Displacements of implant components from impressions to definitive casts : A three dimensional analysis

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감사의글

본 논문이 완성되기까지 시작부터 끝까지 이끌어주신 지도교수 이 근우 교수님께 각별한 감사를 드립니다. distortion과 coordinate system이 무엇인지 알려주신 Jack I Nicholls 교수님께 감사드립니다. 늘 격려해 주시고 관심을 가져주신 이 호용 교수님, 정 문규 교수님, 한 동후 교수님, 한 종현 교수님, 문 홍석 교수님, 심 준성 교수님, 황 선홍 교수님께도 진심으로 감사를 드립니다. 반복되는 측정으로 지쳐 있을 때 옆에서 격려 해준 와싱턴 주립대 보철과 의국원들께도 깊은 감사를 드립니다. 늘 기도와 사랑으로 보살펴주신 아버지, 어머니, 모든 면에서 배려해 주시고 베풀어 주신 장인, 장모님께 또한 진심으로 감사드립니다.

저를 창조하시고 구원해 주셨으며 언제나 제 모든 것을 주관하시는 하늘에 계신 나의 주님께 영광을 돌려드립니다.

실험의 처음부터 끝까지 늘 곁에서 격려해주고 고무시켜준 사랑하는 아내 백 정원에게 이 논문을 드립니다.

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ABSTRACT

Displacements of implant components from impressions to definitive casts: A three dimensional analysis

Purpose: The aim of the present study was to assess the amount of four possible displacements of implant components from making an impression to fabricate a definitive cast.

Materials and Methods: A mandibular master model with 5 parallel implants was fabricated. Performing each of non-splinted and light curing resin splinted open tray impression technique, 5 definitive casts were fabricated per each technique. Using a computerized coordinate measuring machine, 5 part coordinate systems were established and 7 sets of data were obtained for each sample. From the data, the amount of displacement while connecting components, the linear and angular displacement of component during impressions and cast fabrications were calculated.

Results: The average displacements while connecting impression copings and abutment replicas were 31.3 and 30.4㎛ each. Non-splinted group resulted smaller displacement compared to splinted group during impressions (23.6 versus 43.7㎛) but greater displacement during cast fabrications (36.4 versus 20.7㎛).

Discussion: In contrast to previous studies, current study excluded the displacement resulted from connecting an impression coping or an abutment replica and measured the displacement solely resulted from the impression and the cast fabrication to compare the accuracy of impression techniques because the displacement from connecting components had no relation to the impression technique used and could not be controlled.

Conclusions: Connecting a component produced as great as the displacement solely resulted from an impression or a cast fabrication. Non-splinted group was more accurate during impressions but less accurate during cast fabrications.

Key words: implant impression, displacement, CMM

Displacements of implant components from impressions to definitive casts: A three dimensional analysis

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I. INTRODUCTION

Recently, non-traditional methods have been introduced to fabricate passive fitting implant frameworks.[8,20,28] However, these methods are only useful in refining the fit to the definitive cast. Consequently, the utility of the corrective measures is entirely dependent upon the establishment of an accurate definitive cast.

The accuracy of a definitive cast depends on the impression technique, the type of impression material used and the dimensional accuracy of the material used to fabricate the cast. Among those factors, impression technique has the major influence on fabricating an accurate definitive cast.

Copious studies about the accuracy of implant impression have been published and utilized various methods to assess the amount of distortion. Microscope measurements were used to get the distance between implant components or reference points in the definitive casts.[7,11,12,30,31] Strain gauges were utilized to compare the frequency values between the master model and the definitive casts.[3,4,5,13,24] Photogrammetry, Laser videography, and computerized coordinate measuring machines were used to calculate the Cartesian coordinates and the amount of rotational displacements of implant components in the definitive cast.[1,15-18,21,26,27]

Besides the impression techniques, another consideration affecting the accuracy of the definitive cast is the machining tolerances between implant components. Ma et al. defined the machining tolerance as "the difference in rest positions between the components when these components are held in place by their respective fastening screws".[22]

Four kinds of displacement of implant components can be introduced to get a definitive cast. The first is the displacement of each impression coping on the mating surface of each abutment within the range of machining tolerance. The impression technique or the material used results the second displacement of each impression coping. The third is the displacement of abutment replicas on the mating surface of each impression coping in the impression tray within the range of machining tolerance. The fourth is the displacement of each abutment replica in the definitive cast due to the dimensional change of dental stone. Most implant impression studies just compared the difference between the master model and the definitive cast and reported diverse results. However, to compare the difference between impression techniques, the amount of the first and the third displacement should be excluded because these displacements did not result from the difference between impression techniques and cannot be controlled.

The purpose of current study was to assess the amount of 4 possible displacements of components to fabricate an implant definitive cast while performing 2 impression techniques.

II. MATERIALS AND METHODS

Master model fabrication

An acrylic resin[1] model of an edentulous mandible was fabricated. Using a dental milling machine[2], five 4.25mm diameter parallel holes, 13mm deep with centers approximately 8mm apart were drilled within the interforamenal area. Five 4×13mm dental implants[3] were secured in these holes using autopolymerizing acrylic resin[4]. The screw threads of each 3mm collar multi-unit abutment[5] was luted with autopolymerizing resin cement[6] and torqued to 35Ncm with a manual torque wrench[7] before cement set. The abutments were numbered 1 through 5, as shown in Fig 1 and the sequence was used throughout the experiment.

Preliminary cast fabrication

Five closed tray impression copings[8] were hand screwed to the abutments in the master model. An alginate impression[9] of the master model was made. After complete set, the impression was removed from the master model, each impression coping unscrewed and an abutment replica RP[10] hand screwed to each impression coping. Each of the coping/replica assemblies was then inserted into the alginate impression to its most stable position. Type III dental stone[11] was mixed as the manufacturer's direction and poured into the impression to fabricate the preliminary cast.

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1) Lucitone Clear, Dentsply International Inc., York, PA

2) K9, KaVo Elektrotechnisches Werk GmbH, Germany

3) 28922, Nobel Biocare, Yorba Linda, CA

4) Pattern resin, GC International, Scottsdale, AZ

5) 29181, Nobel Biocare, Yorba Linda, CA

6) Panavia 21, Kuraray America Inc., New York, NY

7) 29165, Nobel Biocare, Yorba Linda, CA

8) 29090, Nobel Biocare, Yorba Linda, CA

9) Jeltrate, Dentsply International Inc., York, PA

10) 29110, Nobel Biocare, Yorba Linda, CA

11) Quickstone, WhipMix, Louisville, KY

Non-splinted impression coping group

To make a custom tray, five open tray impression copings[1)] were hand tightened to the abutment replicas in the preliminary cast. Two layers of baseplate wax[2)] were placed over the impression copings and two layers of light curing tray resin[3)] were adapted, trimmed and light polymerized on the preliminary cast. A visible light curing unit[4)] was used for the polymerization. A window was cut in the tray exposing the guide pins. The tray was made at least 3 days before final impressions. For the final impression, 5 open tray impression copings were screwed onto the abutments in the master model. Each guide pin was torqued to 10 Ncm with a manual torque wrench (Fig 2).

Light curing resin splinted impression coping group

An impression technique introduced by Ivanhoe et al.[14] was slightly modified for this group. A high viscosity silicone impression material[5)] was used to fabricate a mold to standardize the dimension of resin splints. For each resin splint, the mold was placed on the preliminary cast, five open tray impression copings were hand tightened onto the abutment replicas in the preliminary cast. A light curing resin[6)] was packed around the impression copings and light polymerized using a light curing unit[7)]. Using the silicone mold, 5 identical resin splints were fabricated. For each resin splint, cuts were made between impression copings using an ultrathin carborundum disc[8)]. Each resin splint was segmented into 5 resin blocks. Each individual resin block was marked to identify its corresponding position. The same method as used for the non-splinted

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1) 29089, Nobel Biocare, Yorba Linda, CA

2) Truwax, Dentsply Trubyte, York, PA

3) Triad TruTray, Dentslpy International Inc., York, PA

4) Triad 2000TM, Dentslpy International Inc., York, PA

5) Express STD Putty, 3M ESPE, St. Paul, MN

6) Triad, Dentslpy International Inc., York, PA

7) Demetron Optilux 501, Kerr corporation, Romulus, MI

8) 25 Jel-thin 9', Jelenko,Heraeus Kulzer Inc., NY

group was used to fabricate a custom tray. For the final impression, the individual resin blocks were secured on the corresponding abutment on the master model. Each guide pin was torqued to 10 Ncm (Fig 3). An adhesive resin[1)] was applied to wet each cut surface, a low viscosity light curing resin[2)] was filled in the cut space. Two curing lights were simultaneously exposed to both buccal and lingual sides of the splinted area for 60 seconds. A high viscosity light curing resin[3)] was applied and light polymerized over each splinted area for reinforcement.

Final impression and cast fabrication

Polyether impression material[4)] was used for final impressions. Polyether adhesive[5)] was applied to the customized tray 15 minutes before making a final impression. Five final impressions were made for each group. One hundred fifty grams of type Ⅳ dental stone[6)] was used to fabricate each definitive cast.

Measurements

A computerized coordinate measuring machine[7)] was used for all the measurements (Fig 4). Every measurement was made by the same operator. The accuracy of the CMM is 0.005mm for X, Y and Z axes. The REFLEX software[8)] was used for geometric transformation and data processing. Five measurement phases were proceeded for each sample (Fig 5).

Five different part coordinate systems were established and 7 sets of data were obtained for each sample. The measuring objects, the measuring points, part coordinate systems established, and the meanings of data obtained were described in table 1. The

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1) Palavit G LC, Heraeus Kulzer, NY

2) Palavit G LC K I, Heraeus Kulzer, NY

3) Palavit G LC K II, Heraeus Kulzer, NY

4) Impregum Penta, 3M ESPE, St. Paul, MN

5) 3M ESPE, St. Paul, MN

6) FujiRock EP, GC International, Scottsdale, AZ

7) Gage 2000, Brown & Sharpe, North Kingston, RI

8) Brown & Sharpe, North Kingston, RI

whole sequences of measurements were illustrated from Fig 6a though Fig 6e.

In Fig 6a, the first part coordinate system was established, the coordinates of the centroids and the angles of tilt of the multi-unit abutments on the master model were calculated (the first set of data). The centroids of the multi-unit abutment 1 and 2 were (0, 0, 0) and (x21, y21, z21) respectively.

In Fig 6b, the coordinates of the centroids and the angles of tilt of the impression copings on the master model were calculated (the second set of data). The centroids of the impression coping 1 and 2 were (x12, y12, z12) and (x22, y22, z22) respectively. The angles of tilt of the impression copings were equal to the angles of tilt of the multi-unit abutments because each impression coping mated its corresponding abutment. Then, the second part coordinate system was established using the impression copings in the master model and the new coordinates of the centroids and the angles of tilt of the impression copings were calculated (the third set of data). The centroids of the impression coping 1 and 2 were (0, 0, 0) and (x22*, y22*, z22*) respectively. Even though, there was no movement of any impression coping, the coordinates of the centroids and the angles of tilt of the impression copings were changed because of the new part coordinate system.

Fig 6c showed the establishment of the third part coordinate system after impression. The coordinates of the centroids and the angles of tilt of the impression copings in the impression tray were calculated (the fourth set of data). The centroids of impression coping 1 and 2 were (0, 0, 0) and (x23, y23, z23) respectively.

In Fig 6d, using the third part coordinate system, the coordinates of the centroids and the angles of tilt of the abutment replicas in the impression tray were calculated (the fifth set of data). The centroids of the abutment replica 1 and 2 were (x14, y14, z14) and (x24, y24, z24) respectively. The angles of tilt of the abutment replicas were equal to the angles of tilt of the impression copings. Then, fourth part coordinate system was established and the coordinates of the centroids and the angles of tilt of the abutment replicas were calculated (the sixth set of data). The centroids of the abutment replica 1 and 2 were (0, 0, 0) and (x24*, y24*, z24*) respectively. Even though, there was no movement of any abutment replica, the coordinates of the centroids and the angles of tilt of the abutment replicas were changed because of the new part coordinate system.

After fabricating a definitive cast, the fifth part coordinate system was established and the coordinates of the centroids and the angles of tilt of the abutment replicas in the definitive cast were calculated (the seventh set of data). The centroids of the abutment replica 1 and 2 were (0, 0, 0) and (x25, y25, z25) respectively.

Statistical analysis

The Kolmogorov-Smirnov test confirmed that each data set did not show normal distribution. The Mann-Whitney test at a confidence level of 95% was used to determine the significance between groups.

Table 1. Five measurement phases

Phase	Measuring points*	The part coordinate system established	Obtained data	distortion
1	Platform and axial wall of multi-unit abutments on the master model	The centroid of No.1 abutment as the origin The planar surface of No. 1 abutment as the XY plane The centroid of No. 5 abutment was laid on the ZX plane	x, y, z coordinates of the centroids and the angles of tilt of the multi-unit abutments on the master model (the first set of data)	The first displacement
2	Platform of multi-unit abutment and outer axial wall of impression copings in the master model		x, y, z coordinates of the centroids and the angles of tilt of the impression copings on the master model (the second set of data)	
		The centroid of No.1 impression coping as the origin The planar surface of No. 1 abutment as the XY plane The centroid of No. 5 impression coping was laid on the ZX plane	x, y, z coordinates of the centroids and the angles of tilt of the impression copings on the master model (the third set of data)	The second displacement
3	Bottom ledge and inner axial wall of impression copings in the impression tray	The centroid of No.1 impression coping as the origin The planar surface of No. 1 impression coping as the XY plane The centroid of No. 5 impression coping was laid on the ZX plane	x, y, z coordinates of the centroids and the angles of tilt of the impression copings in the impression tray (the fourth set of data)	
4	Bottom ledge of impression coping and axial wall of abutment replicas in the impression tray		x, y, z coordinates of the centroids and the angles of tilt of the abutment replicas in the impression tray (the fifth set of data)	The third displacement
		The centroid of No.1 abutment replica as the origin The planar surface of No. 1 abutment replica as the XY plane The centroid of No. 5 abutment replica was laid on the ZX plane	x, y, z coordinates of the centroids and the angles of tilt of the abutment replicas in the impression tray (the sixth set of data)	The fourth displacement
5	Platform and axial wall of abutment replicas on the definitive cast	The centroid of No.1 abutment replica as the origin The planar surface of No. 1 abutment replica as the XY plane The centroid of No. 5 abutment replica was laid on the ZX plane	x, y, z coordinates of the centroids and the angles of tilt of the abutment replicas on the definitive cast (the seventh set of data)	

*; ten points were measured with a 0.5mm diameter stylus on each planar surface and sixteen points were measured with a 2.0mm diameter stylus on each cylindrical wall.

III. RESULTS

The means and standard deviations of the amount of displacement while connecting impression copings and abutment replicas were shown in table 2. The difference between the third and the fourth set of data represented the displacement of each impression coping while making impression (actual amount of distortion resulted from the impression proper). The difference between the sixth and the seventh set of data represented the displacement of abutment replica while fabricating the definitive cast (the actual amount of distortion resulted from the cast fabrication proper). Table 3 showed the means, standard deviations and *p*-values for linear and angular distortions for making impressions, fabricating definitive casts and both impression and cast fabrication procedures. The Δx, Δy, and Δz values are the amounts of displacement of components in the direction of the axis. The Δr was calculated from the equation $\Delta r^2 = \Delta x^2 + \Delta y^2 + \Delta z^2$ and represent the three dimensional linear displacement of each component. The $\Delta\Theta x$, $\Delta\Theta y$ and $\Delta\Theta z$ are the amount of the rotation about each X, Y and Z axis. The amount of displacement while connecting a paired component was as great as the amount of a three dimensional linear distortion while making an impression or fabricating a definitive cast. During the impression procedure, non-splinted group showed statistically smaller Δr whereas light curing resin splinted group showed significantly smaller Δr during the cast fabrication procedure. Considering the total distortion introduced from making an impression to fabricate a definitive cast, there was no significant difference in Δr between 2 groups.

Table 2. The amount of displacement of a paired component on its mating surface during connecting procedures

difference	Meaning	Mean ± SD
Difference between the first set and the second set of data	The displacement of an impression coping on the mating surface of its corresponding multi-unit abutment	31.3 ± 15.5
Difference between the fourth and the fifth set of data	The displacement of an abutment replica on the mating surface of its corresponding impression coping	30.4 ± 15.6

SD; standard deviation

Table 3. The amount of displacement during each procedure

		Linear distortion (㎛)				Angular distortion (degree)		
		Δx	Δy	Δz	Δr	ΔΘx	ΔΘy	ΔΘz
The difference between the third and the fourth set of data (the amount of displacement of each impression coping while making impression)	G1	-3.2 ± 13.9	6.5 ± 21.4	10.3 ±10.0	23.6 ± 14.2	-0.436 ± 0.071	0.015 ± 0.134	-0.380 ± 0.336
	G2	-26.0 ± 32.2	0.6 ± 25.2	10.4 ± 9.8	43.7 ± 20.3	-0.404 ± 0.062	-0.015 ± 0.046	-0.272 ± 0.330
	p value	0.01*	0.237	0.67	0.001*	0.946	0.645	0.588
The difference between the sixth and the seventh set of data (displacement of abutment replica while fabricating the definitive cast)	G1	15.0 ± 9.5	4.0 ± 11.3	-16.8 ± 32.2	36.4 ± 19.2	0.364 ± 0.164	0.085 ± 0.110	0.078 ± 0.216
	G2	9.5 ± 10.2	1.9 ± 17.6	4.1 ± 8.4	20.7 ± 8.3	0.396 ± 0.075	-0.047 ± 0.036	0.290 ± 0.398
	p value	0.16	0.852	0.22	0.015*	0.579	0.85	0.303
The amount of total displacement form an impression and cast fabrication	G1	11.9 ± 16.5	10.5 ± 22.0	-6.5 ± 29.4	36.8 ±18.5	-0.072 ± 0.141	0.100 ± 0.294	-0.301 ± 0.336
	G2	-16.5 ± 24.4	2.5 ± 26.2	14.5 ± 12.1	37.6 ±16.5	-0.008 ± 0.065	-0.062 ± 0.080	0.018 ± 0.293
	p value	0.0007*	0.229	0.609	0.597	0.218	0.002*	0.017*

G1; non-splinted impression coping group

G2; light curing resin splinted impression coping group

*; statistically significant

IV. DISCUSSION

Various methods have been utilized to measure the accuracy of implant impression techniques. The unique advantage of a coordinates system is that it is possible to measure the amount of the displacement of a paired component on its mating surface while connecting components. A frequently used part coordinate system in accuracy studies is as follows; the centroid of cylinder 1 is designated as the origin, the centroid of cylinder 5 is laid on the X axis, the centroid of cylinder 3 is laid on the XY plane.[16,25,26,29] Mulcahy et al. criticized that this part coordinate system could not detect any y-axis distortion, z-axis distortion for cylinder 5 or z-axis distortion for cylinder 3.[23] In current study, the planar surface of cylinder 1 was designated as the XY plane and the centroid of cylinder 5 was laid on ZX plane. The main disadvantage of current part coordinate system is that every coordinate is influenced by the planar surface of cylinder 1. A little angular distortion of cylinder 1 could produce the exaggerated linear and angular distortion of other cylinders. However, current part coordinate system can detect any distortion except the y-axis distortion of cylinder 5 and most of all, current part coordinate system corresponds to the "one screw test" in clinical situation.

Five measurements were performed and 7 sets of data were obtained for each sample. The difference between the third and the fourth set of data represented the amount of the displacement of each impression coping resulted from the impression technique or the impression material used. For the non-splinted group, the distortion mainly resulted from the polymerization shrinkage of the impression material. Current study used 5 parallel implants and non-splinted group showed smaller Δr compared to splinted group. However, Phillips et al. used a master model with 5 non-parallel implants and concluded that the amount of the displacement of impression copings was not statistically different between non-splinted and autopolymerizing resin splinted impression coping group while making impressions.[26]

Feilzer et al. defined the configuration factor as the ratio of the bonded to unbonded surface of the restoration[10] and concluded that if the bonded walls were strongly restrained, it would cause greater tensile stress in the system.[9] The relatively great configuration factor and the restrained resin blocks might cause large tensile strain in the resin splint. Once the guide pins were unscrewed and the impression tray was removed from the master model, the strain might cause some amount of distortion of the entire resin splint.

The difference between the sixth and the seventh set of data represented the displacement of each abutment replica while fabricating a definitive cast. Type IV dental stone has maximum .10% of linear setting expansion.[2] The setting expansion of dental stone can displace impression coping/abutment replica assemblies. There is very little chance of the displacement of impression coping/abutment replica assemblies due to the setting expansion of dental stone in splinted group. The position of each impression coping/abutment replica assembly was maintained only by the impression material in non-splinted impression coping group. Even though the polyether impression material is very rigid after set, the impression coping/abutment replica assemblies can be displaced due to the setting expansion of dental stone.

Considering both the impression and cast fabrication procedure, there was no significant difference of three dimensional linear displacement between 2 impression techniques. The smaller linear displacement of non-splinted group during the impression procedure was attenuated by the greater linear displacement during the cast fabrication and the greater linear displacement of splinted group during the impression procedure was compensated by the smaller linear displacement during the cast fabrication. However, based on the result of Phillips et al., it can be inferred that splinted group may produce smaller amount of total displacement if the alignment of the implants was not parallel.

Ma et al. reported that the machining tolerances between Brånemark standard abutment components ranged from 22 to 100㎛.[22] Binon reported the amount of the rotational freedom between selected hexagonal implant components. The rotational freedom between a Brånemark 3.75mm implant and a standard abutment was 6.7 degrees and the average flat to flat width was 2.707mm.[6] The amount of gap between the outer axial surface of an external hex and the internal axial surface of an abutment can be calculated by the equation $gap = w \times \cos(30-\Theta)^{1/3}$ (w; flat to flat width of external hex, Θ; rotational freedom between components)[19]. Based on the equation, the amount of the gap between a Brånemark 3.75mm implant and a standard abutment was 82㎛ per each side. While connecting implant components, some amount of displacement of a paired component can be introduced within the range of the gap or the machining tolerance. Table 2 showed that just connecting an impression coping or an abutment replicas could introduce more than 30㎛ of displacement. This amount is greater than some of Δr during impressions or cast fabrications and possibly misled the result of previous studies about the accuracy of different implant impression techniques.

Until now, most of implant accuracy studies just compared the definitive cast to the master model and reported diverse results even though the experimental designs were similar. The diverse results came from the ignorance of the possible displacement of a paired component on its mating surface during connecting procedures. In contrast to previous studies, current study compared the amount of the displacement of components solely resulted from the impression technique itself excluding the amount of displacement produced while connecting a paired component. Future implant impression studies should consider the displacement resulted from connecting a paired component to compare the accuracy of different techniques.

V. CONCLUSIONS

Within the limitations of current study, the amount of the displacement of impression copings or abutment replicas on its corresponding mating surface while connecting the component was as great as the amount of three dimensional linear displacement introduced while making impressions or fabricating definitive casts. Non-splinted open tray impression technique group showed smaller three dimensional linear distortion than light curing resin splinted open tray impression technique group while making impressions. However, while fabricating definitive casts, the result was the opposite. Considering the whole displacement from making an impression to fabricating a definitive cast, no significant difference was noted between impression techniques used.

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Figure Legends

Figure 1. The master model and the part coordinate system used.

A; an imaginary line constructed between the centroid of cylinder 5 and the origin.

A was laid on the ZX plane.

C5 is the centroid of cylinder 5.

X; x axis Y; Y axis, X; Z axis.

Figure 2. Non-splinted impression coping group.

Figure 3. Light curing resin splinted impression coping group.

Figure 4. Gage 2000 Computerized Coordinate Machine

Figure 5. Schematic drawing of five measurement phases.

Figure 6a. Measurement phase 1.

The green circles represented the multiunit abutment 1 and 2 in the master model.

Figure 6b. Measurement phase 2.

The dotted blue circles represented the impression coping 1 and 2 in the master model.

Figure 6c. Measurement phase 3.

The dotted blue circles represented the position of impression coping 1 and 2 before impression and the blue circles represented the position of impression coping 1 and 2 after impression.

Figure 6d. Measurement phase 4.

The dotted red circles represented the abutment replica 1 and 2 in the impression tray.

Figure 6e. Measurement phase 5.

The dotted red circles represented the position of abutment replica 1 and 2 before cast fabrication and the red circles represented the position of abutment replica 1 and 2 after cast fabrication.

Figures

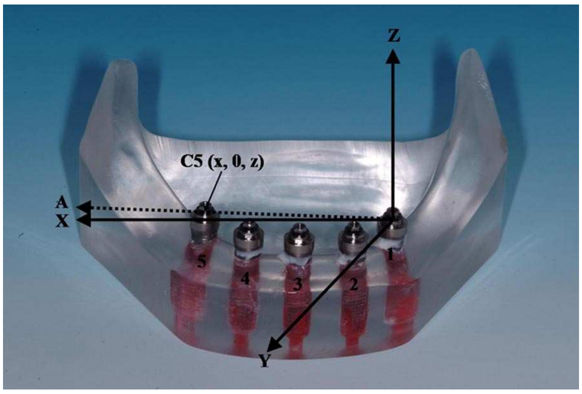

Figure 1. The master model and the part coordinate system used.

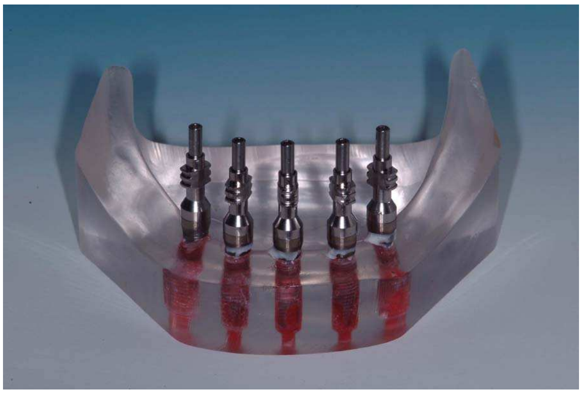

Figure 2. Non-splinted impression coping group

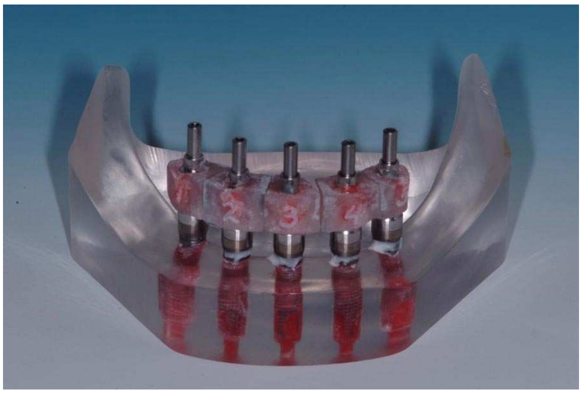

Figure 3. Light curing resin splinted impression coping group

Fig 4. Gage 2000 Computerized Coordinate Measuring Machine.

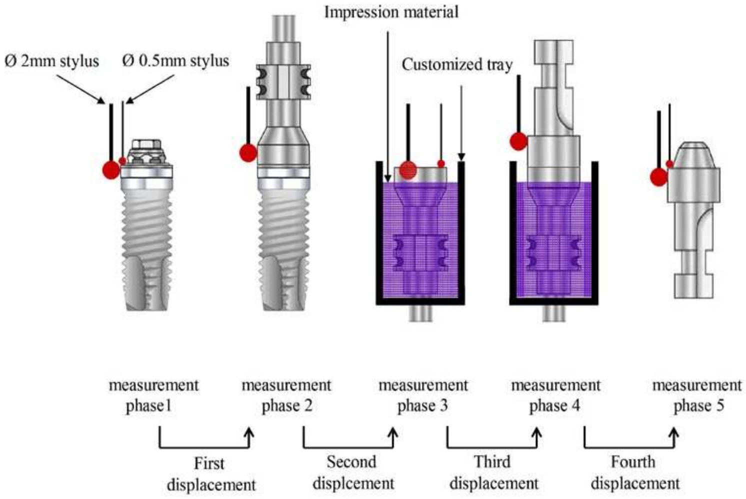

Figure 5. Schematic drawing of five measurement phases.

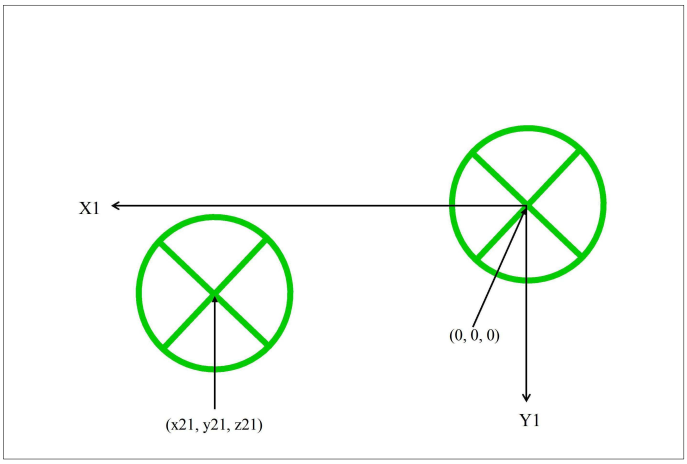

Figure 6a. Measurement phase 1.

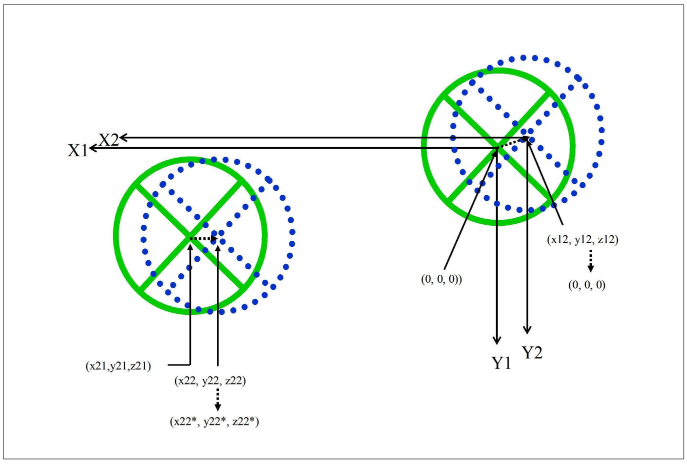

Figure 6b. Measurement phase 2

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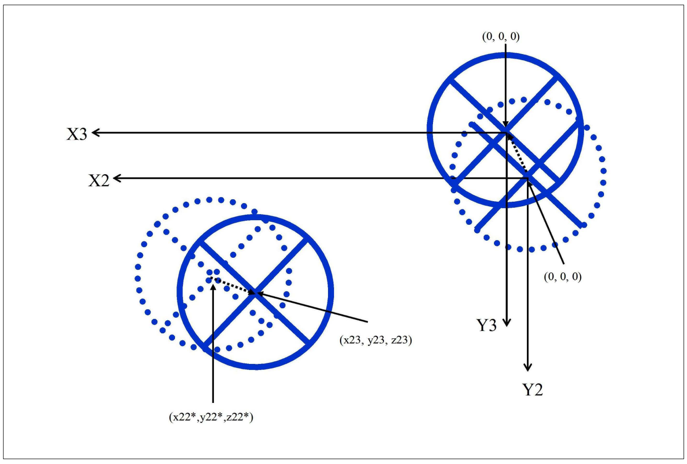

Figure 6c. Measurement phase 3.

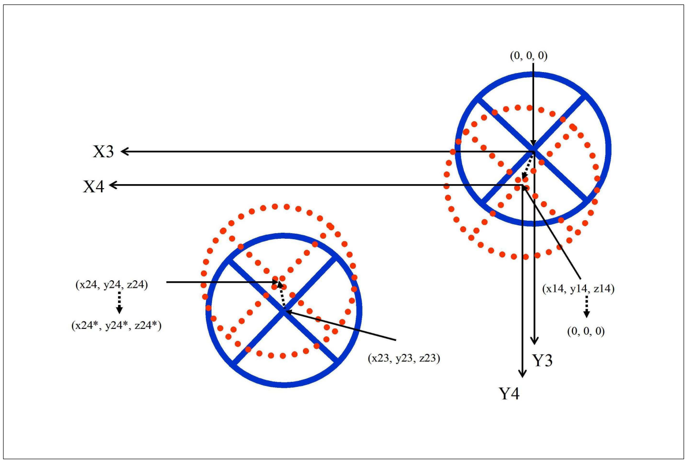

Figure 6d. Measurement phase 4.

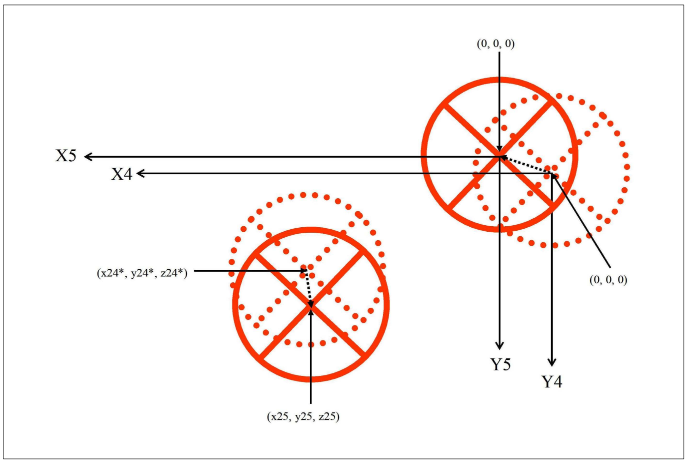

Figure 6e. Measurement phase 5.

국문요약

Displacements of implant components from impressions to definitive casts: A three dimensional analysis

임프란트 인상채득 과정에서는 모두 4번의 부속품의 변위가 발생 가능하다. 첫째, 지대주에 인상 코핑 연결 시 두 부속품 간 공차에 의한 인상 코핑의 위치변화. 둘째, 인상재나 인상방법 자체에서 발생하는 인상 코핑의 위치변화. 셋째, 인상 트레이 내 인상 코핑에 아나로그를 연결할 때 이 두 부속품간의 공차에 의해 발생하는 아나로그의 위치변화. 마지막으로 석고모형 제작 시 석고의 경화팽창에 의한 아나로그의 위치변화이다. 이 중 둘째와 넷째 변위가 실제로 인상법에 의한 변위며 첫 번째와 세 번째 변위는 임상가로서는 조절이 불가능하다. 현재까지 발표된 임프란트 인상에 관한 거의 모든 연구들은 환자모형과 인상 채득 후 제작된 작업모형을 단순히 비교하는 것이었기 때문에 인상의 어떤 단계에서 얼마만큼의 변위가 일어나는지에 대한 고찰은 전혀 이뤄지지 않았으며 무엇보다 임프란트 부속품간의 공차에 의한 변위를 고려하지 않았기 때문에 인상법 자체의 정확도를 평가할 수 없었다. 이에 저자는 임상에서 흔하게 이용되는 2가지 임프란트 인상채득법, 즉 비 연결 고정법과 광중합형 레진을 이용한 연결 고정법을 사용하여 각각의 인상채득 단계에서 발생하는 부속품의 위치변화를 전산화 3차원 측정기로 측정함으로써 인상채득 과정에서 발생 할 수 있는 4가지 변위량을 비교하였다. 첫 번째와 세 번째 변위인 연결과정에서 발생하는 변위량의 비교에선 인상 코핑 연결 시 와 아나로그 연결 시 각각 31.3±15.5, 30.4 ±15.6㎛의 변위를 초래하였다. 3차원적 선형 변위량 총계의 비교에선 두 번째 변위인 인상 채득 과정동안의 변위량은 비 연결 고정법 (23.6±14.2㎛) 이 광중합 레진 연결 고정법 (43.7±20.3㎛)에 비해 유의성 있게 작았다. 그러나 네 번째 변위인 석고모형을 제작하는 과정에서는 반대의 결과를 보였다 (36.4±19.2 대 20.7±8.3㎛). 인상채득과 석고모형 제작과정 동안에 발생한 총 변위량은 두 가지 인상법 간에 차이를 보이지 않았다 (36.8±18.5 대 37.6±16.5㎛). 현재까지 발표된

논문들과 달리 본 연구에서는 인상과정에서 부속품을 연결하는 동안 부속품 간 공차에 의해 필연적으로 발생하는 변위량을 배제한 채 실제로 인상채득 방법의 차이에 의해 발생하는 변위량을 비교하였다. 단순히 인상 코핑이나 아나로그를 연결하는 과정동안에 작업모형의 정확도에 영향을 미치는 정도의 변위가 발생한다는 것을 알 수 있으며 지금까지 공차에 의한 변위량을 배제하지 않은 채 인상법의 정확도를 평가한 과거 연구들의 결과에 대한 재평가가 필요하다고 사료된다.

핵심 되는 말: 임프란트 인상채득, 변위, 전산화 3차원 측정기