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치의학석사학위논문

In-vitro verification of the relative influence of condylar and incisal guidance on occlusion

교합에 미치는 과두유도각 및 절치유도각의
상대적 영향에 대한 실험적 검증

2015년 2월

서울대학교 치의학대학원
치의과학과 보철학 전공
이 원 섭

In-vitro verification of the relative influence of condylar and incisal guidance on occlusion

지도교수 권 호 범

이 논문을 이원섭 석사학위논문으로 제출함

2015년 2월

서울대학교 대학원

치의과학과 치과보철학 전공

이 원 섭

이원섭의 석사학위논문을 인준함

2015년 2월

위 원 장 _____ **(인)**

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위 원 _____ **(인)**

Abstract

In-vitro verification of the relative influence of condylar and incisal guidance on occlusion

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Objectives: The effects of condylar guidance on occlusion have been long discussed throughout the literature. Recently, simplified mounting technique by average setting the posterior component of occlusion has been advocated by some Prosthodontic clinician and this technique has been reported as clinically successful by several authors. However, the experimental explanation how average mounting offsets the consequence of deviation from individual condylar guidance is unclear yet. The purpose of this study was to verify the relative occlusal influence of condylar guidance compared to incisal guidance, and to examine the

occlusal consequence of condylar guidance error during non-working side movement in articulator.

Materials and Methods: Three dimensional positions of non-working side maxillary 1st molar at different condylar and incisal settings were traced by use of laser displacement sensor attached on the motorized stages with biaxial freedom of movement. For the experiment, customized incisal pin andtable for arcon type Denar articulator were prepared. Incisal guidance was set at 0, 10, 20, 30, 40, 50, and 60 degree. Condylar guidance was set at 10, 20, 30, 40, and 50 degree. Respective contribution of the incisal and condylar guidance were analyzed by calculating multiple regression coefficient with resultant coordinate data.

Results: Relative influence of condylar and incisal guidance on vertical displacement of non-working side maxillary 1st molar were calculated as multiple regression coefficients of 0.431 and 0.881, respectively. Relative contribution of both guidance to lateral condylar inclination of non-working side maxillary 1st molar were calculated as multiple regression coefficients of 0.502 and 0.833, respectively. When non-working side excursion was limited to 1mm (along the X axis), difference between Z axis coordinate of 30 degree and that of less than 30 degree within the same incisal guidance setting varied from 172 to 1405 micrometer. Inter-examiner reliability indicated the experimental results to be within statistically highly reliable range.

Conclusion: There was difference in vertical position of maxillary right first molar during non-working side movement when condylar guidance setting varied. However, the incisal guidance had more effect over

condylar guidance on vertical position and the lateral condylar inclination of the non-working side mandibular movement in articulator.

Keywords: Occlusion, Average mounting, Condylar guidance
Student number: 2012-23681

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1. Introduction

The effects of condylar guidance on occlusion had been long appeared on the literature from the past[1-3]. Aull claimed that condylar movements may affect the occlusal patterns of teeth. Weinberg reported that per 4.5 degree error in the non-working side condylar inclination caused approximately 0.2 mm error in the second molar non-working cusp height. Price et al. examined the effect of changes in articulator settings on the path of the mesiolingual cusp tip of the maxillary first molar during eccentric movement and noted that non-working excursion of 3 mm from the designated center point caused 0.24 mm difference in frontal plane, 0.16 mm difference in sagittal plane per 5 degrees incremental change in condylar setting. Condylar guidance as well as incisal guidance were regarded to be crucial factors of occlusal determinants in these literatures.

Different techniques had been developed to transfer the posterior determinants of occlusion to the articulator[4-6] and it is well described in the series of literature[7,8]. However, Preston doubted the technical validity of registering the starting point of condylar guidance due to asymmetric condyle and its resultant imperfect rotation which merely resembles an arc[9]. Moreover, the clinical validity of registering posterior determinants of occlusion had been questioned besides its complexity of instrumentation[10]. Lundeen described ready-made condylar analogs to simplify the articulator setting and concluded that most patients could be treated with preformed condylar analogs[11]. Ellinger et al., reported there were no difference in clinical end results between the patients wearing the dentures fabricated in complex method which

adopted kinematic facebow and eccentric record, and simple method which adopted arbitrary mounting without eccentric record[12]. The results of these literatures strongly challenged the conventional concept of condylar guidance as an occlusal influential factor.

Schuyler stated the importance of incisal guidance over condylar guidance due to proximity to occlusion[13]. Carlsson advocated average value mounting based on the fact that no study could be found contradicting the use of average value mounting to be satisfactory for all prosthetic work[14]. However, Payne indicated the limitations of the average value approach to be unclear proportions of patients that will fall within the average condylar value[15]. Though positive expert opinion and anecdotal experience[16] regarding average mounting is increasing, the experimental explanation how average mounting offsets the consequence of deviation from individual condylar guidance is unclear yet. The aim of this study was to verify the relative occlusal influence of condylar and incisal guidance, and also, to examine the occlusal consequence of condylar guidance error during non-working side movement, which is inevitable in average mounting process.

2. Materials and Methods

Three dimensional positions of the designated non-working side maxillary 1st molar with variation in condylar and incisal settings were traced by use of laser displacement sensor attached on the motorized stages that were able to deliver the laser displacement sensor in two direction freedom.

Custom-built Aluminum incisal table and incisal pin (Hansfactory, Seoul, Korea; Fig 1, 2) were attached to the Denar Mark II articulator (Whip Mix Corp., Fort Collins, CO) to accurately control the incisal guidance.

Co-Cr alloy target (Fig 3) fabricated by selective laser melting technique (HS dental laboratory, Seoul, Korea) was mounted on the articulator at the assumed position of right side maxillary first molar mesiobuccal cusp area via pairing magnetic mounting plate. The orientation of the target position was 11 mm along the X axis, 48 mm along the Y axis, and 35 mm along the Z axis from lateral midpoint of articular condylar head, respectively. The target had a projected point which could be detected by the laser displacement sensor (30-05T1; Sick AG, Waldkirch, Germany). The dimension of the point was 0.07 0.3 mm which was almost identical to the dimension of the laser beam; 0.06 0.27 mm.

The laser displacement sensor which had 0.001 mm resolution was fixed on the motorized stages (SGSP20-35X, SGSP20-35Z; Sigma Koki, Tokyo, Japan) to measure the horizontal movement of target viewed from frontal plane. The motorized stages were able to control

in the increment of 0.001 mm movement which was the same accuracy level of the laser displacement sensor. The motorized stages were assembled to deliver the laser displacement sensor in two direction; anterior and posterior, as well as superior and inferior direction.

Both the articulator and the motorized stages were fixed in parallel position on the custom-built anodized aluminum base plate (PSI trading corp., Suwon, Korea) by lab jack (LJA-10163; Sigma Koki, Tokyo, Japan) and custom built jigs (PSI trading corp., Suwon, Korea) as shown in Fig 4.

The incisal guidance during lateral movement was set at 0, 10, 20, 30, 40, 50 and 60 degrees by custom incisal table and incisal pin. The incisal guidance was defined as the angle formed between the midpoint to the lateral wall of the custom incisal table. The condylar guidance was adjusted from 10 to 50 degrees per 10 degree increments for each incisal guidance setting. The XYZ coordinate position of the target were measured at both centric and at the end of non-working side movement. X (width) coordinate of target at the end of non-working side movement was determined by the difference of distance measured by laser displacement sensor. Y (depth) and Z (height) coordinate of target at the end of non-working side movement were measured by counting the amount of total movement of the motorized stages. Coordinate measurements were done three times each and the mean value were calculated.

For the analysis of the respective contribution of the condylar and incisal guidance to the articulator movement, the multiple regression coefficients were calculated by R program (R Foundation for Statistical

Computing, Vienna, Austria) with the resultant Z coordinate data and lateral condylar inclination data derived from X and Y coordinate data.

To examine the clinically relevant occlusal consequence of condylar guidance error during non-working side movement, the Z axis coordinate when non-working side movement was limited to 1mm (along the X axis) was calculated. This data was compared with the Z axis coordinate at condylar guidance of 30 degree, which was regarded as an average setting.

For the evaluation of the inter-examiner reliability, the same experimental protocol was repeated by other examiner when the anterior guidance was set at 0 degree and intra-class reliability coefficient was calculated.

3. Results

Incisal and condylar guidance both affected vertical (Z coordinate) movement of maxillary right first molar during non-working side movement (Table 1 and Fig. 6). However, incisal guidance had more effect on vertical movement of maxillary right first molar during non-working side movement according to the multiple regression coefficients calculation (Table 4).

Incisal and condylar guidance both had positive relationship with lateral condylar inclination. Lateral condylar inclination increased as the incisal and condylar guidance increased (Table 2, Fig 7). However, incisal guidance had more effect on lateral condylar inclination according to the multiple regression coefficients calculation (Table 5).

When non-working side excursion was limited to 1mm (along the X axis), difference between Z axis coordinate of 30 degree and that of less than 30 degree within the same incisal guidance setting varied from 172 micrometer to 1405 micrometer (Table 3).

Inter-examiner reliability indicated the experimental results to be within statistically highly reliable range (Table 6).

4. Discussion

Condylar guidance did affect the occlusion at the 1st molar level in this experimentally given position. However, it's effect on occlusion was less than the effect from incisal guidance.

Proschel et al. investigated the occlusal parameters of 57 subjects and examined the probable occlusal error from average setting on non-working side molar area in virtual articulator[17]. The average setting caused occlusal error exceeding 200 micrometer in 16% of subjects. This decreased to 13% when condylar guidance were set individually, and to 1.6% when Bennett angle were adjusted customarily. The author concluded mean value setting to be the least precise mode of articulator setting. However, adjusting the individual condylar guidance contributed mere 3% decrease of probable error group exceeding 200 micrometer, which was beyond tolerance limit as suggested by the author.

Schulte et al. quantified the changes of the path of the maxillary left first molar during non-working side movement with variation in anterior and condylar guidance[18]. The results of this mathematical model was that condylar and incisal guidance both determined the path. The author did not support that one factor has greater influence than the other factor. However, the author did not reveal quantitative contribution to occlusion according to magnitudes of condylar and incisal guidance.

Different articles were reported regarding the relative occlusal influence of condylar and incisal guidance[19, 20]. According to Scott,

mandibular movement replica that was named as "cusp writer" revealed that the influence of the incisal guidance on cusp angulation is almost 60 per cent greater in molars and nearly 100 per cent greater in premolars when compared to the influence of condylar guidance. Scott explained the reason as the difference in distance from condyle and canine. Koyano et al. examined the subjects' mandibular incisal movement and concluded there was influence of condylar guidance on mandibular non-working side movement, which was less then canine guidance.

The result of this experiment confirmed incisal guidance as more influential factor to occlusal morphology and therefore in agreement with the previous literatures[13, 19, 20].

It can be speculated that average value mounting may cause positive error when condylar guidance is less than average value in some fixed restorative cases. According to Pelletier et. al., there was no correlation between the anterior and posterior guidance and considerable variation in humans was evident[21]. Therefore, some people will fall within ranges that have less condylar guide inclination than average value.

In this experiment, when non-working side excursion was limited to 1mm (X axis), difference between Z axis coordinate of 30 degree and that of less than 30 degree within the same incisal guidance setting varied from 172 micrometer to 1405 micrometer. The difference tended to increase as incisal guidance increased. Whether this can be regarded as a clinically negligible error or not will require further study.

Previous literatures that investigated condylar guide inclination reported minimum 11.5 degree to maximum 70.0 degree[22-27]. In this experimental setting, condylar guide inclination setting was limited up to 60 degree due to limitation of the articulator. Also, Incisal guidance setting was limited up to 60 degree due to same reason.

5. Conclusion

There was difference in vertical position of maxillary right first molar during non-working side movement when condylar guidance setting varied. However, the incisal guidance had more effect over condylar guidance on vertical position and the lateral condylar inclination of the non-working side mandibular movement in articulator.

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Tables

Table 1. Coordinate measurements (mean value)

Incisal guidance (degree)	Condylar guidance (degree)	X (micrometer)	Y (micrometer)	Z (micrometer)
0°	10°	5919.667	10518.000	1573.330
	20°	5835.667	9808.333	2642.330
	30°	5803.667	8959.000	3753.330
	40°	5532.000	7998.667	4553.670
	50°	5555.333	7508.667	5688.330
	60°	5731.667	6580.333	6701.670
10°	10°	5835.333	9603.000	2764.330
	20°	5869.667	8923.333	3847.000
	30°	5782.667	8206.333	4950.000
	40°	5705.000	7549.000	5959.000
	50°	5469.333	6713.333	6847.000
	60°	5348.333	6139.667	8008.670
20°	10°	5838.333	8857.333	4054.000
	20°	5748.667	8245.000	5088.000
	30°	5773.667	7468.333	6258.330
	40°	5663.000	6981.333	7302.330
	50°	5591.000	6269.000	8316.330
	60°	5822.333	4812.333	9044.330
30°	10°	5794.000	8254.333	5445.000
	20°	5833.000	7485.667	6620.670
	30°	5688.667	6689.667	7772.670
	40°	5653.333	6144.667	8781.670
	50°	5564.667	5558.333	9821.000
	60°	5348.333	4724.667	11088.000
40°	10°	5914.667	7264.333	7186.330
	20°	5810.000	6527.667	8371.330
	30°	5781.000	5964.333	9526.000
	40°	5575.667	5450.000	10583.700
	50°	5543.667	4831.333	11638.000
	60°	5348.333	4105.000	12856.300
50°	10°	5882.000	6280.000	9512.000
	20°	5821.333	5601.667	10709.000
	30°	5714.000	4951.333	11903.000
	40°	5506.667	4242.333	13108.700
	50°	5478.667	4030.333	14097.000
	60°	5395.667	3370.000	15471.000
60°	10°	5779.000	4795.000	13163.300
	20°	5664.000	4378.667	14429.000
	30°	5605.333	3791.333	15735.000
	40°	5620.667	3326.333	16860.300
	50°	5543.000	2847.667	17990.300
	60°	5369.000	2343.000	19399.300

Table 2. Lateral condylar inclination (mean value)

Incisal guidance (degree)	Condylar guidance (degree)	Lateral condylar inclination (degree)
0°	10°	29.371
	20°	30.751
	30°	32.935
	40°	34.668
	50°	36.496
	60°	41.057
10°	10°	31.285
	20°	33.336
	30°	35.171
	40°	37.079
	50°	39.170
	60°	41.059
20°	10°	33.391
	20°	34.885
	30°	37.707
	40°	39.048
	50°	41.728
	60°	50.425
30°	10°	35.066
	20°	37.927
	30°	40.377
	40°	42.615
	50°	45.033
	60°	48.543
40°	10°	39.153
	20°	41.671
	30°	44.106
	40°	45.653
	50°	48.928
	60°	52.493
50°	10°	43.126
	20°	46.102
	30°	49.090
	40°	52.389
	50°	53.660
	60°	58.012
60°	10°	50.317
	20°	52.293
	30°	55.926
	40°	59.383
	50°	62.809
	60°	66.424

Table 3. Z axis movement when incisal pin position was set 1mm away from centric position

Incisal guidance (degree)	Condylar guidance (degree)	Z axis at 1mm excursion (micrometer)
0°	10°	265.780
	20°	452.790
	30°	646.717
	40°	823.151
	50°	1023.940
	60°	1169.236
10°	10°	287.861
	20°	431.117
	30°	603.193
	40°	789.376
	50°	1019.911
	60°	1304.414
20°	10°	457.700
	20°	617.101
	30°	837.982
	40°	1045.979
	50°	1326.580
	60°	1879.407
30°	10°	659.654
	20°	884.446
	30°	1161.892
	40°	1429.153
	50°	1766.897
	60°	2346.832
40°	10°	989.262
	20°	1282.438
	30°	1597.161
	40°	1941.963
	50°	2408.859
	60°	3131.864
50°	10°	1514.650
	20°	1911.752
	30°	2403.999
	40°	3089.974
	50°	3497.726
	60°	4590.801
60°	10°	2745.214
	20°	3295.295
	30°	4150.255
	40°	5068.735
	50°	6317.557
	60°	8279.684

Table 4. Multiple regression coefficients (Z axis)

	Coefficients	Significance
Incisal guidance	.882	.000
Condylar guidance	.431	.000

Table 5. Multiple regression coefficients (Lateral condylar inclination)

	Coefficients	Significance
Incisal guidance	.833	.000
Condylar guidance	.502	.000

Table 6. Intra-class reliability coefficient (X, Y, and Z axis measurements when incisal guidance set at 0 degree)

	Coefficients	Significance
X axis	.926	.006
Y axis	.996	.000
Z axis	1.000	.000

Figures

Figure 1. Customized incisal table

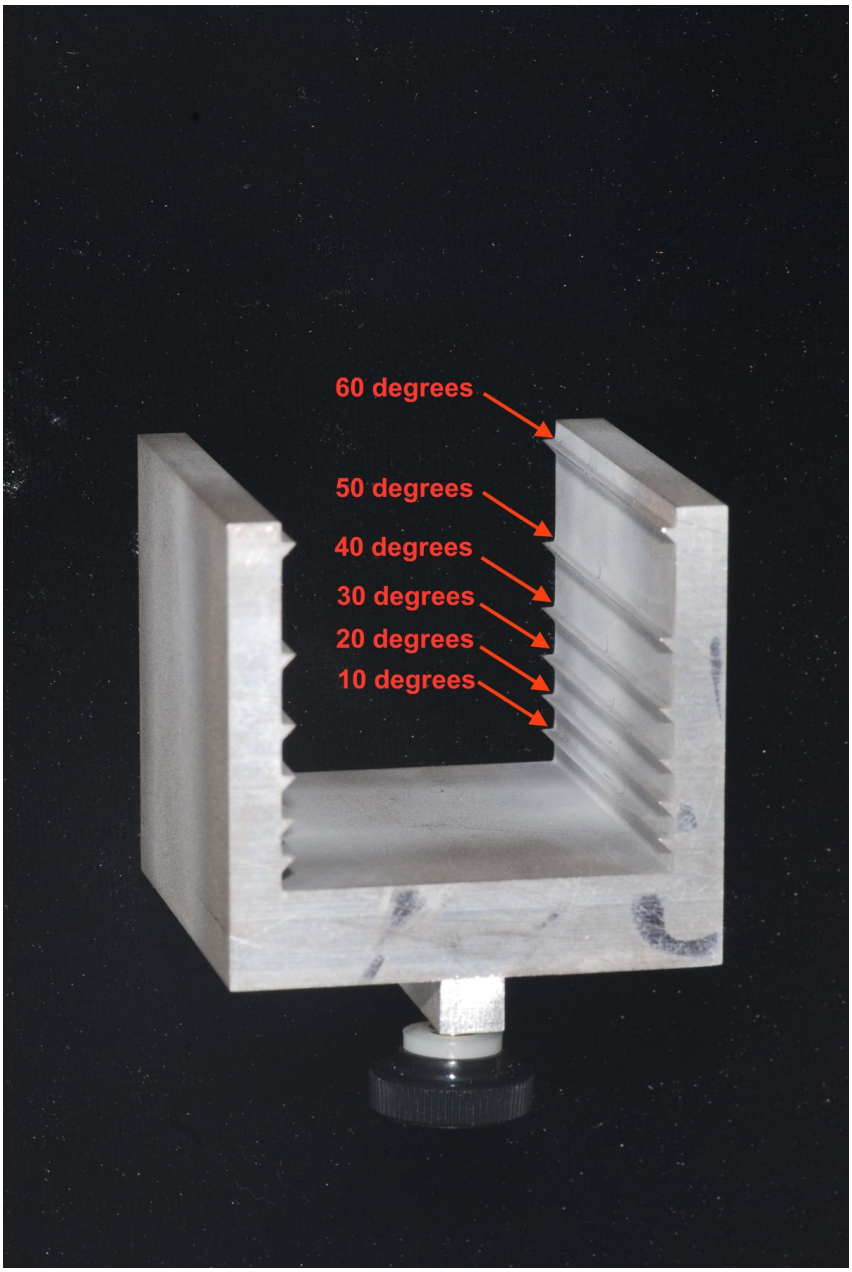


Figure 2. Customized incisal pin

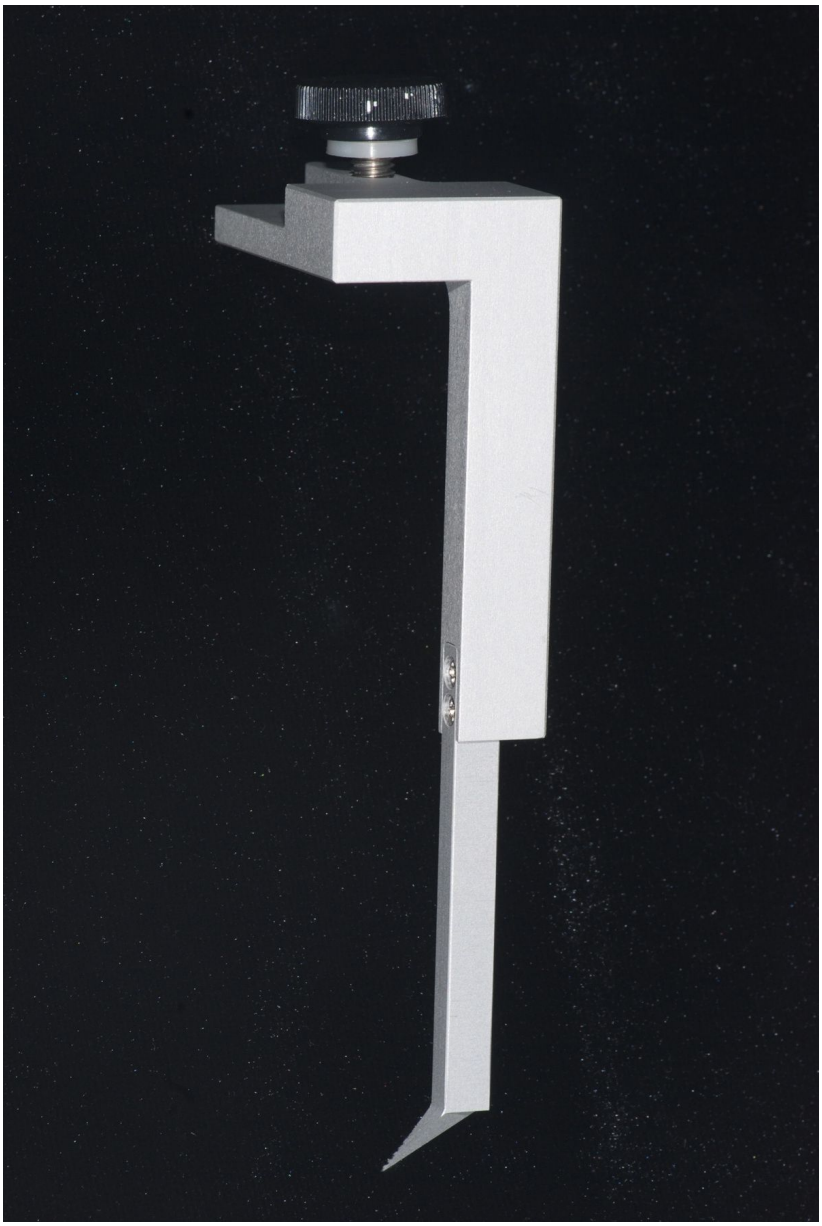


Figure 3. Co-Cr target

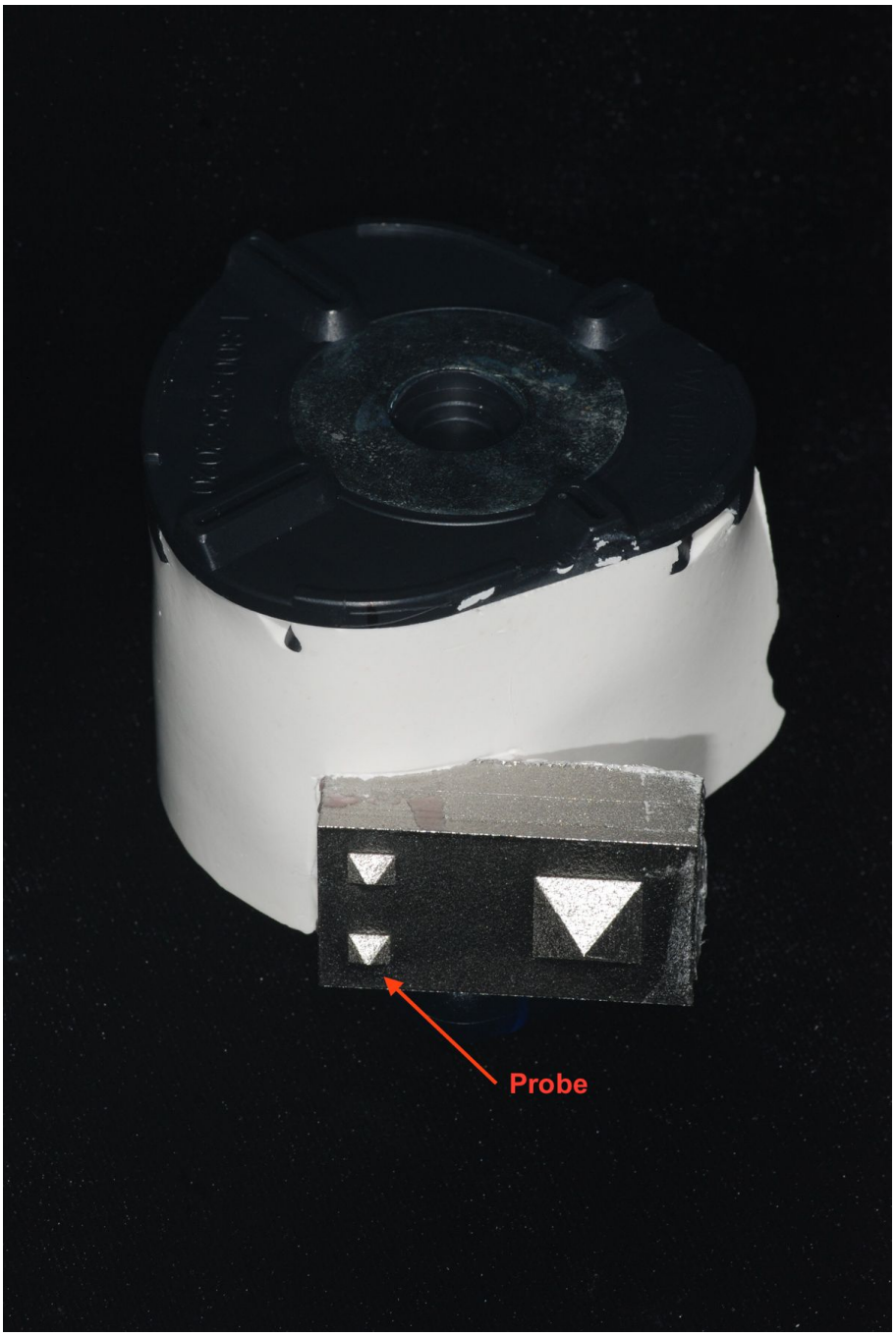


Figure 4. Experimental settings

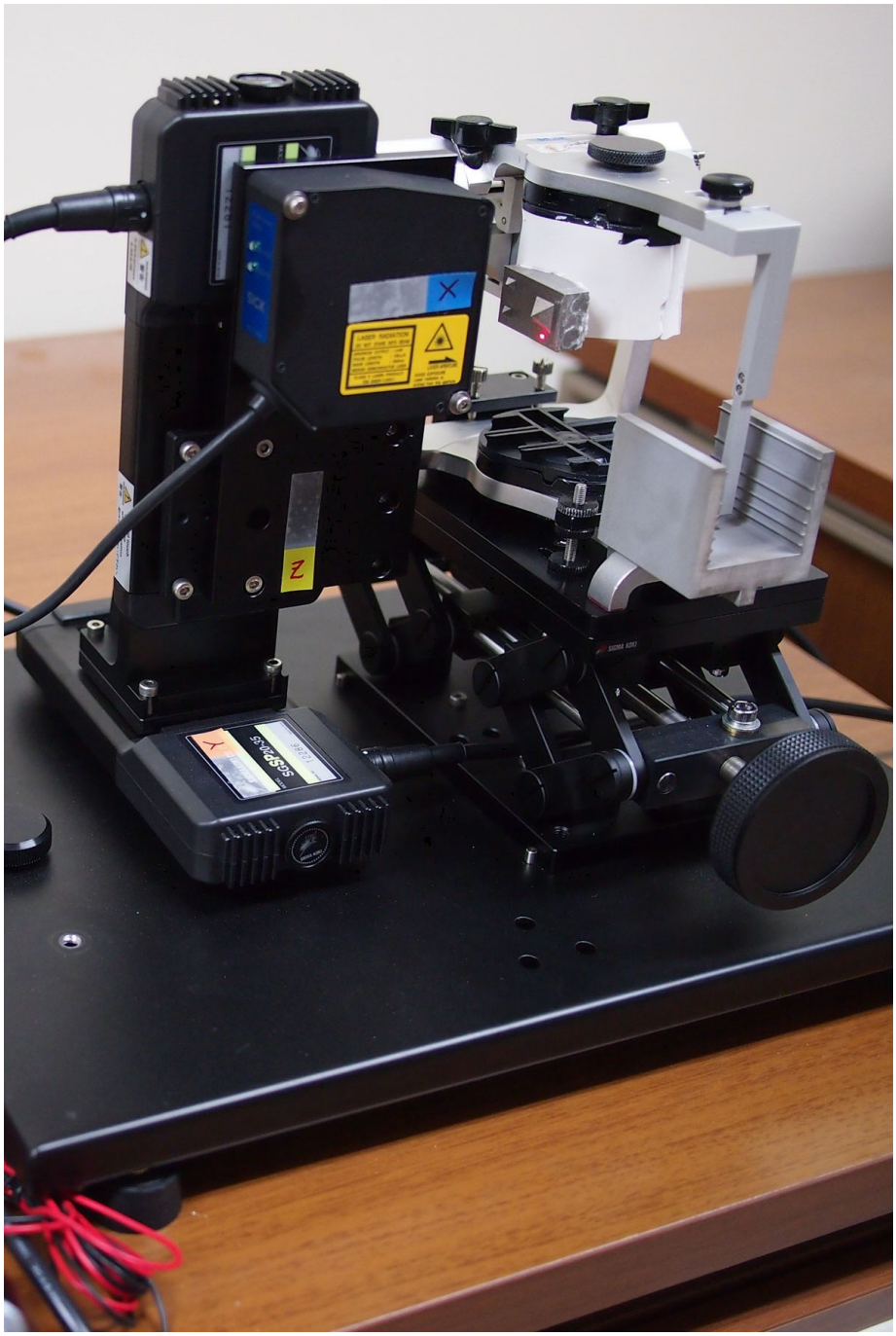


Figure 5. Z coordinate measurements (micrometer)

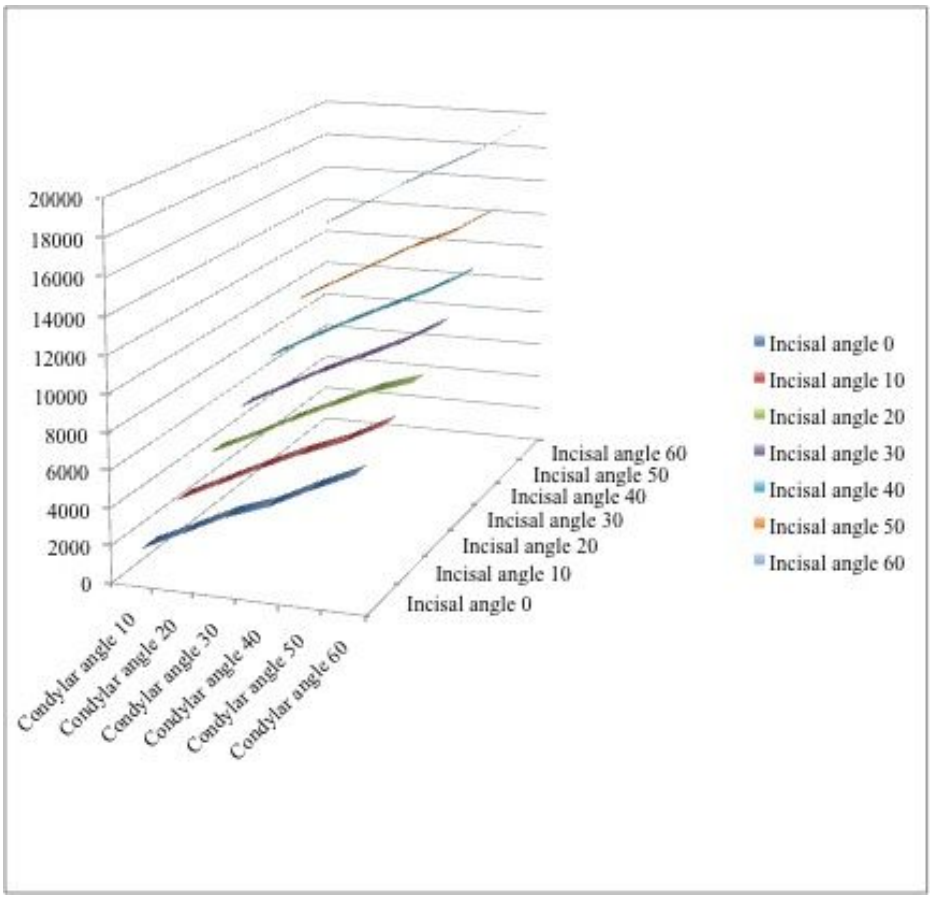
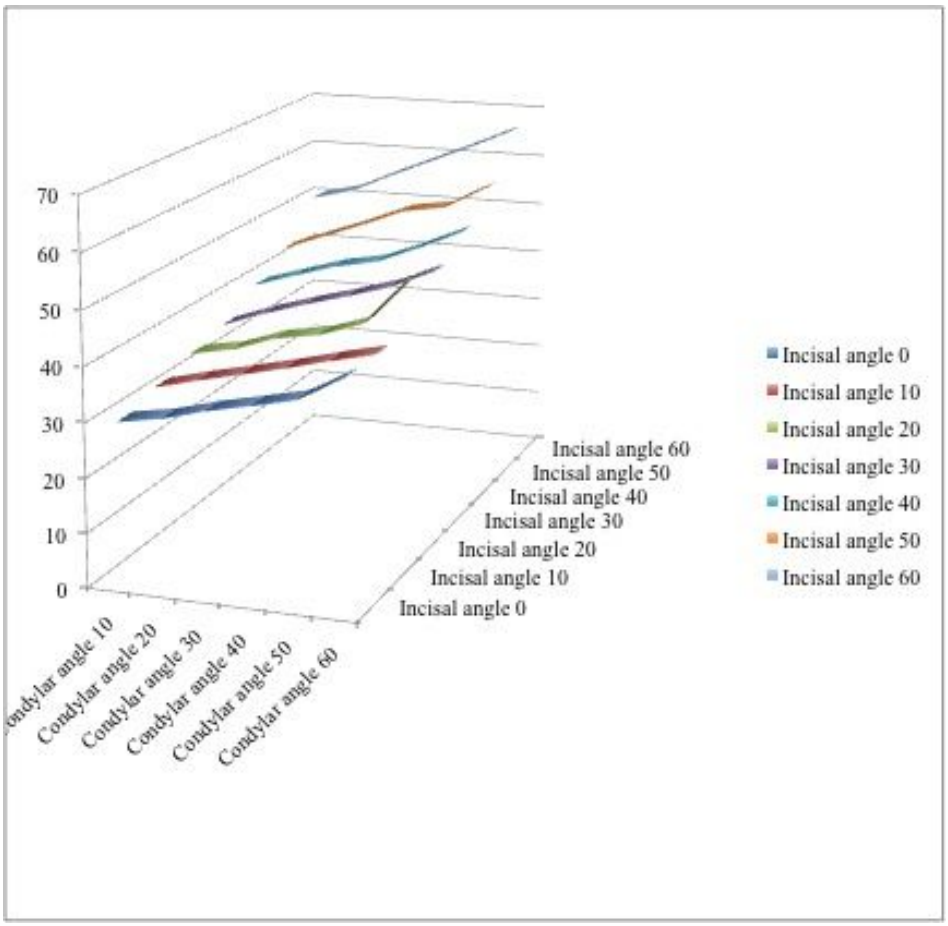


Figure 6. Lateral condylar inclination (degree)



국문초록

교합에 미치는 과두유도각 및 절치유도각의 상대적 영향에 대한 실험적 검증

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1. 목 적

과두유도각의 교합에 미치는 영향은 과거부터 많은 논의가 있었다. 최근 들어 교합기 부착과정을 단순화한 평균치 부착을 선호하는 추세가 몇몇 학자들에 의해 주장된 바 있으며, 이는 임상적으로 유효함을 입증한 보고들이 존재한다. 그러나, 평균치 부착 과정에 수반되는 과두유도각 설정 변화가 교합에 미치는 영향에 대한 실증적 설명은 부족한 것으로 판단된다. 본 실험의 목적은 비작업측 운동시 구치부 교합에 대한 과두유도각과 절치유도각의 상대적 영향 및 과두유도각 설정 오류시 비작업측 교합에 미치는 영향을 교합기상에서 측정하기 위함이다.

2. 방 법

상악 제 1 대구치 위치에 레이저 변위센서로 인식가능한 표적을 제작하여 non-arcon type Denar 교합기에 부착함. 레이저 변위센서는 전동 스테이지에 부착되어 2 축 방향 운동이 가능하도록 설계되었으며, 레이저 변위센서의 거리 측정능을 이용하여 표적의 3 차원적 위치관계 추적이 가능하도록 고안하였다. 실험 목적으로 제작된 절치유도핀과 절치지도판을 이용하여 절치경사각을 0, 10, 20, 30, 40, 50, 60 도로 설정하였다. 상기 실험 결과로부터 다중회귀 계수를 구하여 비작업측 운동시교합기의 상악 제 1 대구치 위치관계에 대한 절치 및 과두유도각의 영향을 비교하였다.

3. 결 과

비작업측 운동시 과두유도각 및 절치유도각이 상악 제 1 대구치의 수직적 위치에 미치는 상대적 영향은 다중회귀계수 산출 결과 각각 0.431 및 0.881 이었다. 측방과로경사도에 미치는 상대적 영향은 다중회귀계수 산출 결과 각각 0.502 및 0.833 이었다. 비작업측 운동을 수평방향 1mm 로 제한할 경우, 과두유도각 30 도 및 30 도 이하 설정시의 상악 제 1 대구치 수직적 위치 차이는 172 ~ 1405 micrometer 로 나타났다. 실험자간 신뢰도는 통계적 신뢰구간에 속한 것으로 조사되었다.

3. 결 론

비작업측 운동시 과두유도각의 설정 변화에 따른 상악 제 1 대구치의 수직적 위치 변화가 관찰되었으나, 절치유도각이 이에 미치는 영향이 더 큰 것으로 조사됨. 측방과로경사각에 미치는 영향 또한 절치유도각의 상대적 영향이 더 큰 것으로 조사됨.

주요어: 교합, 평균치 부착, 과두유도
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