A Radiographic Study on the Horizontal Angle of the Mandibular Condyle in Relation to Temporomandibular Disorders

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I. INTRODUCTION

Recently, temporomandibular disorders (TMD) has been the subject of increased interests among dental and medical professions. TMD refers to a group of clinical problems that involve the temporomandibular joint (TMJ) or/and the masticatory musculature. TMD is a multifactorial disease, because many factors can affect the dynamic balance of the masticatory system involving TMJ. First of all factors, trauma can initiate destruction of the equilibrium of the masticatory system. In addition, there are other contributing anatomic, pathophysiologic and psychosocial factors that may cause TMD. Among the contributing factors, this study is based on the relationship between anatomic factors and TMD.

The successful diagnosis of TMD comes from the comprehensive history screening, the comprehensive examination and the proper diagnostic tests. Among the proper diagnostic tests, the electromyography (EMG) is frequently used to patients with masticatory muscle disorders. Whereas, the radiography is used to patients with arthrogenic disorders. Therefore, the radiography is generally used to confirm the existence of developmental anomalies or suspected pathology, to screen for unsuspected pathology, to identify staging of a disease, and sometimes to evaluate the effects of a given treatment. Although the use of radiography for a diagnosis of TMD has some limitations because of structural variation of TMJ, the radiography plays an important role in the diagnostic assessment of TMD[1,2].

A radiographic study on the horizontal angle of the mandibular condyle has been reported by many investigators[3-12]. Weinberg in 1972 indicated that temporomandibular pain and disk derangement are associated with TMJ asymmetry[3]. Moreover, he

found that 71% of patients with acute TMD have one or both condyles in a retruded position, whereas only 31% of control group have retrusive condylar position[4]. Westesson and Lieberg in 1987 measured the horizontal axis of the mandibular condyles in 364 patients with TMD[5]. They found that the horizontal angle of patients who had unilateral joint disk displacement seemed to be larger than normal disk position of both joints. However, there was no statistically significant difference between two groups. Westesson et al in 1991 examined normal and abnormal TMJs by magnetic resonance imaging (MRI), and they divided subjects into four groups, namely, normal, anterior disk displacement with reduction, anterior disk displacement without reduction, degenerative joint disease. They found the condylar horizontal angle seemed to be increasingly larger with more advanced pathologic changes related to internal derangement and degenerative joint disease[6]. Not all studies showed positive relationship between radiographic findings and TMD. Ebner et al in 1990 divided 18 human cadaver into normal and abnormal group, and they examined a correlationship between radiographic and gross anatomical findings. They found no significant difference in mandibular condylar size and angle between normal and abnormal group[7].

Therefore, the purpose of this study was to evaluate the difference of the horizontal angle between the normal group and the TMD patient group.

II. MATERIALS AND METHODS

This study was made on two groups of subjects divided into the normal group and the TMD patient group with signs and symptoms of TMJ internal derangement (Table 1).

All the subjects were selected and grouped into the normal group and the TMD patient group by the self-administered questionnaire [13,14] (Table 2) and the clinical examination of maximum mouth opening, limitation of mandibular movement, perioral muscle and TMJ palpation, existence of pain during examination, facial symmetry, occlusal state and existence of abnormal pathologic tooth facets at their first visit.

The normal group was composed of 34 young volunteers who comprised 14 males and 20 females with a mean age of 22.9 years(ranged from 20 to 31 years). The normal group had no

Table 1. Age and gender distribution of subjects

Age group (years)	Normal group (n=34)		TMD patient group (n=38)					
			Group I † (n=28)		Group II ‡ (n=5)		Group III ‡ (n=5)	
	M	F	M	F	M	F	M	F
10 - 19	·	·	5	4	1	·	1	1
20 - 29	12	20	7	10	3	1	·	3
30 - 35	2	·	1	1	·	·	·	·
Mean	22.9		22.1					

Group I † : unilateral joint disk displacement with reduction
Group II ‡ : bilateral joints disk displacement with reduction
Group III ‡ : unilateral joint disk displacement without reduction or osteoarthritis

Table 2. Screening Questionnaire for TMD

1. Do you have difficulty, pain, or both when opening your mouth, for instance when yawning ?
2. Does your jaw "get stuck" , "lock" or "go out" ?
3. Do you have difficulty, pain, or both when chewing, talking, or using your jaws ?
4. Are you aware noises in the jaw joints ?
5. Do your jaws regularly feel stiff, tight, or tired ?
6. Do you have pain in or about the ears, temples or cheeks ?
7. Do you have frequent headaches, neckaches or toothaches ?
8. Have you had a recent injury to your head, neck or jaw ?
9. Have you been aware of any recent changes in your bite ?
10. Have you been previously treated for unexplained facial pain or jaw joint problem ?

past history including trauma, TMJ sound, TMJ pain, TMJ arthritis, TMJ luxation, prosthodontic or orthodontic treatment, unproper diet habit and oral parafunction.

The TMD patient group was composed of 38 patients who were referred for receiving treatment of TMD. The TMD patient group was composed of 18 males and 20 females with a mean age of 22.1(ranged from 14 to 33 years). We subdivided the TMD patient group into three groups, namely, unilateral joint disk displacement with reduction (Group I, n=28) and bilateral joints disk displacement with reduction (Group II, n=5) and unilateral joint disk displacement without reduction or osteoarthritis (Group III, n=5) (Table 1).

The submentovertex radiograph was taken under parameters of 90Kvp, 300mA, 0.18sec, the film-focus distance 40″, and the nominal focal spot 2.0/1.0mm Al (Gold Star Tele-Electric Co., Ltd.). The subject's head was tilted back so that the cassette holder is located at the top of the head with the Frankfort plane oriented parallel to the film[15]. The submentovertex radiograph was taken with the subject's head supported by cephalometer -like device which we designed. The cephalometer -like device had a base and two ear rods that consist of metal balls (Fig. 1). These metal indicators were clearly visible on the resulting radiographs as distinct white spots. We used the line connecting the indicators as a reference line. The lateral and the medial poles of the mandibular condyle were connected with a second line that intersected the reference line. The horizontal angle of the mandibular condyle was made of the two lines, the reference line and the poles connecting line (Fig. 2).

Collected data were analyzed using the paired t-test, the student t- test and one way ANOVA & Scheffe Test program in statistical package for social science (SPSS v.8.0). A probability level of less than 5% ($p<0.05$) was considered to be significant.

III. RESULTS

1. Horizontal angle of the mandibular condyle in the normal group and the TMD patient group

The mean value of horizontal angle of the mandibular condyle was 25.0 (±6.79) degrees in the normal group, and was 27.5 (±10.16) degrees

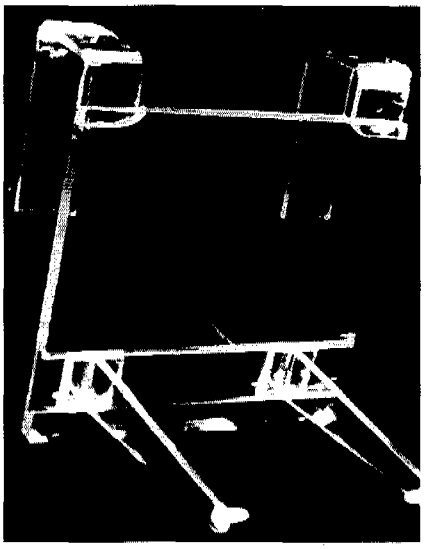

Fig. 1. The cephalometer-like device had a base and two ear rods that consist of metal balls. The submentovertex radiograph was taken with the subject's head supported by cephalometer-like device which we designed.

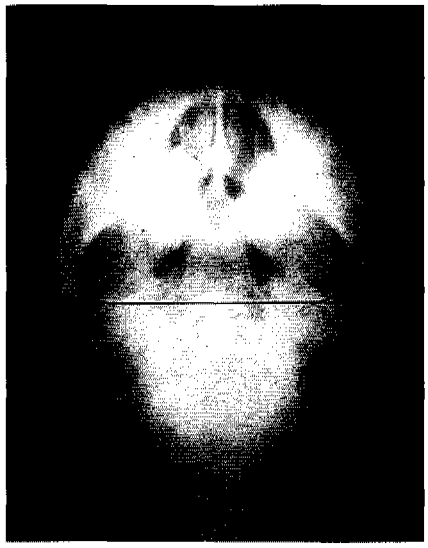

Fig. 2. Submentovertical radiograph of temporomandibular joints. The image of the metal balls in the ear rods have been connected with a line. A second line have been drawn through the lateral and medial poles of the left condyle. The angle between the two lines constitutes the horizontal condylar angle. For illustrational purpose, only the angle of the left joint is shown in the figure.

in the TMD patient group (Table 3-1). The horizontal angle was to be significantly larger for the condyle of the TMD patient group than that for the condyle of the normal group. There was statistically significant difference between the normal group and the TMD patient group($p<0.05$).

The normal group was divided into two subgroups of right and left TMJ groups. The mean value of horizontal angle of the mandi- bular condyle in the right TMJ group was 24.8 (±6.80) degrees, and was 25.3 (±6.86) degrees in the left TMJ group. There was no statistically significant difference in the horizontal angle of the mandibular condyle between right and left TMJ groups. Moreover, the TMD patient group was divided into two subgroups, namely, symptomatic and asymptomatic TMJ groups. Both TMJs of disk displacement with reduction were involved into the symptomatic joint group within TMD patient group. The mean value of the horizontal angle of the mandibular condyle was 28.5 (±10.38) degrees in the symptomatic TMJ group, and was 26.2 (±9.77) degrees in the asymptomatic TMJ group. There was statistically significant difference in the horizontal angle of the mandibular condyle between the symptomatic and asymptomatic TMJ groups ($p<0.05$) (Table 3-2).

2. Horizontal angle of the mandibular condyle in the subdivided TMD patient group according to clinical diagnosis

The mean value of horizontal angle of the mandibular condyle was 27.2 (±10.92) degrees in

Table 3. The mean value of the horizontal angle degrees of the mandibular condyle

Table 3-1. Normal group / TMD patient group

	Normal group (n=68)	TMD Patient group (n=76)	Significance
Mean ± SD	25.0 ± 6.79	27.5 ± 10.16	$p<0.05$

Table 3-2. Right and Left TMJ in the normal group / Symptomatic and Asymptomatic TMJ in the TMD patient group

	Normal group			TMD patient group		
	Right TMJ (n=34)	Left TMJ (n=34)	Significance	Sym* TMJ (n=43)	Asym* TMJ (n=33)	Significance
Mean ± SD	24.8 ± 6.80	25.3 ± 6.86	NS	28.5 ± 10.38	26.2 ± 9.77	$p<0.05$

Sym* : symptomatic TMJ, Asym* : asymptomatic TMJ

the Group I (unilateral joint disk displacement with reduction), 26.3 (±8.38) degrees in the Group II (bilateral joint disk displacement with reduction), 30.2 (±7.04) degrees in the Group III (unilateral joint disk displacement without reduction or osteoarthritis) (Table 4). Group III had the greatest horizontal angle, while Group II had the lowest horizontal angle. However, there was no statistically significant difference among all three subdivided TMD patient groups.

3. Horizontal angle of the mandibular condyle in the symptomatic TMJ of the subdivided TMD patient group according to clinical diagnosis

The mean value of the horizontal angle of the mandibular condyle was 25.0 (±6.79) degrees in the normal group, 29.1 (±11.56) degrees in the symptomatic TMJ of Group I, 27.2 (±4.49) degrees in the symptomatic TMJ of Group II, 29.0 (±7.48) degrees in the symptomatic TMJ of Group III and 28.5 (±10.38) degrees in all the symptomatic TMJ (Table 5). It was revealed that a horizontal angle of the mandibular condyle was to be larger for the symptomatic TMJ of the TMD patient group than the normal TMJ of the normal group. There were statistically significant differences in the horizontal angle of the mandibular condyle between the normal TMJ of the normal group and the symptomatic TMJ of Group I, Group II, Group III and all the symptomatic TMJs ($p<0.05$).

4. Horizontal angle of the mandibular condyle in the asymptomatic TMJ of the subdivided TMD patient group according to clinical diagnosis

The mean value of the horizontal angle of the mandibular condyle was 25.0 (±6.79) degrees in the normal group, 25.3 (±10.11) degrees in the asymptomatic TMJ of Group I, 31.4 (±7.20) degrees in the asymptomatic TMJ of Group III and

Table 4. The mean value of the horizontal angle degrees of the mandibular condyle in the TMD patient group divided into three subgroups (Group Ⅰ, Group Ⅱ, Group Ⅲ) according to clinical diagnosis

Mean ± SD	Group Ⅰ† (n=56)	Group Ⅱ‡ (n=10)	Group Ⅲ※ (n=10)
Group Ⅰ† (27.2 ± 10.92)			
Group Ⅱ‡ (26.3 ± 8.38)	NS		
Group Ⅲ※ (30.2 ± 7.04)	NS	NS	

†,‡,※ : See Table 1, NS : not significant

Table 5. The mean value of the horizontal angle degrees of the mandibular condyle in the normal and the symptomatic TMJs of the subdivided TMD patient group according to clinical diagnosis

		Mean ± SD	Significance
Normal	(n=68)	25.0 ± 6.79	$p < 0.05$
All Sym*	(n=43)	28.5 ± 10.38	
Normal	(n=68)	25.0 ± 6.79	$p < 0.05$
Group Ⅰ† Sym*	(n=28)	29.1 ± 11.56	
Normal	(n=68)	25.0 ± 6.79	$p < 0.05$
Group Ⅱ‡ Sym*	(n=10)	27.2 ± 4.49	
Normal	(n=68)	25.0 ± 6.79	$p < 0.05$
Group Ⅲ※ Sym*	(n=5)	29.0 ± 7.48	

†,‡,※ : See Table 1, Sym* : symptomatic TMJ

Table 6. The mean value of the horizontal angle degrees of the mandibular condyle in the normal and the asymptomatic TMJ of the subdivided TMD patient group according to clinical diagnosis

		Mean ± SD	Significance
Normal	(n=68)	25.0 ± 6.79	$p < 0.05$
All Asym*	(n=33)	26.2 ± 9.88	
Normal	(n=68)	25.0 ± 6.79	$p < 0.05$
Group Ⅰ†Asym*	(n=28)	25.3 ± 10.11	
Normal	(n=68)	25.0 ± 6.79	$p < 0.05$
Group Ⅲ※Asym*	(n=5)	31.4 ± 7.20	

†,※ : See Table 1, Asym* : Asymptomatic TMJ

Table 7. The mean value of the horizontal angle degrees of the mandibular condyle in the symptomatic TMJ of the unilateral symptomatic group and the asymptomatic TMJ of the unilateral symptomatic group, the right TMJ of the bilateral symptomatic group and the left TMJ of the bilateral symptomatic group

		Mean ± SD	Significance
Group I[†], III[∓] Sym*	(n=33)	29.1 ± 10.95	$p < 0.05$
Group I[†], III[∓] Asym*	(n=33)	26.2 ± 9.88	
Group II[+] Right TMJ	(n=5)	27.2 ± 4.76	NS
Group II[+] Left TMJ	(n=5)	25.4 ± 11.55	

†,+,∓ : See Table 1

Sym* : Symptomatic TMJ, Asym* : Asymptomatic TMJ

26.2 (±9.88) degrees in all the asymptomatic TMJ (Table 6). It was revealed that a horizontal angle of the mandibular condyle was to be larger for the asymptomatic TMJ of the TMD patient group than that for the normal TMJ of the normal group. There were statistically significant differences in the horizontal angle of the mandibular condyle between the normal TMJ of the normal group and the asymptomatic TMJ of Group I, group III, and all the asymptomatic TMJs ($p<0.05$).

5. Horizontal angle of the mandibular condyle in the symptomatic TMJ of the unilateral symptomatic group, the asymptomatic TMJ of the unilateral symptomatic group, the right TMJ of bilateral symptomatic group and the left TMJ of bilateral symptomatic group

The mean value of the horizontal angle of the mandibular condyle was 29.1 (±10.95) degrees in the symptomatic TMJ of the unilateral symptomatic group, 26.2 (±9.88) degrees in the asymptomatic TMJ of the unilateral symptomatic group, 27.2 (±4.76) degrees in the right TMJ of the bilateral symptomatic group and 25.4 (±11.55) degrees in the left TMJ of the bilateral symptomatic group (Table 7). It was revealed that a horizontal angle of the mandibular condyle was to be larger for the symptomatic TMJ of the unilateral symptomatic group than that for the asymptomatic TMJ of the unilateral symptomatic group. There were statistically significant differences in the horizontal angle of the mandibular condyle between the symptomatic TMJ of the unilateral symptomatic group and the asymptomatic TMJ of the unilateral symptomatic group ($p<0.05$). But there were no statistically significant difference in the horizontal angle of the mandibular condyle between the right and left TMJs of the bilateral symptomatic group.

IV. DISCUSSION

For several years, many researchers had made an effort to probe the etiology of TMD[16-19]. A part of the researches focused on the relationship between anatomic factors and TMD. Anatomic factors were divided into two factors, skeletal relationships and occlusal relationships. Among the skeletal relationships, this study focused on the horizontal angle of the mandibular condyle as a possible etiologic factors in TMD. Previous many researchers indicated that the horizontal

condylar angle tends to be larger in patients with TMD than in persons with normal TMJ. Two explanations of the relationship were possible : (1) remodelling changes of the bone that occur in association with internal derangement may result in an increased condylar angle, and (2) joints with higher condylar angle may have a greater tendency for disk displacement[6]. Earlier studies have favored the remodelling theory. Hüls and coworkers studies[20,21] examined 122 patients with TMD and noted that unilateral wearing facets were associated with an increased horizontal angle on the contralateral joint. These wearing facets were assumed to be caused by oral parafunctions such as nocturnal bruxism and clenching in an eccentric mandibular position. The lateral pterygoid muscle is strongly active during oral parafunction. The pulling force may initiate rebuilding of the condyle that eventually resulted in an increased horizontal condylar angle[20-23]. But the relationship is not yet fully understood.

Whereas Westesson and Lieberg[5] (1987) measured the angle between the horizontal condylar long axis and the frontal plane and correlated with arthrographic diagnosis in 364 consecutive TMD patients. They found that the horizontal angle of the contralateral joint was larger in patients with unilateral anterior disk displacement than in persons with normal TMJ. However, they have no detailed explanation of the reason why the abnormal joint had higher horizontal angle than normal joint. In addition, Westesson et al[6] (1991) measured the horizontal angle in axial magnetic resonance images of normal and abnormal TMJs, and examined the four group, namely, normal disk position, disk displacement with reduction, disk displacement without reduction, degenerative joint disease. They found that there were statistically significant differences among all four diagnostic groups, and indicated that joints with a larger horizontal angle might have greater tendency for internal derangement and degenerative disease in the joint[6]. They favored the etiologic theory that joints with a higher horizontal angle have a greater tendency for internal derangement to develop. Thus, in a joint with higher horizontal angle, there seems to be a possibility for more stretching in the lateral attachment of the disk to the condyle. The lateral attachment dose not have the same elasticity as the retrodiscal attachment, and if it is stretched beyond its capacity, it could result in permanent elongation that will subsequently lead to displacement of the disk[6].

Previous researchers had been examined patients with wide range of age, whereas in this study, normal and patient groups with narrow range of age were strictly selected as subjects. Restricted age of subject was very important because TMJ morphology was variable according to aging[24-26]. Pereira et al indicated that the frequency of arthrosis and disk displacement is higher in elderly persons than young persons[20]. Hence the subjects was strictly selected as the normal group (mean age 22.9, range from 20 to 31) and the TMD patient group (mean age 22.1, range 14 to 33). In addition, the strict selection of normal group was very important because a number of possible factors affect TMJ morphology. Therefore, the young volunteers were preciously screened by history taking and clinical examination. Finally, selected normal group that had no history of TMD, prosthodontic and orthodontic treatment ; no sign and symptom of TMD ; normal occlusion was selected from young volunteers.

Cephalometer-like device was manufactured for standardization of individual subjects because uncorrected subject's head posture can make an error in measurement of the horizontal angle.

The mean horizontal angle of the normal group was 25.0 (±6.79) degrees (no statistically

difference between right and left joint) in this study, whereas 20.5 degrees in Westesson and Lieberg[5], 21.2 degrees in Westesson et al[6] and 24.5 degrees in Ebner et al[7].

This study showed a distinct difference between the horizontal angle of the normal group and the TMD patient group, that supported previous findings by Westesson and Lieberg in 1987[5] and Westesson et al in 1991[6]. It was also shown that the symptomatic joints or/and the asymptomatic joints of the TMD patient group had greater horizontal angle than normal joint of the normal group, and that the symptomatic joints of the unilateral symptomatic group (Group I & III) had greater horizontal angle than the asymptomatic joints. It was revealed that joints with a higher condylar angle may have a greater tendency for disk displacement. Therefore, we have favored etiologic theory because the young subject had insufficient opportunity for remodelling.

But Group II was no statistically significant difference between right joints and left joints. There is no immediate explanation of this finding because the number of subject was not enough for apprehension of the relationships. However, it was also related to etiologic theory, because bilateral joints disk displacement with reduction had greater horizontal angle than normal joints.

In addition, this study showed that joint disk displacement with reduction had lower horizontal angle than joint disk displacement without reduction or osteoarthritis. It may be that there was a positive relationship between an increase in horizontal angle and pathological severity. However, It was shown that there was no statistically significant difference between disk displacement with reduction and disk displacement without reduction or osteoarthritis. It was probable that the number of joint disk displacement without reduction or osteoarthritis was not enough to evaluate the relationships. So further longitudinal study that had more subject's number was needed to determine whether a horizontal condylar angle of the disk displacement without reduction or osteoarthritis was greater tendency than one of the disk displacement with reduction.

Further study involving the elderly persons may contribute to the understanding of the etiology and the pathogenesis of TMD.

V. CONCLUSIONS

This study showed the horizontal angle of the mandibular condyle in relation to TMD. All the subjects were grouped into the normal group and the TMD patient group by clinical examination. Normal group that had no history of TMD, prosthodontic and orthodontic treatment ; no sign and symptom of TMD ; normal occlusion was selected from young volunteers. The TMD patient group was subdivided into three subgroups, unilateral joint disk displacement with reduction, bilateral joint disk displacement with reduction, unilateral joint disk displacement without reduction or osteoarthritis. The submentovertex radiographs for the horizontal angle of the mandibular condyle were taken with the subject's head posture fixed by cephalometer like device that consist of metal balls in ear rods.

It was shown that there was a significant difference in the horizontal condylar angle between the normal group and the TMD patient group. Besides, there was a significant difference in the horizontal angle between the normal joints of the normal group and the symptomatic joints or the asymptomatic joints of the TMD patient group. It was shown that the higher horizontal condylar angle probably affected the disk displacement of TMJ. Moreover, this study found that joint disk displacement without reduction or osteoarthritis had higher horizontal angle than

joint disk displacement with reduction. The higher horizontal angle might be correlated with pathological severity. However, there was no significant difference in the horizontal condylar angle between disk displacement with reduction and disk displacement without reduction or osteoarthritis. There were statistically significant differences in the horizontal angle of the mandibular condyle between the symptomatic TMJ of the unilateral symptomatic group and the asymptomatic TMJ of the unilateral symptomatic group ($p<0.05$). But there were no statistically significant difference in the horizontal angle of the mandibular condyle between the right and left TMJs in the bilateral symptomatic group.

This paper was intended to study on horizontal angle of the mandibular condyle in relation to TMD. Finally It was suggested that TMJ with disk displacement had higher horizontal angle than normal TMJ.

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국문초록

하악과두의 수평각과 측두하악장애와의 연관성에 관한 방사선학적 연구

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저자는 이하두정방사선사진 (頤下頭頂放射線寫眞, submentovertex radiographs)을 이용하여 하악과두의 수평각과 측두하악장애와의 연관성을 평가하고자 측두하악장애의 병력 및 증상이 없고, 자연치열로 형성된 정상교합을 가진 성인 34명과 전북대학교병원 구강내과에 내원한 측두하악장애환자 38명을 대상으로, 환자군을 임상검사 및 방사선학적 검사를 통해 편측 정복성 관절원판 전방변위 환자군, 양측 정복성 관절원판 전방변위 환자군 및 편측 비정복성 관절원판 전방변위 혹은 골관절염 환자군으로 세분한 후, 좌우측 외이도의 위치를 확인할 수 있도록 소강구 (小鋼球)가 내재된 장치물을 이용하여 채득한 규격화된 이하두정방사선사진상에서 하악과두의 내측극과 외측극을 이은 선과 양측 외이공에 위치한 소강구를 이은 선으로부터 하악과두의 수평각을 측정하였다.

평가 결과 정상군에서의 좌(평균 25.3도), 우(평균 24.8도)측 하악과두의 수평각 (평균 25.0도)은 유의한 차이를 보이지 않았으며, 환자군에서는 이환측 하악과두의 수평각 (평균 28.5도)이 비이환측 하악과두 (평균 26.2도)보다 유의성있게 증가된 수치를 보였다 ($p<0.05$). 또한 환자군 (평균 27.5도)에서의 하악과두의 수평각이 정상군 (평균 25.0도)에서 보다 유의하게 증가된 수치를 보였다 ($p<0.05$). 임상적으로 세군으로 구분된 환자군의 경우, 각군의 이환측 또는 비이환측, 각 군을 합한 이환측 또는 비이환측의 경우에 있어서도 정상군에서 보다 하악과두 수평각이 유의성있게 증가된 수치를 보였다 ($p<0.05$). 세가지로 구분된 환자군 각각의 상호 비교에 있어서는 유의성있는 차이를 나타내지 않았다. 그리고 편측으로 이환된 환자군에서의 이환측 수평각 (평균 29.1도)은 비이환측 (평균 26.2도)보다 유의성있게 증가된 수치를 보였으나 ($p<0.05$), 양측으로 이환된 환자군에서의 좌우측 수평각은 유의한 차이를 보이지 않았다.

이로써 측두하악장애의 진단 차원에서 측두하악장애를 유발하는 여러 요소 중의 하나로 하악과두 수평각에 대한 평가가 고려되어야 할 것으로 사료된다.