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Original Article

Panoramic Assessment of the Effect of Dental Status on the Articular Eminence Inclination

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Abstract

Background: Tooth loss may alter temporomandibular joint loading and morphology. Its relationship with articular eminence inclination remains unclear.. This study aimed to assess the effect of dental status (presence/absence of an occlusal support zone) on the articular eminence inclination (AEI) using panoramic radiographs.

Methods: This cross-sectional study was conducted on the panoramic radiographs of 90 patients, including 30 completely edentulous, 30 dentate, and 30 partially edentulous patients with unilateral loss of posterior support. The AEI was calculated as the angle formed between the line connecting the deepest point of the glenoid fossa to the most prominent point of the articular eminence and the Frankfurt plane. The data were analyzed by ANOVA and the Tukey, Kruskal-Wallis, Mann-Whitney, and t-tests (alpha = 0.05).

Results: The right-side AEI in dentate patients (58.1 ± 2.6 degrees) was significantly greater than that in fully edentulous (49 ± 3.64 degrees) and unilaterally edentulous (50.2 ± 6.04 degrees) patients ($P < 0.001$); the difference between the completely edentulous and unilaterally edentulous cases was not significant ($P = 0.56$). Similarly, the left-side AEI in completely edentulous (47.33 ± 3.24 degrees) and unilaterally edentulous (50.2 ± 6.55) patients was not significantly different ($P > 0.05$), but both values were significantly lower than that in dentate (56.77 ± 3.24 degrees) patients ($P < 0.001$). Dental status was an influential factor on AEI ($P < 0.001$), but its interaction effect with gender was not significant ($P = 0.084$).

Conclusion: Dental status had a significant effect on the AEI, irrespective of gender. AEI in dentate patients was significantly greater than that in completely and partially edentulous patients, but was not significantly different in the latter two groups.

Keywords: Articular eminence, Radiography, Panoramic, Dentition

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Background

The effects of aging and changes in dental status on the anatomy and morphology of the temporomandibular joint (TMJ) are concerning for dental clinicians. Tooth loss and loss of occlusal support are important risk factors for the development of temporomandibular disorders (TMDs) (1). TMDs include clinical signs and symptoms such as pain in the TMJ and muscles of mastication, a clicking sound when opening or closing the mouth, and jaw pain and deviation when opening and closing the mouth (2). Approximately 40%–75% of people have at least one sign of TMDs, such as the clicking sound. Moreover, 33% of the population has at least one symptom, such as joint pain. Furthermore, nearly 5%–7% of TMD patients need treatment to alleviate their signs and symptoms (3). No treatment of TMDs would lead to the development of chronic maxillofacial pain, inability to chew, speech impairments, and changes in the daily lifestyle of patients (4).

Using a complete removable denture is the main treatment option for the reduction of TMD signs and symptoms. Removable dentures can reconstruct the reduced vertical height, correct the centric relation, and consequently decrease TMD signs and symptoms (5). The association of TMJ morphology and function has been well established. However, there are limited studies regarding the association of TMJ morphology and complete edentulism (6).

Granados (7) concluded that tooth loss can damage the TMJ and particularly the articular eminence. The etiology of skeletal changes in the TMJ structure is multifactorial, and several intrinsic and extrinsic factors may be involved in this process. The intrinsic factors include age, gender,

genetics, and weight gain, while the extrinsic factors encompass biomechanical and traumatic factors related to the TMJ structure and chronic overload (8). Some explanations have been offered to describe changes in TMJ morphology and structure due to aging. It has been suggested that aging may be mainly responsible for such changes; however, Sa et al (9) found no significant difference in this regard when comparing different age groups. Some other researchers suggested that changes in dental status and function are mainly responsible for the morphological changes of the TMJ. For instance, Unal Erzurumlu and Celenk (6) concluded that the articular eminence inclination (AEI) was lower in edentulous patients compared with dentate individuals; in addition, the AEI was greater in females than in males. Hamza et al (10) observed no significant difference in AEI between males and females. Another study demonstrated significant differences in AEI among different races (11). Sugisaki et al (12) evaluated the internal condylar structure using cone-beam computed tomography (CBCT) and reported the presence of regular sheets of trabeculae in dentate individuals; nonetheless, the bone trabeculae were abnormally narrow and rod-shaped in edentulous patients. However, the main limitation of their study was that the edentulous patients were significantly older than the dentate patients, and therefore, it could not be determined with certainty whether the changes were related to aging or dental status (12). Oruba et al (13) discussed that as long as the posterior occlusal support is present, age has no significant effect on the AEI; however, when the occlusal support is lost, the AEI decreases.

Knowledge about the morphological changes of the TMJ structure is important since it can aid in the prevention of the functional problems of the TMJ and improve the quality of life of edentulous patients. Thus, this study aims to assess the AEI based on the dental status, age, and gender of patients using panoramic radiography. The null hypothesis of the study is that dental status has no significant effect on the AEI.

Materials and Methods

This cross-sectional study was conducted on panoramic radiographs of 90 patients, including 30 completely edentulous, 30 dentate, and 30 partially edentulous patients with unilateral loss of posterior support. The radiographs were taken at the Oral Radiology Department of Tehran Islamic Azad University of Medical Sciences between 2023 and 2024. It should be noted that the radiographs were taken for purposes not related to this study (e.g., denture treatment, tooth extraction, root canal therapy, and the like) and were retrieved from the archives. The study protocol was approved by the Ethics Committee of the Islamic Azad University of Medical Sciences (IR.IAU.DENTAL.REC.1402.58).

Eligibility Criteria

Good-quality panoramic radiographs of patients between 20 years and 80 years visualizing both the TMJs and articular eminence were selected by convenience sampling. The radiographs of patients with craniofacial abnormalities, systemic diseases that could change the morphological structure of the TMJ (e.g., rheumatoid arthritis, trauma, and maxillofacial fractures), and cases with jaw pathologies were excluded from the investigation (6). The radiographs of patients with a history of denture use were excluded as well.

Sample Size

The sample size was calculated to be 30 in each group according to a study by Hamza et al (10) using the multiple linear regression feature of PASS 11 and assuming $\alpha = 0.05$, $\beta = 0.2$, a mean standard deviation of AEI = 6.6 degrees, and an effect size of 0.36.

Data Collection

Demographic information of patients, including their age and gender, was collected. All panoramic radiographs were obtained by a digital X-ray unit (Sirona Dental Systems GmbH, Germany). According to the dental status (i.e., presence/absence of an occlusal support zone), the patients were assigned to three groups of dentate patients (n = 30), completely edentulous patients (n = 30), and unilaterally edentulous patients with unilateral loss of posterior support (n = 30) (6).

The panoramic radiographs of patients were evaluated by a calibrated oral radiologist using ImageJ software, version 1.45. To measure the AEI, first, the deepest point of the glenoid fossa was connected to the most prominent point of the articular eminence. Next, the Frankfurt plane was drawn by connecting the most inferior point of the orbit and the most superior-posterior point of the external

Figure 1. AEI Measurement in a Patient With Unilateral Loss of Posterior Support. *Note*. AEI: Articular eminence inclination

Figure 2. AEI Measurement in a Completely Edentulous Patient. *Note*. AEI: Articular eminence inclination

auditory meatus. The angle formed at the intersection of these two lines indicated the AEI (Figures 1-3). The panoramic radiographs were traced twice, and the intraclass correlation coefficient was calculated to assess the reliability of the measurements. The intraclass correlation coefficient was estimated to be 0.89, indicating high reliability of measurements.

Statistical Analysis

The obtained data were analyzed using SPSS, version 29 (SPSS Inc., IL, USA). The mean age was compared by one-way analysis of variance (ANOVA), and gender distribution was compared by Fisher's exact test among the three groups. The Kolmogorov-Smirnov test was applied to analyze the normality of data distribution. The right-side AEI data had a normal distribution ($P=0.127$), while the left-side AEI data were not normally distributed ($P=0.042$). Thus, the mean AEI in general and on the right side was compared among the three groups by one-way ANOVA, followed by Tukey's test for pairwise comparisons. The mean AEI on the left side was compared among the three groups by the Kruskal-Wallis test, followed by pairwise comparisons with the Mann-Whitney test. A paired t-test was employed to compare the mean right-side and left-side AEI within each of the three groups. Males and females were compared by the independent t-test regarding the right-side AEI and by the Mann-Whitney U test for the left-side AEI. Eventually, linear logistic regression was applied to analyze the effect of gender and dental status on AEI.

Figure 3. AEI Measurement in a Dentate Patient. *Note*. AEI: Articular eminence inclination

Results

Ninety panoramic radiographs were evaluated. Table 1 presents the mean age and gender distribution of patients in the three groups. The three groups had a significant difference in the mean age ($P<0.001$), but not in gender distribution ($P=0.668$).

Table 2 provides the mean AEI on the right and left sides in the three groups. Based on the results, a significant difference existed in both the right-side and left-side AEI among the three groups ($P<0.001$ for both sides). The pairwise comparisons of the three groups regarding the right-side AEI by the Tukey's test and left-side AEI by the Mann-Whitney test revealed that the mean AEI in dentate patients was significantly greater than that in unilaterally edentulous patients in both the right ($P=0.004$) and left ($P<0.001$) sides. Furthermore, the AEI of both the right and left sides in dentate patients was significantly greater than that in completely edentulous patients ($P<0.001$). However, the difference between the partially edentulous and completely edentulous patients was not significant, neither on the right ($P=0.121$) nor on the left ($P=0.111$) side.

The comparison of the mean right-side and left-side AEI within each group (Table 3) demonstrated no significant difference in any group ($P=0.07$ for the completely edentulous, $P=0.921$ for the partially edentulous, and $P=0.088$ for the dentate group).

Table 1. Distribution of Demographic Parameters in All Three Groups

Parameter	Completely Edentulous (n = 30)	Unilaterally Edentulous (n = 30)	Dentate (n = 30)	*P* Value
Mean age ± SD (years)	12.43 ± 61.57	19.35 ± 53.83	12.33 ± 40.93	0.001[a]
Male	15 (50%)	12 (40%)	15 (50%)	0.668[b]
Female	15 (50%)	18 (60%)	15 (50%)	

Note. AEI: Articular eminence inclination; SD: Standard deviation; ANOVA: Analysis of variance.
[a] One-way ANOVA; [b] Fisher's exact test.

Table 2. Mean AEI (Degrees) in the Right and Left Sides in the Three Groups (N = 90)

Side	Completely Edentulous	Partially Edentulous	Dentate	Statistic	*P* Value
Right	3.64 ± 49	6.04 ± 50.2	2.60 ± 58.13	14.347 F =	< 0.001[a]
Left	3.24 ± 47.23	6.55 ± 50	3.24 ± 56.77	40.134 H =	< 0.001[b]

Note. AEI: Articular eminence inclination.
[a] One-way ANOVA; [b] Kruskal-Wallis test.

Table 3. Comparison of the Mean Right-Side and Left-Side AEIs (Degrees) Within Each Group (n = 30)

Group	Right-Side AEI	Left-Side AEI	Correlation Coefficient	*P* Value*
Completely edentulous	3.64 ± 49	3.24 ± 47.33	-0.109	0.07
Partially edentulous	6.55 ± 50	6.04 ± 50.2	-0.522	0.921
Dentate	3.24 ± 56.77	2.60 ± 58.10	0.011	0.088

Note. AEI: Articular eminence inclination. * Paired t-test.

Based on the comparison of the mean AEI based on gender (Table 4), there was no significant difference between males and females in the right-side AEI ($P>0.05$). Contrarily, the mean left-side AEI was significantly larger in females in completely edentulous patients ($P=0.045$) and significantly larger in males in partially edentulous patients ($P=0.03$). The difference between males and females was not significant in this regard in dentate patients ($P=0.87$).

Regarding the effects of dental status, age, and gender on AEI (Table 5), the logistic regression showed that gender alone had no significant effect on the right-side (Figure 4) ($P=0.983$) or left-side (Figure 5) ($P=0.258$) AEI. Conversely, dental status alone affected the AEI on both sides ($P<0.001$). Nonetheless, the interaction effect of dental status and gender was not significant on the left-side ($P=0.237$) or the right-side ($P=0.063$) AEI.

Discussion

This study assessed the AEI based on the dental status, age, and gender of patients using panoramic radiography. The results confirmed that the AEI in dentate patients was significantly greater than that in completely and partially edentulous patients. Thus, the null hypothesis of the study was rejected.

An asymmetry was also noticed in the right-side and left-side AEI within each group, indicating that aside from dental status, gender, and age, some other factors, such as occlusion and diet, among others, may influence the AEI. This finding is in agreement with the results of Hamza et al (10). They used CBCT and found a significant difference between the right-side and left-side AEI in all three groups of dentate, completely edentulous, and partially edentulous patients. Further, Jasinevicius et al (14) evaluated the AEI asymmetry on 134 dry skulls of two different racial groups and reported significantly different right-side and left-side AEI values in 90% of the skulls. These findings indicate that AEI is influenced by a number of factors other than the dental status.

The present findings indicated greater right-side and left-side AEI in dentate patients compared with completely and partially edentulous patients; however, the difference

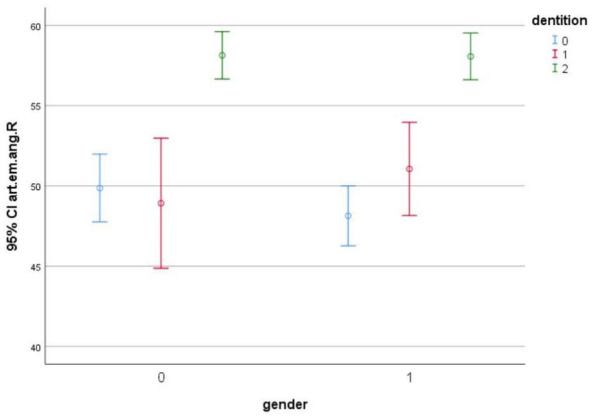

Figure 4. The Role of Gender in the Articular Eminence Slope on the Right Side. *Note*. CI: Confidence interval

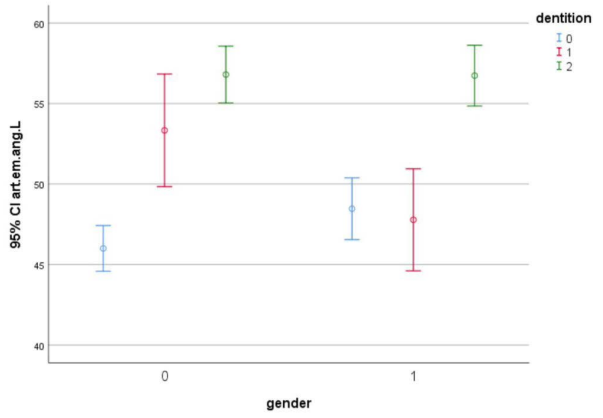

Figure 5. The Role of Gender in the Articular Eminence Slope on the Left Side. *Note*. CI: Confidence interval

Table 4. Comparison of the Mean AEI (Degrees) Based on Gender

Groups (N=90)	Right-Side AEI			Left-Side AEI		
	Male	Female	*P* Value[a]	Male	Female	*P* Value[b]
Completely edentulous (n=30)	3.61±49.87	3.37±48.13	0.443	2.56±46	3.46±48.47	0.045
Partially edentulous (n=30)	6.37±48.92	6.37±51.06	0.932	5.49±53.33	6.37±47.78	0.02
Dentate (n=30)	2.66±58.12	2.63±58.07	0.586	3.41±56.73	3.24±56.77	0.87

Note. AEI: Articular eminence inclination.
[a] Independent t-test. [b] Mann-Whitney U test.

Table 5. Effects of Dental Status, Age, and Gender on the AEI Using the Logistic Regression

Variable	Univariate Analysis of Variance					
	Right Side			Left Side		
	Mean Square	F	*P* Value	Mean Square	F	*P* Value
Gender	0.283	0.015	0.983	342.231	18.093	0.258
Dental status	744.555	39.44	0.001	701.934	37.11	0.001
Dental status * gender	27.671	1.466	0.237	123.044	6.505	0.062

Note. AEI: Articular eminence inclination.

between the latter two groups was not significant. Consistent with our results, Unal Erzurumlu and Celenk (6) investigated the panoramic radiographs of patients and found significantly lower AEI in edentulous patients compared with dentate individuals. Additionally, Modgi et al (15) demonstrated that AEI in edentulous patients was significantly smaller than that in dentate patients. They added that the longer the duration of edentulism, the greater the reduction in AEI would be (15). A similar study used CBCT and showed significantly greater AEI in dentate patients compared with completely and partially edentulous patients (10). Abdul-Nabi and Al-Nakib (16) examined two groups of dentate and edentulous patients and concluded that the AEI of the dentate group was significantly greater than that of the edentulous group, which is in line with the present results. Granados (7) found that AEI was greater in patients who were edentulous for a longer period of time, highlighting the effect of edentulism duration on the TMJ morphology (7,16-18).

Our findings confirmed greater left-side AEI in males than females in the partially edentulous group and greater left-side AEI in females than males in the edentulous group; no other gender-related differences were found. Unal Erzurumlu and Celenk (6) evaluated panoramic radiographs and observed no significant difference in AEI of males and females, irrespective of their dental status, which corroborates our findings.

This study had some limitations. The main limitation was related to using panoramic radiography, which has drawbacks, such as a two-dimensional nature, low resolution, and risk of superimposition of important anatomical landmarks, affecting the validity and reliability of the findings. CBCT is more advantageous and precise, with real three-dimensional and high spatial resolution (19,20). In addition, the anterior guidance is closer to the teeth and has a greater effect on occlusion than the condylar inclination; however, since this study was conducted on panoramic radiographs, it was impossible to measure overjet and overbite on panoramic radiographs. Therefore, we could not measure the anterior guidance in this study, which was a limitation. Future studies are required on both the AEI and anterior guidance (13). According to Ma et al, TMD patients with chewing side preference seem to have a deep glenoid fossa with steep eminence, which might be considered one characteristic imaging feature (21). Lack of knowledge about the duration of edentulism of patients was another limitation. Due to the limited information on patients' history (e.g., the time since tooth loss), longitudinal studies are necessary to investigate whether the long-term effects of tooth loss have a different association with the AE inclination. Furthermore, the effects of factors such as malocclusion and masticatory habits should be taken into account in future studies.

Conclusion

Dental status had a significant effect on the AEI, regardless of gender. AEI in dentate patients was significantly greater than that in completely and partially edentulous patients, but was not significantly different in the latter two groups.

Authors' Contribution

Conceptualization: Sandra Mehralizadeh.
Data curation: Farbod Behnia.
Formal analysis: Mohamad Javad Kharazifard.
Investigation: Sandra Mehralizadeh.
Methodology: Sandra Mehralizadeh.
Project administration: Sandra Mehralizadeh.
Resources: Sandra Mehralizadeh.
Supervision: Sandra Mehralizadeh.
Validation: Sandra Mehralizadeh.
Visualization: Sandra Mehralizadeh.
Writing–original draft: Hedieh Emami Aleagha.
Writing–review & editing: Hedieh Emami Aleagha.

Competing Interests

None to declare.

Ethical Approval

This study was approved by Islamic Azad University, Tehran Medical Branch (Approval number: IR.IAU.DENTAL.REC.1402.58).

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