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Analysing the precision of dental impression on angulated implants using full arch and sectional approaches in the abutment and fixture levels

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Abstract

Aim and background: The goal of this research is, to study the effect of different dental impression methods in the abutment and fixture levels using the Sectional (SE) and Full Arch (FA) approaches in some implants with internal connectionsas well as different angles of each implant placements on the accuracy of the final casts. **Methods and Materials:** 4 analogues(implant replicas) were placed on both sides of the imaginary arch (the premolar and the first molar area)in a way that, the opposite side analogues would buccolingually make an angle of 40- 60 degreeswhile, each of the analogueswere tilted 10 degreesmesially in their longitudinal axis. The dental impression procedure in both fixture and abutment levels was conducted by the same person using Poly Vinyl Siloxane (PVS). 10 FA and 10 SE dental impressions were taken from each fixture and abutmentlevels. The impressions were castedusingDental Stone Type IV. The center to center distance between the implants (a, b and etc.) along with their angles (θ1, θ2 and etc.) on the initial cast and the duplicated cast were all measured using the Coordinate Measuring Machine (CMM) device in the X-Y-Z axis. The results were analyzed using a statistic software called Statistical Package for the Social Sciences (SPSS 20) based on theT-Test, One-Way ANOVA and Two-Way ANOVA statistical methods. ($p<0.05$) **Results:** The results of the Two-Way ANOVA showed a significant difference between the studied groups. ($P<0.001$) The results of the One-Way ANOVA illustratedchanges of line and angle movements in all positions as (Δa, Δb, Δc, etc.) and (Δθ1, Δθ2, etc.) while, using FA impression in the fixture and the abutment levels showed a significant statistical difference. ($P<0.001$) The results of the T-Test in the SE approach in two levels of fixture and abutment demonstratedthat, only changes in θ2angle wassignificant, as other changes of (Δf and Δθ1)also showed a significant difference. ($P>0.05$) Moreover, the SE approach in abutment's level was significantly more precise in accordanceto the fixture level. **Conclusion:** In angulated implants, it is recommended to make the dental impressionin the abutment level using a sectional approach which, has higher precision.

Keywords: Dental impression, Precision of dental impression, Impression approaches, Implant and Angulated implant.

INTRODUCTION

The success of Osseo-integrated implants in the treatment of Edentulous has been established. [1, 2]After installing the fixtures, the need for a precise dental impression is required. Obviouslyconducting such impressions and the preparation of prostheticsareboth one of the most important clinical stages. At this stage, an accurate record of the three-dimensional relationships between the implants, tooth and proximal structures arevital. Failure at this stage would lead to lab errorsand thus making prosthetics with insufficient compliance, inaccuracies in occlusion, unwanted histologic reactions in soft and hard tissues around the implant itself which, could lead to a failing treatment particularly in fixed prosthetics that are relying on the implants.

On the other hand, making exact impressions of dental implants, especially in the cases where there are many implants with different angles will lead to more difficulties. There are several ways to conduct dental impressions for implants in which some are more precise than the others. [1] Precision in the prepared impression depends on many different factors [2] including the component of the impression[1, 3], the angle of the implants [4], type and number [1], depth of the implants [5], the using tray[6] and different levels of impression. [7] Many studies have examined the effect of the angle of the implant on the precision of the impression. However, some researchers have not yet found a significant difference between the

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precision of the impression in parallel and angulated implants. Whereas, some of the other researchers found a significant difference between the precisions of the impression in parallel and angulated implants. Some of the studies suggest that the precision of the impressions in the angulated implants is due to the number of the implants. The results of two studies show a lower precision level of angulated implants in comparison to the parallel ones. In these studies the number of the implants were 4 and 5 respectively.(2, 8) Moreover, two other studies also showed that by using 2 or 3 angulated implants, the precision of the impression does not change that much.(4)

At the clinics, we could come acrossconditions which, the implants that are located on each sides of the arch are placed with greater angle in accordance to each other. This condition is especially seen in the maxillarywhere,the recede of the ridge occurs from the buccal ridge. As it has been explained earlier, most of the recent researchesare about the non-parallel implants with a minor distance and on one side of the arch. Therefore,there is no research regarding the impression methods of the impressionin cases which, the implants are placed on both sides of the arch being respectively angular to each other. The question is, is it better to conduct implant impressions using the FA approach or the SE one? Or is it better to carry on with the procedure by choosing the fixture or abutment levels?This study is set to answer these questions with the usage of 20 and 30 degrees angulated implants in a reconstructed edentulous maxillary model.

METHODS AND MATERIALS

In this experiment, analuminum reference model was usedwhile containing 4internal connectionimplant analogues (Noble Biocare, Replace Select, 10×4.5$_{mm}$, Kloten, Switzerland) which, were positioned in the first premolar and the first molar regions of the imaginary arch, as the center to center distance between the analogues from each side were 16$_{mm}$. According to the normal arch measurement,the width of the imaginary arch was considered 35$_{mm}$ in the premolar and 40$_{mm}$ in the molar regions. [9 Therefore, 4 holes with a diameter of 3$_{mm}$ (in accordance to the measurement of the analogue diameter) and a height of 10$_{mm}$ (according to the measurement of the implant analogues) were created in the model.

Holes were formed in such a way that, analoguenumber 1 and 4 were both baccally producingan angle of 20˚in contrast to the vertical axis as being tilted 10˚ mesially. In addition, analogue number 2 and 3 hadbuccal angles of 30˚in contrast tothe vertical axis while being tilted 10˚ mesially. [10]Then,4 metal cylinders were placed as an index to achieve accurate placement of the impression tray in all 4 corners of the model with a distance of 5$_{mm}$ from each corners.

For making 40 special impression trays, all we needed to do was, preparing a cast from the initial model so the trays could be built. For this purpose 2 layers of baseplate wax (Dentsply, Modeling Wax, Weybridge, UK) were placed on the initial model in which, 3 stops were added to place the tray in a correct position and keeping the right distance of the tray. Therefore, it could be done with more precision by making sure that there is a same thickness of 3$_{mm,}$all across the molding. Afterwards, the impression copying fixture level - open tray, was installed on the initial model. The impression procedure was done using A-Silicon (Zhermack, Elite-HD,Rovigo, Italy)and the implant analogues were attached to the copings.Cast was made bythe Die Stone type IV (Herostone Vigodent, Rio de Janeiro, Brazil) and was used to make all the special trays. In this research,two types of trays(full archand sectional) were built and in both types, fixture level and abutment level were used as the sub-groups.

All 40 open trays were made of visible light-polymerizing material (Dentsply, Triad Trutray, Intl, York, USA) with a persistentthickness of 2$_{mm}$for FA and SE moldings. The impression copings were attached to the analogues on the fixture levels, to be able to produce the trays for them (fixture levels). After attaching the abutments to the analogues, the impression copings on the abutment levels were also mounted to provide the trays on the abutment level. At the top part of all the trays, an area was created to be attached to the vertical surveyor roddue to equalizing the exit path (extraction path) of the trays. 4 holes were made on the top region of the impression copings. Each holewas 2$_{mm}$ wider than the diameter of the impression coping.All trays were kept at the room temperature for 24 hours (before the impression procedure taking place). An adhesive (Universal, 3M ESPE, Seefeld, Germany) was applied to the trays 15 minutes prior to the impression procedure (as the product instructions indicated). [4]All impression materials were made usingthe medium viscosity PVS(Kettenbach, Monopren transfer, Aarbergen, Germany). To conduct the impression procedure in Fixture Level Full Arch (FLFA) and Fixture Level Sectional (FLSE) groups, the impression copings of fixture level were tightened by the wrench to the initial model using the equivalent torque (10N/ cm) as Vigolo et al. recommended. [11]In Abutment Level Full Arch (ALFA) and Abutment Level Sectional (ALSE) groups, the 17˚ multi unite abutments were tightened by the wrench to the fixture number 1 and 4 using the equivalent torque (15N/ cm). The 30˚ multi unite abutments were also tightened by the wrench to the fixture number 2 and 3 using the equivalent torque of 15N/ cm. Then the impression copings of the abutment levels, were tightened to them using the equivalent torque of 10N/ cm by the use of the wrench.

An adequate impression materialsweremixed due to the manufacturer's instruction, with the use of an impression gun known as Apply Fix 4 (Kettenbach, Aarbergen, Germany). Afterwards, the impression materials were applied to the tray and around the copings till they were fully covered. Then the tray was positioned onto the initial model, using a dental surveyor vertical rod before placing 1.5$_{kg}$ weight at its top to equalize the pressure throughout.[12]The collection of the tray, the model and the weight were kept in a box containing water with 36±1 degrees Celsius to stimulate the temperature conditions of the oral cavity. [2]

The surveyor table was positioned with a 30˚ tilt for extracting the sectional tray in the fixture level. After 10 minutes, the coping screws were opened by a screw driver as all the impressions were checked for precision, any possible bobbles especially around the implants and not fully attached impression materials to the trays. If any problem such had occurred, the process was again repeated. All impression components along with the copings were rinsed under the tap water for 10 seconds before leaving them to dry gradually. [12] After this stage, implant analogues were attached to theimpression copings and were tightened with hand. Here we must mention that, all the impression procedures were conducted by the same conductor. The bidding and boxing process was then conducted 20 minutes after the impression progression while 6mm base height was achieved. The Casts were made using the Die Stone type IV (Herostone Vigodent, Rio de Janeiro, Brazil) with the vacuum machineas the powder to liquid ratio volume stood at 30$_{gr}$/ $_{ml}$ in the exact way that the manufacturer recommended. After the setting stage completed (120 minutes), all the casts were set apart from the impressions. All casts were kept at the room temperature for at least 24 hours before beginning the measurements.

For all the angulated and dimensional measurements, we used CMM (Wenzel, Coordinate Measuring Machine LH78, Wiesthal, Germany) having a sphere with fixed and standard diameter along with a specific and standard location on its table to be able to calibrate the probe's 3D position and the measurement of its tip, every time the probe is changed. This device is kept in a room with isolated walls and a separate air generating system to keep the temperature and the humidity unchanged throughout the 24 hours period.

The sensitivity of the probe's tip is really high as it can measure the position of every spots on the surface of any object within the table's measurement range in contrast to the standard sphere in X, Y and Z dimensions and the measurement precision of 0.1_{μ}. By accurate adjustments and defining the cylindrical and conical objects in the software (metrosoft 3.6), this device is capable of measuring different points of the analogue levels every time and determining the coordination of the cylindrical and conical object centers in accordance to the standard sphere, it can even define the Out of Sphericity (OS) amount of the cylindrical and conical objects which, includes the difference between the surfaces of the measured cylindrical and conical objects in comparison to the ideal ones.

The maximum desired number of spots for this analysis and measurements from the level of the object in accordance to the standard adjustments of the software is 11 spots (with a minimum of 4 and an optimum number of 7). Therefore, by placing the original model on the table and the contact of the device probe with the analogue regions, and also the contact of the probe with the analogues and abutments in 7 spots, the center in comparison with the standard sphere, were measured along with their OS.

For determining the coordinate of X, Y and Z each of the analogues are explained by the following definition. The center of the analogue number 1 is defined as the point of internal reference (zero). To define the Z-plane the center of analogue 1, was connected to the center of the analogue 2.By using the Pythagorean theory for a 3D model, in all 40 casts, the distance of the analogues from the reference point and from each other was set as (a, b, c, d, e, f) and then calculated by the following formula $\sqrt{x^2+y^2+z^2}$. [13]

For measuring the distance difference between the implants according to the original cast, the following formula was usedΔD = $\sqrt{Xn^{2}+Yn^{2}+Zn^{2}}$-$\sqrt{Xn^{2}+Yn^{2}+Zn^{2}}$in which, X, Y and Z refer to the points of the original Aluminum model and x, y and z refer to the points in the casts. For measuring the angular changes of the analogues (θ) the analogues angles of 2, 3 and 4 in comparison to Z axiswere defined and for the analogue number 1 inthe original model and in all other cases, the measurements was done by the software. [2]Statistical analysis was done using the SPSS 20 and Two-Way ANOVA, T-test and One Way-ANOVA.

RESULTS

Smirnov-Kolmogorov showed that the relevant data to linear measurements (Δa, Δb, Δc, etc.) and angular measurements (Δθ1, Δθ2, etc.) have normal distribution. ($P<0.05$)

The Average and the deviation criterion of the different impression for Noble Replace system is given in micrometer below.

Two-Way ANOVA was used to evaluate the effects of different impression methods in the fixture and abutment levels and also the evaluation of the full arch and sectional impressions on the positional changes of implants.

Hence the displacement is more important in comparison to the direction of the movement, evaluating the groups and determining the average displacement, the absolute displacement volume was used which, showed a significant difference between the results in this study. ($P<0.001$)

The changes in the linear and the angles movement, in all situations and full arch impressionson the fixture and abutment levels showed a significant statistical difference between the results by carrying out One-Way ANOVA. ($P<0.001$)

Due to the significant changes of dual interactions in some measurements, the data was analyzed using a T-test. T-test results in the sectional method in the fixture and abutment levels showed a significant angular changes in θ2 only while other changes did not show a significant difference between the data.

In addition, the sectional impression method in the level of abutment was found to be more significant andprecise than impressions in the fixture level.

Table 1: The average and the deviation criterion of the changed distances in micrometer and the (θ)angles ondifferent methods of impression in comparison to the original model

Measurement	Abutment level				Fixture level			
	Sectional		Full arch		Sectional		Full arch	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Δa	-	-	31.2	18	-	-	39.9	29
Δb	-	-	21.4	21.2	-	-	49.4	13.4
Δc	-	-	22.6	10.5	-	-	37.5	29.1
Δd	-	-	16.6	6.8	-	-	27.8	20.9
Δe	-	-	30.7	12	-	-	37.2	36.6
Δf	16.99	22	27.8	12.5	21.3	16.3	41.1	13.4
Δθ1	1.18	0.383	1.215	0.475	1.26	0.405	1.45	0.0504
Δθ2	1.235	0.437	1.236	0.44	1.246	0.632	1.484	0.318
Δθ3	-	-	1.234	1.029	-	-	1.277	0.423
Δθ4	-	-	1.158	0.409	-	-	1.203	0.489

Table 2: Two-Way ANOVA results

Source	Sum of Squares	Df	Mean Square	F	P-value
Technique Condition	0.078	1	0.078	0.725	0.0001
	0.020	1	0.020	2.847	
Error	0.985	36	0.027		
Total	4.199	40			
Technique Condition	0.532	1	0.531	2.683	0.009
	0.418	1	0.418	2.112	
Error	7.128	36	0.198		
Total	66.923	40			

Table 3: The results of One-Way ANOVA analysis

Condition	Technique	Mean±SD	P-value
Full arch (Δa, Δb, …)	Fixture	0.0426±0.066	0.001
	Abutment	0.0239±0.0409	
Full arch (Δθ)	Fixture	1.228±3.25	0.001
	Abutment	1.024±0.3	

Table 4: T-test results

Condition	Method	Mean±SD	P-value
	Fixture	0.0411±0.0134	
Sectional (Δf & Δθ1)		1.37±0.278	0.384(Δf)
	Abutment	0.0169±0.022	0.648(Δθ1)
		1.118±0.489	
Sectional (Δθ2)	Fixture	1.483±0.064	
	Abutment	1.159±0.44	0.001

DISCUSSION

The results of the current research showed, the sectional impression method in the fixture and abutment levels are more precise than full arch impression method. The results also showed a significant difference in comparison to other groups in which, the sectional impression method is closer to the reality.

Comparing impression methods in f, θ1 and θ2showed, there is a significant difference between these methods. (P<0.001)In addition, a sectional impression method is more precise than the FA one. The reason for this is that, since the extraction of the tray in the full arch method is vertical to the level of the cast then, it would be influenced by the f in the opposite arch and therefore the greater distortion of the impression is present. However, in the sectional method the tray is extracted parallel to axis of the implants so the distortionin the impression is less.

Comparison of sectional impression method in the fixture and abutment levels showed that thereis not a significant difference betweenthe f and θ1 intwo approaches because the direction of tray extraction in fixturesare parallel to the implantslongitudinal axisand in abutments in direction of abutments. These compensate the angulation of implants. Hence the direction of tray in cases where, implants are angulated with less than 30 degrees, will have no effects on the precision of the impressions. However, in the cases in which, the degree θ2of the implants are more than 30 degrees, there is a significant difference between impressions in sectional method in fixture and abutment levels and as impressions in the abutment levelsare more precise than impressions in fixture levels because of the compensations of angulation in abutment levels.

The result of this study showed a significant difference between full arch impressions in abutment and fixture levels. In addition, the comparison of linear changes in points a, b, c, d and e in the full archimpressions in abutment and fixture levels showed, in general, impressions in abutment levelshave higher precision. The impression in abutment and fixture levels in the full arch method, the highest displacements are observed at point's e and b. The highest amount of errors in the abutment levelsare, at the point e as in FLFA is at point b. This is due to the bigger angles between implants 2 and 3. The highest amount of errors in ALFA are seen at point e which, has the greatest distance between the implants. Most of the time, the changes in distance were negative, meaning that changes are in line withthe reduction of the distances,the same direction as the contraction directionof impression material.

The average in the linear changes in points a, b, c, d, e in the FLFA is 27.8$_{\mu}$ to 49.4$_{\mu}$which is in line with the results of other studies. Kim reported that the amount of the changesare from 30.4$_{\mu}$ to 31.3$_{\mu}$. [(13)] In addition, HSU illustrated that the amount of changes in the anterior regions are 40$_{\mu}$ to 60$_{\mu}$ as in the posterior regions are 50$_{\mu}$ to 60$_{\mu}$. [(14)]In 2013, Martinez and his colleagues reported in their study, comparing different impression methods in angulated implants of 15˚ and 30˚and observing that there is a significant difference between the groups. In their experiment,the lowest amount of change was 38.37$_{\mu}$ in the in full arch method and metal splint groups. Interestingly, in this experiment, the exact position of the implants were not attained in any of the impression methods. [(15)]This shows that the exact fit of the superstructure might be unattainable. Since the exact acceptable amount of misfit frame and rack on several implants are not determined, it is possible to define the discrepancy amount of less than 30$_{\mu}$, which is not detectible clinically, as the reference to accept or reject the fit frame and rack.[(16)]

In this study, the greatest amount of angular changes are observed in FLFA in a domain of 1.203 degree for the implants with lesser angles and 1.484 degrees for implants with greater angles. Results illustrated that an increase in angle leads to lesser precision of the impression.

Kim studies showed, the angular distortion according to the Z plan, to be 0.4 degrees which, is far less than the results of the current study.[(13)]This couldpossibly be explained by splinting the impression copings andtheir significant reduction in rotation, in Kim's study.

In 2013, Wegner et al. studied the effects of the implant systems, methods and the impression materials on the cast precision which, came to the conclusion that the type of the implant system can affect the precision of the cast more than other factors. They believed that the angle change between 0.7˚ to 2˚ is variable between the two systems. In the 3D studies, they reported the displacement value as 155±71$_{\mu}$and 217±72$_{\mu}$ for the two systems which, are different in comparison to the values attained in the current study. [(17)] The reason for this difference is due to the different implant system that was used in Wegner's study and the impression method of "pick up reposition" which,could led to the increase in impression errors.

In 2010, Alikhasi and his colleagues carried out a study on the precision of impressions on the abutment and fixture levels using CMM. They showed that impressions from the fixture level is significantly more precise than theabutment level. Their result was in controversy with many other studies as they stated the reason for this,is due to be the plastic material of the impression copings. For this reason they stated that usage of plastic impression copings in abutment levels have a lower precision in comparison to the metal impression transfers in fixture level.[18] In the current study, metal impressiontransfers were used and conflicting results were obtained in a way that,impressions in the abutment level were significantly more precise than impression in the fixture level. By comparing the current study with others, in aspects of the model type, number and position of the bases, impression material, measurement techniques and data processing, the following points should be evaluated:

In this study, the Aluminum model is used which, leads to more strengthfor the bases in their positions. The usage of the similar metalmodels, in Assif's study [19], HSU's study [14] and in other studies [20 and 21] are also seen. This could be justified as the stabilization in the base of the model in comparison to acrylic and plaster models.[4, 22, 23, 24, 25, 26, 27, 28, 29, and 30] By using an acrylic model in Mahshid and Eshtiyani's study [30] and also Vigolo's study [24] which, might lead to an error in the position of the bases due to an inefficient use of acrylamide compared to the metal that, is a significant factor of the mentioned studies. In this study, 4 bases were used in the original model which, is the positive points of the study. In the current study, examining the precision of transferring the bases position by the impression material and the presence of angles in the bases(angled 20˚ and 30˚ buccolingually and 10˚ mesio-distally) which, is closer to the problematicclinical cases, are assessed as on the other hand, it enable us to evaluate the quantity and the quality of the angles effect on creation of the impression errors.

Numerous studies, have used Polyether and Polyvinyl Siloxane as the selected impression materials to deliver the implant positions. [31] Sorrentino et al. stated, the presence of complete parallel implants in clinics are rare because of the anatomic limitations and recommended the use of additive silicone impression materials of polyether with regular consistencyto acquire more precision in impressions where, there are angulated implants with different angles. [12]

Other studies showed, additive silicones had less elastic modulus compared to the polyether ones. Therefore, in the case of undercuts and non-parallel implants presence, the extraction of impressions are easier while making less definite shape change between the impression and copings. [8 and 32]

This study also usedPolyvinylSiloxane, due to its high precision in transferring the implants, having consistency of monophasic medium and also offering dispenser along with these materials which, make them much easier to use.

In the current study, to be able to evaluate the dimensional differences, since the goal of this research was to study the bases dimensional differences and theprecision of their position transferring from the model tothe samples, instead of examining each of the X and Y axis with the cost of data loss from the Z axis, a new variable called "spatial position" was definedfor each of the bases. This new variable, has an equal influence from dimensional measurements X, Y and Z axis and in the case of not having significant results in each of the individual axis, it makes it possible to evaluatethe overall effect of all 3 axis at the same time. Mahshid and Ashtiyani used this variable and determined the differences between the base lines, after evaluation of each individual axis for dimensional measurements.[30] Moreover, Kalalipour and Seyedan primarilyevaluated the dimensional difference independently for X and Y axis in his assessment and then compared the distance difference through linear calculations.[33] However, these distances were only determined by calculating 2 axis as Z axis got eliminated for the sake of X and Y axis independent evaluationwhich, led to the reduction of value and precision of the results attained from the comparison of the linear distances.

In the current study, the variable (linear spatial position)was used, which is consistent with the formula of ΔD= $\sqrt{Xn^2 + Yn^2 + Zn^2}$-$\sqrt{Xn^2 + Yn^2 + Zn^2}$. The disadvantage of this method is due to the impossibility of evaluating each axis individually. Since the goal of the impression procedure in prosthesis which, are implant dependent, mostly the correct transferring of implants spatial position according to implants and their surrounding tissues are vital so practically, there is no need for the individual evaluation of all axis as formed errors in transferring this position which, could lead to the next undesired difficulties that are caused by the dimensional differences in all three axis and by having no relations to the individual cause and reasons of any of these phenomenon.

CONCLUSION

For more precise impression in angulated implants, it is recommendedto conduct the procedure using the sectional method along with abutment levels, which have more precision.

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