# Association between Temporomandibular Disorders and Asymmetrical Articular Eminence

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**Abstract**

Articular eminence (AE) can lead to rapid degeneration due to heavy occlusal loads. Asymmetrical AE is common in individuals with temporomandibular disorders (TMD). It is also associated with gender, age, occlusion, missing teeth, and sleep bruxism. Therefore, further research is required to analyze the relationship between these conditions and asymmetrical AE, and we examined the associations between TMD diagnoses and asymmetrical AE inclination.

This research implemented a cross-sectional study in the diagnosis process using diagnostic criteria for TMD and transcranial radiographs from 70 subjects (14 male and 56 female) aged 20 years and older. A one-way analysis of variance was used to determine the association between TMD diagnoses and asymmetrical AE. An independent *t*-test was used to determine the association between gender, age, occlusion, missing teeth, and sleep bruxism to asymmetrical AE. A chi-square test was used to determine the influence of gender, age, occlusion, missing teeth, and sleep bruxism in association with TMD diagnoses. A logistic regression multivariate test was used to determine which factors are the most influential to asymmetrical AE.

The TMD diagnosis is related to asymmetrical AE. A post hoc test showed significant values in intraarticular disorders and combination disorders. Gender and age were associated with TMD diagnoses. Based on a multivariate test, TMD diagnoses were the most influential factor in asymmetrical AE, with an odds ratio of 9.75 for intraarticular disorders and 4.13 for muscle disorders. TMD diagnoses are significantly associated with asymmetrical AE. TMD with intraarticular and muscle disorders are 9.75 times more likely to cause asymmetrical AE compared with TMD with muscle disorders.

**Clinical article (J Int Dent Med Res 2019; 12(3): 1029-1034)**

**Keywords:** Asymmetrical articular eminence, Inclination, TMD, Transcranial.

**Received date: 11 February 2019** **Accept date: 19 March 2019**

## Introduction

The temporomandibular joint (TMJ) works bilaterally as a unit in which one side of the joint could not move without the movement of the other side.[1] Unilateral chewing produces one-sided loading of mastication.[2] Those with heavier loading tend to have a greater inclination towards articular eminence (AE).[3] The normal asymmetrical AE inclination range is between 0–5°.[4,5,6] Iwasaki *et al.* had a study comparing the asymmetrical inclination between subjects with disc displacement and healthy subjects and showed that asymmetrical AE is commonly found four times more often in individuals with disc displacement than in healthy patients.[7] There has not yet been any research that explains the association between asymmetrical AE with temporomandibular disorders (TMD), such as muscle disorders, intraarticular disorders, or a combination of both. It would be beneficial for clinicians to assess the prognosis and management of TMD based on the asymmetrical AE inclination found in transcranial radiography.

Studies have shown that gender, age, occlusion, missing teeth, and habitual sleep bruxism affect AE inclination.[1,4,7,8,9,10,11,12,13] Moreover, these variables have also been commonly associated with TMD patients who are female, patients aged 20–40 years, patients with stable occlusions and without missing teeth, and patients with chronic sleep bruxism.[2,14,15,16,17]

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## Materials and methods

Approved by the Ethical Committee in the Faculty of Dentistry Universitas Indonesia, this study was performed at the Dental Hospital, in the Faculty of Dentistry, Universitas Indonesia. It was consisted of 70 subjects (14 male and 56 female) aged 20 years and older with TMD. There was no control subject by reason of the avoidance of unnecessary x-ray exposure towards healthy subject. Under the approval of informed consent, each subject was examined using diagnostic criteria for (DC) TMD to assess the type of TMD. Essential data were gathered, including gender, age, occlusion, missing teeth, and sleep bruxism habit. Dental impressions and transcranial radiography on each side of the TMJ were taken to complete the data. Each transcranial radiograph was then attached in a radiograph viewer and captured using Canon EOS 70D with standard settings (automatic shutter speed and aperture, white balance 5500K). Using CorelDRAW Graphics Suite X5, the AE inclination of the digital transcranial radiograph was calculated to evaluate the difference of the angle between each side. The best fit line method was used to calculate the inclination, which is an angle between the top line of the Frankfurt horizontal plane and the slope line of the posterior inclination of AE [13, 18-20]. A reliability test of the DC TMD examination, sleep bruxism diagnostic questionnaire, and AE inclination measurements were taken from 20 subjects.

Different statistical measurements were used. A test-retest reliability method was chosen to determine the reliability by a single rater. A Kolmogorov-Smirnov normality test was conducted to examine the subject distribution. A one-way analysis of variance (ANOVA) was used to determine the association between TMD diagnoses and asymmetrical AE. An independent *t*-test was used to determine the association between gender, age, occlusion, missing teeth, and sleep bruxism to asymmetrical AE. A chi-square test was used to determine the influence of gender, age, occlusion, missing teeth, and sleep bruxism in association with TMD diagnoses. A logistic regression multivariate test was used to determine which factors are the most influential to asymmetrical AE.

## Results

The test results showed high reliability with an Intraclass Correlation score for DC TMD examination, Sleep Bruxism Questionnaire, and AE inclination measurement of the right and left sides, respectively: 0.87, 0.86, 0.97, 0.98.

The subject distribution for gender, age, occlusion, missing teeth, sleep bruxism habit, and TMD diagnoses are shown in Table 1. Most subjects had a combination of muscle and intraarticular disorders and were female, aged 20–40 years, had stable occlusions, no missing teeth, and did not have sleep bruxism.

| Variable | n | % |
|---|---|---|
| Gender | | |
| Male | 14 | 20 |
| Female | 56 | 80 |
| Age | | |
| 20-40 | 57 | 81.4 |
| >40 | 13 | 18.6 |
| Diagnoses | | |
| Muscle disorders | 10 | 14.3 |
| Intraarticular disorders | 15 | 21.4 |
| Combination disorders | 45 | 64.3 |
| Occlusion | | |
| Stable | 65 | 92.9 |
| Unstable | 5 | 7.1 |
| Missing teeth | | |
| No | 41 | 58.6 |
| Yes | 29 | 41.4 |
| Sleep bruxism | | |
| Yes | 24 | 34.2 |
| No | 46 | 65.7 |

**Table 1.** Frequency Distribution of Variables.

A normality test of TMD diagnoses showed a normal distribution ($p > 0.05$). According to the one-way ANOVA test, TMD diagnoses were strongly associated with asymmetrical AE inclination ($p < 0.5$; Table 2). A post hoc test showed a significant difference between muscle disorders and the combination of muscle and intraarticular disorders ($p = 0.000$) and between muscle disorders and intraarticular disorders ($p = 0.042$; Table 3).

| | | n | Mean ± SD | *p*-value |
|---|---|---|---|---|
| **Asymmetrical AE Inclination** | Muscle disorders | 10 | 3.53 ± 2.05 | 0.001* |
| | Intraarticular disorders | 15 | 8.54 ± 4.69 | |
| | Combination disorders | 45 | 10.09 ± 4.92 | |

*One-way ANOVA; Data were considered significant when $p < 0.05$.

**Table 2.** Association Between TMD Diagnoses and Asymmetrical Articular Eminence (AE) Inclination.

| | | Mean Differences | CI 95% Min. | CI 95% Max. | *p*-value |
|---|---|---|---|---|---|
| **Muscle** | **vs. intraarticular** | 5.02 | -9.33 | -0.13 | 0.042* |
| **Intraarticular** | **vs. combination** | 1.54 | -5.2 | 1.53 | 0.56 |
| **Combination** | **vs. muscle** | 6.56 | 2.62 | 10.5 | 0.000* |

*Data were considered significant when $p < 0.05$.

**Table 3.** Post hoc Analysis of TMD Diagnoses.

Conversely, gender, age, occlusion, missing teeth, and sleep bruxism have no significant association with asymmetrical AE inclination ($p > 0.05$). However, asymmetrical AE inclination was higher in females, aged 20–40 years, with unstable occlusions, missing teeth, and with a habit of sleep bruxism (Table 4).

| | Variable | n | Mean ± SD | p |
|---|---|---|---|---|
| **Asymmetrical AE Inclination** | Occlusion | | | 0.242* |
| | Stable | 65 | 8.56 ± 4.85 | |
| | Unstable | 5 | 11.33 ± 7.54 | |
| | Gender | | | 0.103* |
| | Male | 14 | 6.78 ± 5.91 | |
| | Female | 56 | 9.25 ± 4.76 | |
| | Age | | | 0.616 |
| | 20-40 | 57 | 8.53 ± 4.1 | |
| | >40 | 13 | 9.74 ± 8.21 | |
| | Sleep Bruxism | | | 0.889 |
| | Yes | 24 | 8,88 ± 4,84 | |
| | No | 46 | 8.7 ± 5.23 | |
| | Missing Teeth | | | 0.775 |
| | No | 41 | 8.67 ± 4.6 | |
| | Yes | 29 | 8.89 ± 5.73 | |

*Variable included in the multivariate analysis

**Table 4.** Association Between Gender, Age, Occlusion, Missing Teeth, and Sleep Bruxism with Asymmetrical AE Inclination.

Based on the results of the bivariate analysis, gender, occlusions, and TMD diagnoses were all variables that can be included in the multivariate analysis. The asymmetrical AE inclination was divided into two groups: 1–5° and >5°. The results showed that TMD diagnoses have the strongest association with asymmetrical AE inclination. The highest odd ratio was with the combination muscle and intraarticular disorders (9.75), and the lowest was with intraarticular disorders (4.13; Table 5). The logistic regression for asymmetrical AE inclination was formulated as: −0.405 + 1.417 × (intraarticular diagnoses) + 2.277 × (combination diagnoses).

| | | Asymmetrical Inclination $0^0$-$5^0$ n | % | AE $> 5^0$ N | % | *p*-value | OR (CI 95%) |
|---|---|---|---|---|---|---|---|
| **TMD Diagnoses** | Muscle disorders | 6 | 60 | 4 | 40 | | - |
| | Intraarticular disorders | 4 | 26.7 | 11 | 73.3 | 0.104 | 4.13 (0.75-22.71) |
| | Combination disorders | 6 | 13.3 | 39 | 86.7 | 0.004 | 9.75 (2.11-45) |
| | | 16 | 22.9 | 54 | 77.1 | | |

**Table 5.** Multivariate Analysis of Variables Toward Asymmetrical AE Inclination.

Gender and age had a significant association with TMD diagnoses amongst other variables, such as occlusion, missing teeth, and sleep bruxism ($p < 0.05$; Table 6).

| | TMD Diagnoses | | | | | | |
|---|---|---|---|---|---|---|---|
| | Muscle Disorders | | Intraarticular Disorders | | Combination Disorders | | *p*-value |
| | n | % | n | % | n | % | |
| **Occlusion** | | | | | | | |
| **Stable** | 9 | 90 | 14 | 93.3 | 42 | 93.3 | 0.936 |
| **Unstable** | 1 | 10 | 1 | 6.7 | 3 | 6.7 | |
| **Gender** | | | | | | | |
| **Male** | 6 | 60 | 2 | 13.3 | 6 | 13.3 | 0.009* |
| **Female** | 4 | 40 | 13 | 86.7 | 39 | 86.7 | |
| **Age** | | | | | | | |
| **20-40** | 5 | 50 | 14 | 93.3 | 38 | 84.4 | 0.029* |
| **>40** | 5 | 50 | 1 | 6.7 | 7 | 15.6 | |
| **Sleep Bruxism** | | | | | | | |
| | 5 | 50 | 4 | 26.7 | 15 | 33.3 | 0.472 |
| **Yes** | 5 | 50 | 11 | 73.3 | 30 | 66.7 | |
| **No** | | | | | | | |
| **Missing Teeth** | | | | | | | |
| **No** | 5 | 50 | 11 | 73.3 | 25 | 55.6 | 0.403 |
| **Yes** | 5 | 50 | 4 | 26.7 | 20 | 44.4 | |

*Chi-square test; Data were considered significant when $p < 0.05$.

**Table 6.** Association Between Occlusion, Gender, Age, Sleep Bruxism, And Missing Teeth with TMD Diagnoses.

## Discussion

A study by Lora *et al.* showed that the comparison of TMD between females and males was about 4:1.[14] This result is consistent with our study, where the percentage of female subjects was 80% and the male subjects was only 20% (Table 1). According to a study by Smith *et al.* in Syed, females are more attentive than males when it comes to health issues, and more likely to seek treatment.[21]

Few studies have assessed that people 20–40 years old are more susceptible to TMD[15,16], whereas reproductive hormones, such as estrogen, reach the highest levels during that age range and can lead to degradation of the TMJ ability to withstand occlusal loads.[22] This could be the reason behind the majority of 20- to 40-year-old subjects (Table 1).

Consistent with this study, Patil *et al.* found that TMD was more common among patients with stable occlusions.[17] Humphrey *et al.* in Patil discovered that fully dentate patients have 5 to 6 times more occlusal loading than patients with dentures.[17]

We also found an association between TMD diagnoses and asymmetrical AE inclination ($p = 0.001$; Table 2). This result is consistent with a study from Iwasaki *et al*. who reported that asymmetrical AE inclination was found in four times more subjects with disc displacement than in healthy subjects.[7] Sembulu *et al.* explained that AE is related to occlusal loading.[23] Greater occlusal loading causes a steeper AE and vice versa.[3] Different occlusal loading between both sides will produce a different AE inclination. [7]

Comparing the absolute mean differences showed significant results between muscle disorders and a combination of muscle and intraarticular disorders as well as between muscle disorders and intraarticular disorders (Table 3). Furthermore, the mean asymmetrical AE inclination of muscle disorders was 3.53°, which is in the normal range of asymmetrical AE inclination (0–5°). Thus, this study confirmed that asymmetrical AE inclination was not found in muscle disorders but was found in TMD that has progressed into intraarticular disorders.

In this study, occlusion did not have a significant association with asymmetrical AE inclination ($p > 0.05$) (Table 4). A previous study confirmed that occlusions might not be crucial for the deformation of AE.[3] This may be caused by the preference of the chewing side generated by the central nervous system, which tends to chew on the most comfortable side.[2] However, the mean asymmetrical AE inclination in the unstable occlusion group was higher than in the stable occlusion group. Consistent with Huang *et al*., unilateral chewing preference caused by unilateral missing teeth gives more occlusal loading to the nonfunctional side.[10] If it happens during developmental growth, degeneration of cranium morphology, including AE will irreversibly occur.[1]

In concordance with other previous studies, gender reveals a weak association with asymmetrical AE inclination.[4,12,23] In fact, female subjects had a greater asymmetrical AE inclination compared with male subjects (Table 4). High-level estrogen in females may cause the degradation of the TMJ adaptation to the occlusal load . [22]

Age was not significantly associated with the asymmetrical AE inclination, but subjects older than 40 years of age have a higher absolute mean of asymmetrical AE inclination than subjects between 20 and 40 years of age (Table 4). As patients get older, the TMJ adaptation decreases and can no longer adjust to oral changes. [8]

A previous study suggested that functional activity may lead to AE remodeling and parafunctional activity .[4] Although insignificant, this study found that patients with a sleep bruxism habit have a slightly greater absolute mean of asymmetrical AE inclination (Table 4).

This study also found that subjects with missing teeth have a higher absolute mean of asymmetrical AE inclination than subjects without missing teeth (Table 4). Missing teeth in one or both sides of the jaw may contribute to the loss of centric occlusions and centric relation, hence bring the position of the condyle up to the posterosuperior glenoid fossa. This new position can cause AE inclination to be flatter than before.[9,24] Otherwise, subjects without missing teeth have a stable centric relation and occlusion, thus maintaining the condyle position in its superoanterior glenoid fossa.

The multivariate test showed that among gender and occlusion, TMJ diagnoses played the most significant role in the asymmetry of AE inclination. According to the OR score, TMD patients subjected to intraarticular disorders are 4.13 times more likely of having asymmetry AE inclination, whereas patients subjected to a combination of muscle and intraarticular disorders have the highest risk at 9.75 times.

Stable occlusions had the highest proportion of muscle and intraarticular disorders (64.6%; Table 6). As suggested by Alzarea, the proprioceptive ability of teeth may initiate TMD symptoms .[25] Therefore, in this study, subjects with stable occlusions have the highest proportion of combination disorders.

Female subjects have been found to have

a higher prevalence of TMD symptoms than male subjects. [25,26] In fact, Atsu *et al.* showed that TMD were commonly found four times more often in females. [27] In our study, female patients who suffered from a combination of muscle and intraarticular disorders, intraarticular disorders, and muscle disorders represented 69.6%, 23.2%, and 7.1%, respectively (Table 6). On the other hand, there were only 42.9% of male patients in each combination disorder and muscle disorder. This result revealed that female patients had the highest proportion of severe TMD ($p < 0.05$). This inequality may be contributed to estrogen and progesterone that can sensitize muscle and joint pain by lowering the pain threshold .[14] Moreover, psychologically, females are more prone to stress, which may induce TMD. [22,27]

Age was found to be associated with TMD diagnoses ($p < 0.05$). Combination disorders and intraarticular disorders were primarily found in 20- to 40-year-old patients (24.6% and 66.7, respectively; Table 6). On the contrary, muscle disorders were commonly found in those over 40 years of age (38.5%). This result may be because of the high levels of estrogen and progesterone in 20- to 40-year-old patients, which contribute to the degeneration of the TMD ability towards occlusal loading. [14]

No relationship was found between sleep bruxism and TMD diagnoses ($p > 0.05$; Table 6). Raphael *et al*. stated that personal information given by the subjects might be inaccurate, thus needs an additional examination, such as polysomnography .[28,29] However, habitual sleep bruxism subjects have a higher number of combination and intraarticular disorders.

This study showed that dentate subjects had a higher percentage of combination and intraarticular disorders. In fact, intraarticular disorders were commonly found three times more often in dentate subjects (Table 6). This result may be related to the proprioceptive ability that is optimum in dentate patients and may induce a parafunctional habit that leads to TMD .[1]

## Conclusions

There was an association between TMD diagnoses and asymmetrical AE inclination. Intraarticular disorders and a combination of muscle and intraarticular disorders significantly influenced the asymmetrical AE inclination. Occlusion, gender, age, missing teeth, and chronic sleep bruxism were not associated with asymmetrical AE inclination. Among several variables, only gender and age affected TMD diagnoses. For the future study, unilateral chewing should be considered as one of the confounding variables. It is advisable to use Cone-Beam Computed Tomography to improve significant accuracy in measuring AE inclination.

## Declaration of Interest

The authors report no conflict of interest.

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