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Relationship between Mandibular Asymmetry and Temporomandibular Disorders

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Purpose: This study was performed to investigate the relationship between temporomandibular disorders (TMDs) and the asymmetry of the mandibular height.

Methods: We compared 100 randomly selected TMD patients diagnosed by the research diagnostic criteria for TMD (RDC/TMD) Axis I with 100 non-TMD control subjects matched with the TMD patients in age and gender. The mandibular heights were measured on an orthopantomogram and the asymmetry index (AI) was calculated as previously described.

Results: The absolute AI value of 4.37% turned out to be the least cut-off value defining asymmetry, which showed a significant difference in asymmetry incidence ($p<0.01$) between the TMD and control groups. The risk of TMD increased in the asymmetry group by 4.57 (odds ratio). The incidence of asymmetry was not related to age and gender in both of the TMD and control groups. When dividing the TMD group according to the RDC/TMD Axis I diagnosis, neither the incidence of muscle disorder nor disk displacement was related to the incidence of asymmetry. However, a higher incidence of asymmetry was observed in the subjects classified into the arthrosis/arthritis groups ($p<0.01$).

Conclusions: Although it does not imply a direct cause-and-effect relationship, asymmetry resulting in more than 4.37% difference between mandibular heights may increase the risk of TMD and correlates positively to the incidence of arthritic change in the temporomandibular joint of TMD patients.

Key Words: Asymmetry index; Mandibular asymmetry; Temporomandibular joint; Temporomandibular joint disorders

INTRODUCTION

The temporomandibular joint (TMJ) is the most unique articulation in the body. When it moves, two distinct motions occur at the joint: rotation and translation.[1] Because these complex movements take place simultaneously on both sides, TMJ asymmetry is believed to cause temporomandibular disorder (TMD).[2,3]

A number of studies have been performed to assess the relevance of mandibular asymmetry and TMD.[2,4-9] Panoramic radiograph has been most commonly used for those studies[5,9-13] since it can easily be obtained and allows a bilateral view for measuring vertical differences between both sides of the joints. From the results of such previous studies, mandibular asymmetry was observed to relate to the juvenile chronic arthritis,[11] TMD and para-function,[8] and articular disc displacement.[2,14-16]

On the other hand, some limitations have been raised over those observations as well. It was pointed out that the cause of TMD is multifactorial and the criteria for diagnosis is unclear.[17] To clarify the relationship between TMD and asymmetry, gender, age and the influence of other factors should be considered and the diagnostic criteria for TMD should be clear.[4]

Efforts to standardize the examination procedure of TMD and enhance its reliability resulted in the research diagnostic criteria for TMDs (RDC/TMD).[18] The RDC/TMD consists of guidelines and procedures that help the examiner gain an adequate inter-observer reliability by using diagnostic criteria for examining muscle pain, disc displacement, and arthralgia and arthritis of the TMJ.

This study was performed to investigate the relationship between the asymmetry of the mandibular height and clinically diagnosed TMD based on RDC/TMD Axis I in a sample in which the age and gender were controlled for.

MATERIALS AND METHODS

1. Subjects

We selected randomly records of 10 adult patients, 5 males and 5 females, per decade of age from the third to sixth decade and over the sixth decade to make up a TMD group consisting of 100 TMD patients. All of the subjects had presented with complaints of TMD-related symptoms at the TMJ and Orofacial Pain Clinic of the Seoul National University Dental Hospital from 2009 to 2011 and been diagnosed with TMD based on the clinical examination according to the RDC/TMD Axis I and plain radiographic examination including orthopantomogram, TMJ orthopantomogram, and transcranial radiograph. The control group was made up of records of 100 patients in the same manner as the TMD group from the pool of patients who had presented with other dental problems that were not related to TMDs and without any presence or history of TMD-related symptoms, such as joint noise, pain, or discomfort when moving the jaw. Patients with a history of inflammatory joint disease, trauma, maxillofacial deformities, and maxillofacial surgery can affect the TMJ and were excluded from both the TMD and control group. This study protocol was approved by the Institutional Review Board of Seoul National University Dental Hospital (#CRI11001).

2. Clinical Diagnosis Based on RDC/TMD Axis I

In this study, the diagnosis of TMD was based on the RDC/TMD Axis I by a single examiner (Lee), a specialist on TMD and one of the authors of this study. The RDC/TMD Axis I diagnosis consisted of three categories with diagnostic criteria for each category: group I (muscle disorder, MD group), group II (disc displacement, DD group), and group III (arthralgia/arthrosis/arthritis, AR group), which were diagnosed based on the results of the clinical examinations and radiographic findings. Although, each group is divided into subgroups in detail, in order to evaluate the relationship between RDC/TMD diagnosis and the mandibular asymmetry more clearly, in this study, the RDC/TMD Axis I diagnosis was applied just dichotomously as in the previous study that evaluated the reliability and validity of diagnostic algorithms of RDC/TMD.[19] The diagnosis was made only to determine if a patient belonged to any of the RDC/TMD Axis I groups. The patients belonging to any subgroup of group I were designated as the MD group and the patients belonging to any of group II as the DD group. In the case of a group III diagnosis, the patients were classified into the AR group and the non-AR group to evaluate the relationship between articular bone change and asymmetry.

3. Estimation of Mandibular Asymmetry

Orthopantomograms (Orthopantomograph OpR 100; Instrumentarium Corp., Helsinki, Finland) were taken and

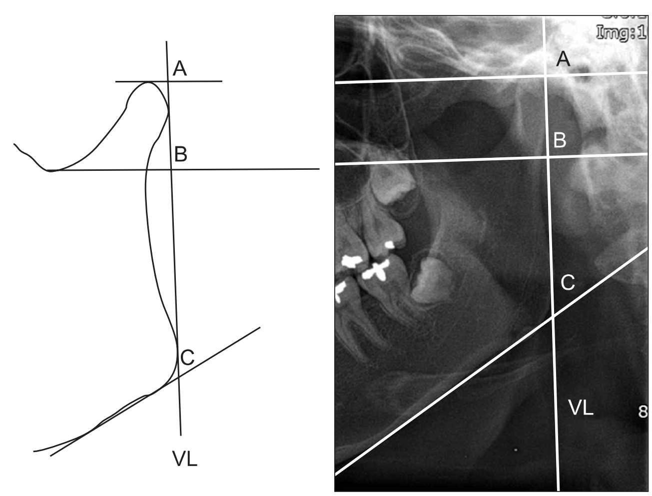

Fig. 1. The reference points of estimation of mandibular asymmetry. VL, the line that passes the most lateral points of the condyle and the angle of the ramus; A, the point where VL crosses the line that is perpendicular to the VL and passes the most superior point of the condyle; B, the point where VL crosses the line that is perpendicular to the VL and passes the most inferior point of the mandibular notch; C, the point where VL crosses the line that is perpendicular to the VL and tangent to the inferior border of mandible. Condylar height (CH), the distance between A and B; ramus height (RH), the distance between B and C; total height (TH), condylar height+ramus height.

digitalized by scanning image plates with the FCR XG5000 (Fujifilm Corp., Tokyo, Japan). Mandibular height was measured on images paper-printed in gray scale by a single examiner (Noh).

To evaluate the mandibular vertical asymmetry in the orthopantomograms, mandibular heights were measured as described previously.[11] The reference points and lines were shown in Fig. 1. The height was measured in mm on a 0.1 mm basis. The percent difference for total height (TH) and the asymmetry index (AI) were calculated with the following formula.[6]

$$AI = TH_{right} - TH_{left} / TH_{right} + TH_{left} \times 100$$

4. Statistical Analysis

To define the mandibular asymmetry affecting the TMD incidences, the cut-off value was estimated from the percentile curve of the absolute AI, which made a significant difference in the asymmetry incidence between the TMD and control group. The risk of TMD by mandibular asymmetry defined with the cut-off value of the absolute AI was analyzed by logistic regression analysis. All statistical analyses were performed using SPSS IBM Statistics 21.0 for Windows (IBM Co., Armonk, NY, USA).

RESULTS

The mean age of the patients was 44.96 years in the TMD group and 45.43 years in the control group, which were not significantly different from each other.

Referring to the percentile curve of the absolute AI for all subjects including the TMD and control groups, the AI absolute value for the 90th percentile, 4.37%, turned out to be the smallest value that made a significant difference in the asymmetry incidence between the TMD and control group ($p<0.01$). Based on this value, there were 16 asymmetry patients in the TMD group and 4 in the control group. The risk

Table 1. Asymmetry group distribution of the TMD and control group

	TMD	Control	Odds ratio[a]	Significance[b]
Number of patients (male+female)				
Asymmetry	16 (8+8)	4 (2+2)	4.57**	
Normal	84 (42+42)	96 (48+48)		
Total	100	100		
Asymmetry index (mean±SD)				
Asymmetry	5.81±0.92	5.43±0.90		NS
Normal	1.52±1.03	1.45±1.28		NS
Total	2.20±1.87	1.61±1.49		*

TMD, temporomandibular disorder; SD, standard deviation; NS, not significant.
[a]Statistical analysis by binomial logistic regression analysis. [b]Statistical analysis by independent sample t-test.
*p<0.05. **p<0.01.

Table 2. Incidence of asymmetry according to age and gender in the TMD and control group (n)

Age group	Gender	TMD group			Control group			Total		
		Asymmetry	Normal	Total	Asymmetry	Normal	Total	Asymmetry	Normal	Total
20s	Male	1	9	10	0	10	10	1	19	20
	Female	3	7	10	0	10	10	3	17	20
30s	Male	1	9	10	0	10	10	1	19	20
	Female	3	7	10	0	10	10	3	17	20
40s	Male	4	6	10	0	10	10	4	16	20
	Female	0	10	10	1	9	10	1	19	20
50s	Male	1	9	10	0	10	10	1	19	20
	Female	2	8	10	1	9	10	3	17	20
Over 60s	Male	1	9	10	2	8	10	3	17	20
	Female	0	10	10	0	10	10	0	20	20
Total		16	84	100	4	96	100	20	180	200

TMD, temporomandibular disorder.
No significant differences by chi-square test were found among the age groups and between the genders within TMD, control, and total subjects.

Table 3. Asymmetry group distribution of the TMD group according to the RDC Axis I

	RDC group, n (%)				Significance[a]
	Non-MD		MD		
Asymmetry	9 (16.1)		7 (15.9)		NS
Normal	47 (83.9)		37 (84.1)		
Total	56 (100)		44 (100)		
	Non-DD	Right DD	Left DD	Both DD	
Longer right	3 (8.1)	3 (11.1)	0	2 (14.3)	
Longer left	0	3 (11.1)	4 (18.2)	1 (7.1)	NS
Normal	34 (91.9)	21 (77.8)	18 (81.8)	11 (78.6)	
Total	37 (100)	27 (100)	22 (100)	14 (100)	
	Non-AR	Right AR	Left AR	Both AR	
Longer right	5 (7.4)	0	1 (10)	2 (25.0)	
Longer left	2 (2.9)	5 (35.7)	1 (10)	0	**
Normal	61 (89.7)	9 (64.3)	8 (80.0)	6 (75.0)	
Total	68 (100)	14 (100)	10 (100)	8 (100)	

TMD, temporomandibular disorder; RDC, research diagnostic criteria; MD, muscle disorder; DD, disc displacement; AR, arthrosis; NS, not significant.
[a]Statistical analysis by chi-square test.
**p<0.01.

of TMD was higher in the asymmetry group by 4.57 (odds ratio) (Table 1).

The difference in asymmetry incidence among the age groups was not significant. Asymmetry subjects were equally observed, 10 out of 100, in both genders (Table 2).

When dividing the TMD group according to the RDC/TMD Axis I diagnosis, the incidence of asymmetry was not different between the MD and non-MD group or between the DD and non-DD group. However, the subjects in AR group showed a higher frequency of asymmetry compared to non-AR group ($p<0.01$) (Table 3).

DISCUSSION

There have been various reports about the issue whether mandibular asymmetry affects the occurrence of TMDs. Some studies have shown that the condylar-mandibular ramus asymmetry is more pronounced in TMD patients. A significant difference in condylar height between TMD patients and asymptomatic individuals has been reported, but no significant difference when comparing gender or age in both groups.[4)] No statistically significant differences between age, condylar asymmetry, and ramus asymmetry of the experimental and control groups were found in the study on the relationship between AI and handedness in a group of TMD patients.[5)]

Other studies have shown the relationship between asymmetry and signs of TMD. It was reported that the degree of mandibular vertical asymmetry is significantly correlated with TMJ internal derangement symptoms.[14)] The unilateral TMJ osteoarthritis (OA) was suggested to relate to the dentofacial morphology. However, the cause and effect relationship among TMJ OA, the masticatory muscle function, and the dentofacial morphology could not be elucidated.[20)]

It is still controversial whether asymmetry affects the occurrence of TMDs. It might be partly because, although age and gender is well known to affect the occurrence of TMDs, such factors were not properly controlled for analysis in most previous studies.[2,4-9,12,21)] Differences in the relationship between age and condylar asymmetry in TMD patients have been shown,[7)] and a correlation between the condylar AI and age was observed only in the experimental group with TMD but not in the control group.[6)] However, the sample size was rather small and the subjects were not distributed evenly in age and gender.

In this study, we controlled the distribution of age and gender to avoid their influence on the occurrences of TMD and asymmetry. As far as we know, this is the first attempt to control for the influence of age and gender to study the relationship between TMD and asymmetry, based on 100 age-and-gender-matched TMD subjects and 100 non-TMD control subjects.

Another important issue was to elucidate the relationship between the mandibular asymmetry and TMD so to adopt proper diagnostic criteria for TMD and asymmetry itself. The clear classification of the TMD patients and control group, as well as the asymmetry and normal patients, should precede the analysis. The RDC/TMD Axis I, which had been introduced and revised recently and is the most widely used in the clinical research field, was adopted to define the TMD patients in this study.[18,19,22] In the case of mandibular asymmetry, there have been lots of suggestions to define how much difference between both TMJs can be defined as 'asymmetry.' It was suggested that a ≤3% AI can be attributable to technical errors due to the head position during the orthopantomogram, and thus, an AI greater than 3% should be considered as mandibular asymmetry.[23] While many studies have used the method presented by the Habets et al.[23] to measure mandibular asymmetry, a reliable method for measuring AI on orthopantomograms was reported.[11] However, the threshold value for the inclusion criteria of the asymmetry group was not introduced in the study, but only the mean and standard deviation of the AI in the experimental groups. Based on previous studies regarding this issue, the methods presented to measure asymmetry were various and there has been no specific 'gold standard' for the threshold value. At this point, before defining mandibular asymmetry, the most important thing to keep in consideration is that the threshold we need is not to determine whether someone's mandible is symmetrical, but if someone's mandibular asymmetry is problematic for TMD.

For this purpose, firstly, we tried to determine the cut-off AI value, which made a difference in the incidence of asymmetry between the TMD and control groups by referring to the percentile distribution of the absolute AI value in all the subjects. From the results, the 90th percentile value of absolute AI, 4.37%, turned out to be the smallest value to have a significant difference between the groups by 4.57 (odds ratio), which means that once someone has asymmetry of the mandibular height by more than 4.37%, he/she has more risk for TMD by 4.57 fold. It has a much higher clinical implication than the previous studies because the value was estimated from the sample controlling for age and gender in terms of an evenly randomized selection for all ages and genders.

However, the increased risk of TMD by asymmetry in our results should be interpreted carefully. Despite that the asymmetry distribution was significantly more frequent in the TMD group, it was merely 16 out of 100 TMD subjects and many more TMD subjects, 84 out of 100, did not show asymmetry. This result implies asymmetry of mandibular height must be able to play an offensive role in occurrence of TMD; however, it is not sufficient to support a direct cause and effect relationship.

It is because TMD usually occurs when various contributing factors undermine orthopedic stability of the TMJ. While the TMJ remains healthy in a balanced environment between the adaptive capacity of the TMJ and functional demand,[24,25] when functional demand exceeds the adaptive capacity of the joint due to any of the debilitating factors affecting the TMJ, it is brought to maladaptation and the tissue response of the TMJ may shift from adaptation to degeneration and destruction. Although asymmetry functions as a debilitating factor for a stable orthopedic state, its effect is not fully independent, but is affected by the interaction with other contributing factors.[17] On the other hand, there should be various factors to promote asymmetrical growth in the growth phase,[20,26-28] which might increase the risk for TMD as well as asymmetry. Thus, it can also be postulated that asymmetry might be just a result of the growth phase with such factors affecting the TMJ and growth rather than an actual causative factor of TMD.

Since TMD is a complex disease, which covers many different varieties of symptoms, it was difficult to categorize its clinical characteristics. The relationship between the incidence of asymmetry and TMD in this study was investigated in TMD patients diagnosed according to RDC/TMD Axis I because, as described above, the diagnostic criteria of TMD is very important to evaluate its relationship with some factor. The result showed the MD group and DD group had no difference but the AR group had a statistically significant difference ($p<0.01$). This upholds the connection between unilateral OA and facial asymmetry, keeping up with the earlier reports of Matsumoto et al.[20]

In animal research, the ablation of the articular disc decreases the ramus height, thus leading to a mandibular midline shift on the affected side.[29] These results suggest that unilateral TMJ OA may result in a shortened vertical dimension within the joint, thereby causing facial asymmetry. Though the accurate causes of TMJ OA are unclear, much evidence suggests that mechanical overload could be regarded as an initiating factor for TMJ degeneration, thereby resulting in condylar resorption and facial asymmetry.[28] As such, the result of RDC III showed a close connection between asymmetry and OA, yet it cannot be confirmed by just this result whether asymmetry is the cause of OA or its result.

In conclusion, mandibular asymmetry by more than 4.37% of difference between the mandibular heights of both sides may increase the risk of TMD and it has a significant positive correlation with TMJ OA. Henceforth, for further investigation on the cause and effect relationship between the mandibular asymmetry and TMD, a longitudinal observation of a sufficiently large size of controlled sample should be done for a sufficiently long time covering the growth phase.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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