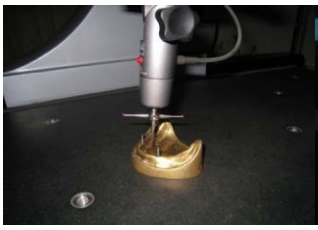
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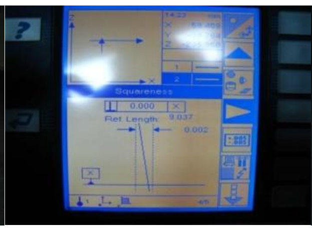

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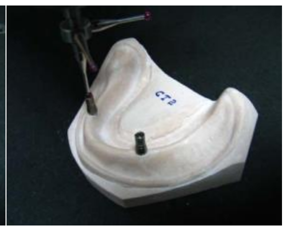
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RESULTS:

An in vitro study was conducted to assess the accuracy of casts obtained using closed tray and open tray techniques. The evaluation involved measuring strain values with a strain gauge and comparing the coordinates of abutments fitted over casts obtained with both techniques using a coordinate measuring machine. Ten samples from each group were analyzed, and the strain values and coordinates were tabulated. Statistical comparisons were made using One-way ANOVA and Mann-Whitney tests. The results are summarized in Tables I, II, and III.

Table I presents the strain gauge values for the samples. Closed tray samples are labeled as CT 1 to CT 10, and open tray samples as OT 1 to OT 10. Strain values are measured in microstrain units. Among the closed tray samples, CT 1 exhibited the highest strain value of 518 µstrains, while CT 2 had the lowest at 275 µstrains. For open tray samples, OT 5 had the highest strain value of 280 µstrains, and OT 4 had the lowest at 85 µstrains. The mean strain value for closed tray samples was 358.8 µstrains, whereas for open tray samples it was 151.5 µstrains, indicating that open tray samples had lower strain values.

Table II and Table III display the coordinate measuring machine values for closed tray and open tray samples, respectively. The x-axis and y-axis distances between the center points of abutments at 35 and 45 positions, as well as the angularity of the abutments, are tabulated. Among the specimen casts, OT – 4 and CT – 7 showed the nearest values to the master model for the x-axis distance, while OT – 1 and CT – 7 showed the nearest values for the y-axis dimension at 35 positions. OT – 5 and CT – 1, CT -5 showed the nearest values for the y-axis dimension at 45 positions. OT – 7 and CT – 5 showed the nearest values for abutment angularity at 35 positions, and OT – 8 and CT – 4 for abutment angularity at 45 positions.

The mean value of the open tray technique for the x-axis dimension is closer to the master model value of 27.21mm, indicating that the open tray technique exhibits less distortion in the x-axis direction compared to the closed tray technique.

For the y-axis values at the 35 position, the mean value for closed tray impression casts is 8.654 mm, while for open tray impression casts it is 9.100 mm. The mean value of the open tray technique is close to the master model value of 9.115 mm.

Similarly, for the y-axis values at the 45 position, the mean value for closed tray impression casts is 8.592 mm, and for open tray impression casts it is 8.79 mm. The mean value of the open tray technique is close to the master model value of 8.965 mm.

Hence, the open tray technique demonstrates the least amount of variation from the master model value in the y-axis direction compared to the closed tray technique.

Regarding angularity, the mean value of the closed tray technique for abutments at the 35 position is 0.09172 radians, while for the open tray technique it is 0.08298 radians, both of which are close to the master model value of 0.08472 radians. Similarly, for abutments at the 45 position, the mean value of the closed tray technique is 0.07925 radians, and for the open tray technique it is 0.07452 radians, both close to the master model value.

Table I. Strain Gage Values for sample casts

Model Codes Closed tray technique CT	**Strain Values (Microstrain)**	**Model Codes Open Tray technique OT**	**Strain Values (Microstrain)**
CT 1	518	OT 1	182
CT 2	275	OT 2	98
CT 3	308	OT 3	210
CT 4	276	OT 4	85
CT 5	285	OT 5	280
CT 6	386	OT 6	126
CT 7	439	OT 7	148
CT 8	379	OT 8	133
CT 9	282	OT 9	120
CT 10	440	OT 10	133

*Master model strain value – 0

Table II. X, Y Coordinates and angularity of abutments at 35 & 45 positions of closed tray specimens.

Closed Tray Technique									
		Y- axis (mm)				Angle (Degrees)			
X-axis	Diff	35	Diff	45	Diff	35	Radians	45	Radians
26.791	0.422	8.657	0.458	8.875	0.09	4°33'27"	0.073798	4°13'42"	0.073798
26.782	0.431	8.601	0.514	8.77	0.195	5°51'12"	0.10216	5°15'48"	0.091862
26.696	0.517	8.624	0.491	8.74	0.225	4°49'01"	0.084072	4°13'42"	0.073798
26.688	0.525	8.683	0.432	7.79	1.175	4°36'31"	0.080435	4°13'39"	0.073784
26.634	0.579	8.579	0.536	8.874	0.091	4°10'47"	0.07295	4°14'11"	0.073939
26.756	0.457	8.695	0.42	8.76	0.205	4°45'41"	0.083102	4°13'40"	0.073789
26.799	0.414	8.759	0.356	8.81	0.155	6°22'45"	0.111337	5°16'54"	0.092182
26.769	0.444	8.698	0.417	8.77	0.195	6°29'18"	0.113243	4°13'41"	0.073793
26.673	0.54	8.524	0.591	8.74	0.225	6°47'40"	0.118585	5°15'28"	0.091766
26.714	0.499	8.723	0.392	7.8	1.165	4°26'41"	0.077575	4°13'42"	0.073798
27.213		9.115		8.965		4°51'16"		4°30'86"	

Values in red colour at base of table – Master model values

Table III. X, Y Coordinates and angularity of abutments at 35 & 45 positions of open tray specimens.

Open Tray Technique									
		Y- axis (mm)				Angle (Degrees)			
X- axis (mm)	Diff	35	Diff	45	Diff	35	Radians	45	Radians
27.112	0.101	9.112	0.003	8.91	0.055	4°45'12"	0.082961	4° 11' 58"	0.073296
27.088	0.125	9.01	0.105	8.544	0.421	4°38'40"	0.081061	4° 10' 53"	0.072981
26.983	0.23	9.028	0.087	8.6105	0.3545	4°55'30"	0.085957	4° 21' 9"	0.075967

27.201	0.012	9.218	-0.103	8.677	0.288	4°40'32"	0.081604	4° 13' 2"	0.073602
27.003	0.21	9.303	-0.188	8.943	0.022	4°56'37"	0.084537	5.52'23"	0.074357
26.901	0.312	9.031	0.084	8.8765	0.0885	5°28'46"	0.095634	5° 8' 10"	0.089641
26.944	0.269	9.055	0.06	9.037	-0.072	4°17'55"	0.075025	5.30"50"	0.069505
27.189	0.024	9.052	0.063	8.7435	0.2215	4°20'48"	0.075864	3° 55' 42"	0.068564
27.182	0.031	9.098	0.017	8.677	0.288	4°50'28"	0.084493	4° 17' 38"	0.074943
26.991	0.222	9.101	0.014	8.928	0.037	4°44'26"	0.082738	4° 8' 49"	0.072378
27.213		9.115		8.965		4°51'16"		4°30'86"	

Values in red colour at base of table – Master model values

One way ANOVA analysis for X axis values of sample casts

Null Hypothesis: There is no significant difference between the x axis values of close tray technique and open tray technique when comparing with the master model.

Table IV. One way ANOVA analysis for X axis values of sample casts.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.542	1	0.542	71.407	.000
Within Groups **Total**	0.137 **.678**	18 **19**	0.008		

Since the computed value of F (71.407) is greater than the critical value, the null hypothesis is rejected, indicating a significant difference between the closed tray technique and the open tray technique.

Table V. Ranks for the sample groups.

	Tray type	N	Mean Rank	Sum of Ranks
Yaxis-35	1.00	10	15.50	155.00
	2.00	10	5.50	55.00
	Total	**20**		

Table VI. Mann – Whitney analysis for Y – axis values at 35 positions.

	Yaxis-35
Mann-Whitney U	0.000
Wilcoxon W	55.000
Z	-3.780
Asymp. Sig. (2-tailed)	0.000
Exact Sig. 2*(1-tailed Sig.)	0.000(a)

a. Not corrected for ties.
b. Grouping Variable: Tray type

Since Wilcoxon W value(55.00) lies between the median 1 and median 2, the null hypothesis is rejected and it is concluded that there is a significant difference between the close tray technique and open tray technique.

Table VII. Ranks for the sample groups

	Tray type	**N**	**Mean Rank**	**Sum of Ranks**
Yaxis-45	1.00	10	11.70	117.00
	2.00	10	9.30	93.00
	Total	**20**		

Table VII. Mann – Whitney analysis for Y – axis values at 45 positions

	Yaxis-45
Mann-Whitney U	38.000
Wilcoxon W	93.000
Z	-.908
Asymp. Sig. (2-tailed)	.364
Exact Sig. 2*(1-tailed Sig.)	.393(a)

a. Not corrected for ties.
b. Grouping Variable: Tray type

Since the Wilcoxon W value (93.00) lies between the median 1 and median 2, the null hypothesis is rejected, indicating a significant difference between the closed tray technique and open tray technique.

Table IX. Ranks for the sample groups.

	Tray type	N	Mean Rank	Sum of Ranks
Radians-35	Closed	10	11.10	111.00
	Open	10	9.90	99.00
	Total	**20**		

Test Statistics (b)

Table X. Mann – Whitney analysis for angularity values at 35 position

	Radians-35
Mann-Whitney U	44.000
Wilcoxon W	99.000
Z	-.454
Asymp. Sig. (2-tailed)	.650
Exact Sig. 2*(1-tailed Sig.)	.684(a)

a Not corrected for ties.

b Grouping Variable: Tray type

Since Wilcoxon W value (99.00) lies between the median 1 and median 2, the null hypothesis is rejected and it is concluded that there is a significant difference between the close tray technique and open tray technique.

Mann – Whitney analysis for angularity values at 45 position

Ranks

Table XI. Ranks for the sample groups

	Tray type	N	Mean Rank	Sum of Ranks
Radians-45	Closed	10	12.70	127.00
	Open	10	8.30	83.00
	Total	**20**		

Test Statistics (b)

Table XII. Mann – Whitney analysis for angularity values at 45 position

	Radians-45
Mann-Whitney U	28.000
Wilcoxon W	83.000
Z	-1.666
Asymp. Sig. (2-tailed)	0.096
Exact Sig. 2*(1-tailed Sig.)	0.105(a)

a Not corrected for ties
b Grouping Variable: Tray type

Since Wilcoxon W value (83.00) lies between the median 1 and median 2, the null hypothesis is rejected and it is concluded that there is a significant difference between the close tray technique and open tray technique.

Mann-Whitney Test – for strain gage values

Ranks

Table XIII. Ranks for the sample groups

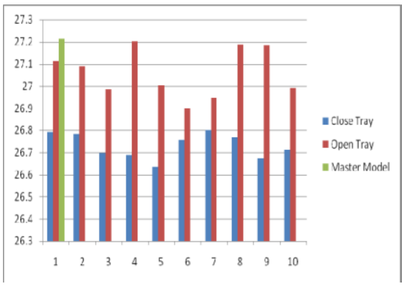
	Strain tray	N	Mean Rank	Sum of Ranks
Strain values	Closed	10	15.30	153.00
	Open	10	5.70	57.00
	Total	**20**		

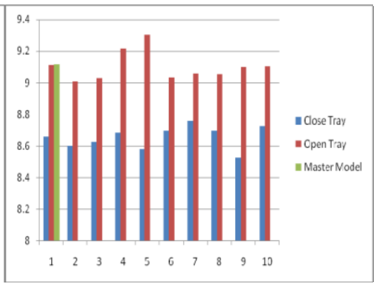
Table XIV. Mann – Whitney analysis for strain gage values

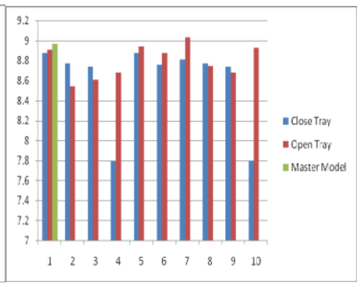
	Strain values
Mann-Whitney U	2.000
Wilcoxon W	57.000
Z	-3.630
Asymp. Sig. (2-tailed)	0.000
Exact Sig. 2*(1-tailed Sig.)	0.000(a)

a Not corrected for ties.
b Grouping Variable: Strain tray

Since Wilcoxon W value (57.00) lies between the median 1 and median 2, the null hypothesis is rejected and it is concluded that there is a significant difference between the close tray technique and open tray technique**.**

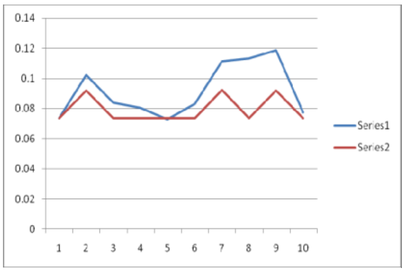


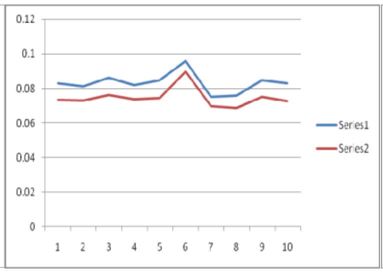


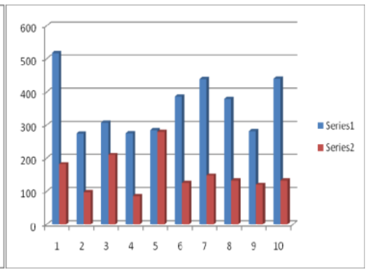


I **II** **III**

Graphs: I. Graph showing X axis values (Close Tray, Open Tray and Master Model Values)**, II.** Y axis values at 35 (Close Tray, Open Tray and Master Model Values)**, III.** Y axis values at 45 (Close Tray, Open Tray and Master Model Values).







IV **V** **VI**

Graph IV & V: Series 1 – 35 position; Series 2 – 45 position, Graph VI: Series 1 (Closed) Series 2 (Open) tray values

Graphs: IV. Closed Tray Angular Difference **V.** Open Tray Angular Difference **VI.** Strain Gage values (in μ-strains) for closed tray & Open tray techniques.

DISCUSSION:

The process of osseointegration is a time dependent procedure [14]. The end result of this procedure is a very strong interface between the bone and implant. It is due to the unique property of the bone to remodel in accordance with the imposed functional load. If the implant is overloaded this process is compromised and a poorly differentiated interface will result which will ultimately lead to the failure of the implant [14]. Thus, a proper osseointegrated prosthesis will have a good retention and stability, aesthetics, improved function, better patient comfort [14]. Osseointegration is defined as a process whereby clinically asymptomatic rigid fixation of alloplastic materials is achieved and maintained during functional loading [14]. Such stable bone implants have an interface that mainly consists of bony tissue. It differs from the natural dentition, where the teeth are anchored to the surrounding bone by means of a highly differentiated connective tissue, the periodontal ligament [14]. The bond acting over an osseointegrated implant is a biomechanical one. This means that bone will grow in to surface irregularities of the implants with a resultant three dimensional stabilization. Many studies were done to determine the effects of misfit of the prosthesis on the osseointegration [17, 18, 20, 23].

Many clinicians and authors [17, 18, 20, 23] have addressed the idea that passive fit of implant prostheses is essential for the long-term treatment success. The statistical correlation between prosthesis misfit and marginal bone level changes in maxillary implants with in vivo measurements has been examined [21]. This human retrospective study by David assif et al [13] found that although none of the prostheses were passively fitting, no evidence of bone loss was present even after 5 years. One of the conclusions from this study was that there must be a range of prosthesis misfit tolerated by osseointegrated implants that allows for long-term stability. Work supporting this theory has found that clinically well-fitting prostheses produced a considerable amount of misfit load but no loss of osseointegration. Though the prosthesis misfit may not affect osseointegration, there is evidence that prosthesis misfit is likely to increase the incidence of mechanical component loosening or fracture [9]. The causes of component failure and loosening are multifactorial, but it must be assumed that prosthesis misfit plays an important role in complications such as occlusal and abutment screw loosening and fracture in linked implant restorations. Because of these concerns, prosthesis misfit should be minimized. This signifies the importance of the accuracy of the impression techniques & materials employed in implant supported restorations.

In the past though many studies were done comparing the closed tray indirect transfer /open tray direct transfer impression techniques [3, 4, 21], stock closed tray vs custom open trays [24], Impression materials (Vinyl polysiloxane vs Polyether) [7] and splinted vs non splinted transfer techniques [15, 16, 19, 22, 23, 26, 28] but not much literature is available comparing the direct transfer snapon impression coping closed tray impression technique and direct transfer open tray impression technique. The present study compares the direct transfer snap on impression coping closed tray impression technique and direct transfer open tray impression technique made with a single impression material (Vinyl Polysiloxane). A single impression material was chosen for the study as the main attention was on the accuracy of transfer technique rather than the material accuracy. Vinyl polysiloxane was chosen as the material exhibit good resistance to permanent deformation [11], good flexibility and is most commonly used in day to day clinical practice.

This study aims at comparing the accuracy of the casts obtained with closed tray (Indirect transfer) impression technique and the open tray (Direct transfer) impression technique. A model was created with provisions to fix implant fixtures. The implant fixtures with the model, forms the base for the study. Impressions of the model were made with various implant impression techniques. Casts obtained from the impressions were assessed for accuracy using strain gauges and coordinate measuring machine (C.M.M) and statistically analyzed.

Strain Gage: In the study the strain gauge is attached to the cast bar in the middle of it and the output is connected to the strain gage which interprets the strain value in micro strain. The bar was cut and laser welded after fabrication for strain free fit in the master model as per the studies done by Stephen J. Riedy et al [29]. The bar is fitted on the master model and tightened with fixation screws and hand wrench (Torque at 10 Ncm). The strain value is noted down (0 microstrain). Then the bar is fitted on the samples. The resultant strain on seating the constructed bar on the sample casts of two different techniques are tabulated (Table. I). Strain gage was selected for this study instead of other methods like travelling microscope [3,24] or reflex microscope [22] because there is a component of operator error in the measurement with these instruments which is ruled out in the case of strain gage.

Coordinate Measuring Machine (C.M.M.): Measurement accuracy and precision improved dramatically with the invention of the electronic touch trigger probe incorporated C.M.M. The pioneer of this new probe device was David McMurtry. It is a contact device; the probe has a spring-loaded ruby ball stylus. As the probe touched the surface of the component the stylus deflects and simultaneously sends the X.Y, Z coordinate information to the computer. The C.M.M used in this study is of the above said type. The X, Y coordinates and angularity of the standard abutments fitted to implants in the master model (with torque of 10 Ncm) and to the implant analogues in the specimen casts are recorded and tabulated (Table II, III). Coordinate measuring machine to measure three dimensional coordinates is superior to the reflex microscopes used in the previous study [22] in that the C.M.M automatically calculates the centroid point of the abutment and calculates the distance from that point unlike the reflex microscope which has to be done manually or from a point other than centroid.

The result of this study provide an indepth analysis of the advantages/ disadvantages of the open and closed tray techniques, inherent inaccuracies of them and a guidance for the implant prosthodontist for the appropriate selection of the impression technique for better success. This will eliminate the shortcomings of the impression step in the treatment thereby reduce the factors contributing to the mechanical failure of implants thus improvising the predictability of the implant prosthodontics.

The results show a wide statistically significant diversion of values of casts obtained with closed tray impression technique with snapon transfer copings from the master model values.

The values obtained from strain gage for master model and the specimen casts of the two groups were analysed with Mann Whitney test. The Wilcoxon W value (57.00) lies between the median 1 and median 2, hence it is concluded that there is a significant difference between the close tray technique and open tray technique (Table XIII, XIV). The mean of strain values for closed tray samples is 358.8 µstrains and for open tray samples is 151.5 µstrains. Hence the open tray samples show the minimum strain value of the two groups compared.

The values obtained with direct transfer open tray impression technique is close to the master model There is less strain on the bar on open tray impression casts compared with the bar on closed tray impression casts.

The values of x axis, y axis variation and angularity variation obtained with Coordinate measuring machine was analyzed with One way ANOVA test (for x axis) and Mann Whitney test (for y axis variation & angularity variation).

Value of F (71.407) is greater than the critical value for ANOVA analysis of X axis variation (Table IV). The mean value for x – axis distance (in mm) in closed tray technique obtained casts is 26.73mm and means value for open tray casts is 27.05 mm. The mean value of open tray technique is closer to master model value of 27.21mm. Hence the open tray technique has the least amount of distortion in x axis direction among the two techniques. According to Mann Whitney analysis, the Wilcoxon W value (55.00) for y axis variation at position 35 (Table V, VI) and Wilcoxon W value (93.00) for y axis variation at position 45 (Table VII, VIII) lies between the median 1 and median 2. Hence the difference between the groups is statistically significant. The mean value of y axis values (in mm) of abutment at 35 positions for closed tray impression casts is 8.654 mm and mean value for open tray impression casts is 9.100 mm. The mean value of open tray technique is close to the master model value of 9.115 mm. The mean value of y axis values (in mm) of abutment at 45 positions for closed tray impression casts is 8.592 mm and mean value for open tray impression casts is 8.79 mm. The mean value of open tray technique is close to the master model value of 8.965 mm. Hence the open tray technique has the least amount of distortion in y axis direction among the two techniques. Similarly the Mann Whitney test results for angularity variation at 35 position (Wilcoxon W value (99.00) – Table XI, X) and at 45 position (Wilcoxon W value (83.00) – Table XI, XII) lies between the median 1 and median 2. The mean value of angularity (in radians) of abutments in 35 position of closed tray technique casts is 0.09172 and that of open tray technique casts is 0.08298 which is close to the master model value of 0.08472 Similarly the mean value of angularity values (in radians) of abutments in 45 position for closed tray impression casts is 0.07925 and that of open tray technique casts is 0.07452 which is close to the master model value of 0.07520. Hence the results show a statistically significant variation ($P < 0.001$) among both the groups (techniques) and favour the open tray impression technique to be more accurate than closed tray technique (i.e less distortion in the angularity of implants with the open tray impression technique transfer compared to the closed tray impression transfer).

The results of the study are in accordance with the studies done by Alan B. Carr 3, Jason et al 24, Jose et al 25, Kivanc Acka et al 27. Alan B. Carr did a similar study comparing open tray technique and closed tray technique with closed tray impression post (without snapon transfer copings). He evaluated the accuracy of sample casts with travelling microscope and concluded that the open tray impression transfer is more accurate than the closed tray impression technique.

The results of the study correlate with the results of Kivanc Acka et al [27] in which he has compared open tray & closed tray technique with polyether impression material and closed tray impression with snap on impression copings using vinyl poly siloxane impression material (VPS) and has evaluated using coordinate measuring machine. The statistical analysis of the groups showed significant differences in the X and Y directions. But there was not a significant difference in angularity between the polyether direct and polyether indirect groups. The inaccuracy is incorporated in the closed tray impression technique is consistent with the findings of Jorgenson [3]in that a permanent deformation was induced in an elastomeric impression material when recovering it from structures having undercuts 1.0 mm in height and depth. The transfer coping below the height of contour could easily provide such an undercut and lead to deformation. Improper alignment of the flat surface of closed tray impression post to the snap on impression coping, distortion and incomplete recovery of the vinyl polysiloxane impression material due to application of excess pressure in a direction opposite to that of flat surface while aligning them will lead to X axis and angularity variation.

The inaccuracy in y axis may be due to the improper seating of the closed tray transfer into the snap on impression coping to the full depth, or conversely excess pressure to seat which deforms the impression material with less-than-ideal elastic recovery. Liou et al[7] has reported that indirect impression copings do not return to their original position when replaced in vinyl poly siloxane impression. All these factors for error incorporation in the transfer process is eliminated with open tray impression technique. Also due to the smaller number of components involved in the transfer process the less the chance of error incorporation with the open tray impression technique.

CONCLUSION:

From the foregoing study for evaluating the accuracy of casts obtained from various implant impression techniques following conclusions have been drawn. The open tray impression technique for transfer of 3 dimensional implant position from master model to specimen casts using direct impression coping for open tray internal hex is more accurate than the closed tray impression technique using direct impression coping for closed tray internal hex. The open tray impression technique showed better accuracy than the closed tray technique on all the three parameters evaluated (x – axis, y – axis and angularity). This clinically implies that, more the number of components used for the impression procedure, the more the chance for inaccuracy (error) getting incorporated. Hence a direct transfer impression technique with less number of components possible ensures the high accuracy of transfer of implant positions from master cast to the laboratory cast which implies the accurate transfer of implant location from the patient to the laboratory cast.

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