doi: 10.30934/kusbed.1271577 **e-ISSN:** 2149-8571

Kocaeli Üniversitesi Sağlık Bilimleri Dergisi

Özgün Araştırma / Original Article

http://dergipark.org.tr/kusbed

INVESTIGATION OF CONDYLE POSITIONS IN PATIENTS WITH TEMPOROMANDIBULAR JOINT DISORDER BY CONE-BEAM COMPUTED TOMOGRAPHY

Fatma Akkoca[1], Sadeq Mohammed Taqi Fadhıl[2], Rıdvan Akyol[3*]

[1] Dokuz Eylül University, Faculty of Dentistry, Department of Dentomaxillofacial Radiology, Izmir, Türkiye;[2] Prosthodontist Specialist, Private Dentist, Antalya, Türkiye; [3] Nuh Naci Yazgan University, Faculty of Dentistry, Department of Dentomaxillofacial Radiology, Kayseri, Türkiye

ORCID iD: Fatma Akkoca: 0000-0002-4522-656X; Sadeq Mohammed Taqi Fadhıl: 0000-0001-8365-3370; Rıdvan Akyol: 0000-0003-3122-4675

***Sorumlu Yazar / Corresponding Author:** Rıdvan Akyol, **e-posta / e-mail:** ridvanakyol10@gmail.com

Geliş Tarihi / Received: 27.03.2023 **Kabul Tarihi / Accepted:** 16.08.2023 **Yayım Tarihi / Published:** 04.10.2023

Abstract

Objective: The condylar position refers to the location of the mandibular condyle within the glenoid fossa when the teeth are in maximum intercuspal, and it is an important indicator of the temporomandibular joint (TMJ) function. This study aimed to assess the condylar position of the TMJ in patients with TMJ disorder using cone-beam computed tomography (CBCT).

Methods: The present study utilized CBCT to evaluate the condylar position of the TMJ in a sample of 56 patients. Among them, 28 patients were asymptomatic while the remaining 28 had been diagnosed with TMJ disease. To evaluate the presence of TMJ disorders, the Research Diagnostic Criteria for Temporomandibular Disorders was employed. This diagnostic tool is widely used in clinical and research settings to assess TMJ-related pain and dysfunction.

Results: The agreement was excellent, according to the intra-observer and inter-observer correlation values obtained. There was no statistically significant difference between the two groups in terms of age and gender distribution. The results showed that the anterior and posterior joint spaces were significantly higher in the symptomatic group compared to the asymptomatic group. However, there was no statistically significant difference between the two groups in terms of superior joint space and articular eminence inclination values. Gender did not create a significant difference in any parameter.

Conclusion: The results of this study emphasize that CBCT images have an important role in detecting significant changes in condyle position in patients with TMJ disorders. However, further large-scale studies are necessary to validate and enhance the findings.

Keywords: *Condyle position, cone-beam computed tomography, temporomandibular joint, temporomandibular joint disorder.*

Introduction

The position of the mandibular condyle in the glenoid fossa when the teeth are in maximum intercuspal is called the condylar position of the temporomandibular joint (TMJ). The optimal condylar position, which is also referred to as centric relation, is characterized by the uppermost and central placement of the teeth in relation to the articular eminence, and it is ideally congruent with the maximum intercuspation of the dental arches. The condylar position is modulated by various dynamic factors such as functional matrix activities, alterations in occlusal relationships, growth and remodeling processes, as well as physiological adaptations.[1]

The clinical relevance of mild to moderate levels of condylar eccentricity has not been definitively established in the existing literature. Moreover, a mild degree of condylar eccentricity is present in approximately one-third to half of the healthy individuals. As a result, the TMJ is not considered a reliable parameter for evaluating the soft tissue compartment. Nevertheless, a markedly eccentric condylar position may serve as an indicator of underlying TMJ disorders.[2]

Several prior investigations have shown that morphological changes associated with age, such as joint compartment flattening, can affect condyle locations. Many techniques have been used in the literature to examine the link between the condyle and the glenoid fossa.[3,4]

TMJ disorders represent a significant public health concern, affecting a substantial portion of the population with a prevalence of approximately 5% to 12%. Clinical manifestations of TMJ disorders include muscle pain, arthralgia, restricted range of motion, and joint sounds.[5] Despite conflicting opinions in the literature, there is a general consensus that the relationship between condyle position and TMJ disorders can aid in diagnosis. Earlier studies have indicated that the condyles of joints with internal irregularities tend to be positioned in a more posterior location.[6] It is evident that the position of the condyle is closely associated with disc displacement, particularly in joints with decreased disc displacement. In comparison to joints without disc displacement, the condyle is displaced posteriorly in such joints.[7] The relationship between condylar position and disc displacement has been widely investigated in the literature, underscoring the significance of condylar position in the diagnosis and treatment of TMJ disorders.

The majority of asymmetrical changes and morphological variations in condyle position have been attributed to mandibular deviation and dentoskeletal discrepancies during functional movements.[8] Clinical examination is not sufficient in the diagnosis of TMJ-related disorders and should be supported by imaging.[9] Evaluation of the condylar position with cone-beam computed tomography (CBCT) provides advantages such as fast scanning time (10 - 70 s), low radiation dose exposure of the patient, and prevention of adjacent anatomical structure superpositions.[10,11]

In the literature, there are studies using CBCT to determine the articular eminence slope and condyle morphology.[12-14] Unlike these studies, only patients with Angle Class I occlusion were evaluated in our study. Additionally, in this study, the anterior and posterior joint spaces were examined separately in symptomatic and asymptomatic patients. The objective of this research is to evaluate the condylar position via CBCT in both a group diagnosed with TMJ disorder and an asymptomatic control group.

Methods

The present study followed the Principles of the Declaration of Helsinki and obtained ethical approval from the Scientific Research and Publication Ethics Committee of Nuh Naci Yazgan University (Decision no: 2022/8842). The study aimed to evaluate condylar position using CBCT in two groups consisting of 28 asymptomatic individuals and 28 patients with TMJ disorders. The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) index was used to evaluate the patients.[15]

The asymptomatic group was determined as 28 patients without TMJ disease and Angle Class I occlusion who were examined in the Department of Oral and Maxillofacial Radiology at Nuh Naci Yazgan University. This group consists of CBCT images taken for various purposes, such as implant treatment, evaluation of impacted teeth, and apical lesions. The groups were matched for age and gender. Patients with orthodontic/TMJ treatment, congenital craniofacial anomaly, and trauma history were excluded from the study.

In this study, CBCT scans were acquired using a KaVO OP 3D Pro scanner manufactured by PaloDEx Group Oy in Tuusula, Finland. The scans were obtained with the subjects' mouths closed and in the maximum intercuspidation position. The exposure settings of the scanner were 90 kV and 8 mA, with exposure times ranging from 17.5 to 26.9 seconds. The field of view (FOV) used was 13 × 15 cm, and the voxel size for the selected left and right TMJ images was 0.320 mm. The sagittal slices were measured by maxillofacial radiologists. To obtain these slices, a panoramic line was drawn in axial slices in accordance with the longitudinal axis of the condyle, and the medial pole of the condyle was connected to the lateral. Subsequently, sagittal slices were obtained perpendicular to the longitudinal axis of the mandibular condyle. For measurements, the central sagittal slice spanning the condylar midpoint was used as the reference slice. This approach allowed for accurate and reliable measurement of the condylar position in the CBCT images.

In this study, various measurements were made on the CBCT scans to evaluate the condylar position. The superior joint space was calculated as the distance on the true horizontal line from the highest point of the condylar head to the superior point of the glenoid fossa. Additionally, the anterior and posterior joint spaces were measured by drawing tangent lines from the highest point of the articular cavity on the anterior and posterior surfaces of the condyle. The anterior and posterior joint spaces were measured as the closest points to the opposing glenoid fossa wall (Fig. 1A). In addition, the articular eminence inclination was measured by drawing a tangent line from the greatest point of the glenoid fossa to the anterior articular eminence inclination and calculating the angle between this line and a true horizontal line (Fig. 1B).[16] Measurements in CBCT were performed independently at different times by two oral and maxillofacial radiologists. Observers repeated the measurement of 20% of the sample size after one month. The data used in the study were obtained by averaging the measurements of two observers.

Statistical Analysis

IBM SPSS Statistics software, version 22.0, was used for the statistical analysis. The gender distribution of the groups was evaluated using the Pearson chi-square test, while the Mann Whitney-U test was employed to match the mean age between the groups. The normality of the data was evaluated

using the Shapiro Wilk test. To perform a comparison of quantitative results between the symptomatic and asymptomatic groups, a nonparametric test, the Mann Whitney-U test, was employed. A *p* value less than 0.05 was statistically significant. A power analysis was also carried out to establish the optimum sample size for the investigation. A minimum of 28 individuals per group was necessary based on an effect size of 0.8, a power level of 0.90, and a 5% error level.

Results

Literature includes several classifications for interpreting the interobserver correlation strength.[17] According to these classifications, the intra-observer and interobserver correlation values obtained in this study were categorized as excellent. (Table 1).

In this study, a total of 56 patients were included, 28 of whom were in the symptomatic group (mean age 34.46 ± 9.92 years; 13 males and 15 females) and 28 of whom were in the asymptomatic group (mean age 32.71 ± 9.16 years; 12 males and 16 females). There was no statistically significant difference in terms of mean age and gender distribution between the two groups (p=0.496, p=0.788), as shown in Table 2.

The results of the study revealed that the anterior and posterior joint spaces were significantly higher in the symptomatic group compared to the asymptomatic group, while there was no difference of statistically significant in terms of the superior joint space and articular eminence inclination values between the two groups. The detailed statistical analysis of these results is presented in Table 3.

Furthermore, in Table 4, the mean values of joint spaces and articular eminence angles of the patients in the symptomatic group were evaluated according to gender. The results indicated that gender did not create a significant difference in any parameter (p>0.05).

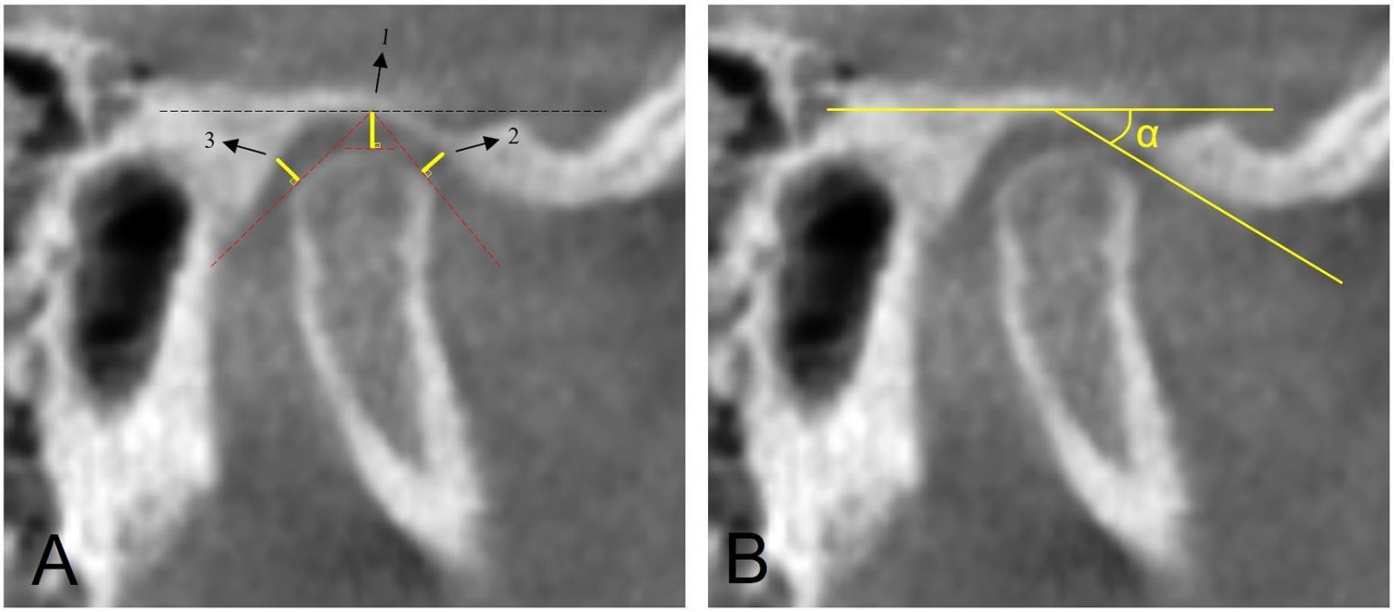

Figure 1: **A)** Cone-beam computed tomography images of measurement of superior, anterior, and posterior joint spaces **1:** Superior joint space, **2:** Anterior joint space, **3:** Posterior joint space. **B)** Cone-beam computed tomography image of the articular eminence inclination

Table 1. The reliability analysis results used to evaluate the intra- and inter-observer agreement of measurements

		Obs 1	**Obs 2**	**Obs 1&2**
Superior Space	ICC	0.885	0.923	0.907
Anterior Space		0.912	0.897	0.915
Posterior Space		0.925	0.923	0.902
Articular Eminence Inclination		0.856	0.874	0.884

ICC: Intraclass correlation coefficient, Obs: Observer

Table 2. Evaluation of the groups in terms of mean age and gender distribution

		Symptomatic Group	Asymptomatic Group	t	*p*
Age	Mean ± Sd	34.46 ± 9.92	32.71 ± 9.16	0.685	0.496[a]
Gender	N (%)	28 (50.00)	28 (50.00)		
Female		15 (26.78)	16 (28.57)	0.072	0.788[b]
Male		13 (23.21)	12 (21.42)		

[a]: Pearson Chi-square test, [b]: Student t test, N: Number, Sd: Standard deviation, t: Test statistic value

Table 3. Temporomandibular joint variables in asymptomatic and symptomatic groups

	Groups	N	Mean ± Sd	Median (Min-Max)	*p* value
Superior space (mm)	Asymptomatic	28	3.31 ± 0.50	3.13 (2.70-4.65)	0.101
	Symptomatic	28	3.04 ± 0.79	2.90 (1.40-5.10)	
Anterior space (mm)	Asymptomatic	28	2.13 ± 0.30	2.05 (1.70-3.05)	<0.001*
	Symptomatic	28	2.87 ± 0.65	2.75 (1.80-4.80)	
Posterior space (mm)	Asymptomatic	28	2.09 ± 0.30	2.05 (1.65-2.85)	0.043*
	Symptomatic	28	2.36 ± 0.69	2.28 (1.15-4.55)	
Articular eminence inclination	Asymptomatic	28	42.24 ± 3.70	43.08 (35.50-48.40)	0.268
	Symptomatic	28	39.57 ± 6.98	41.10 (23.25-48.40)	

Max: Maximum, Min: Minimum, N: Number of patients, Sd: Standard deviation, *: $p<0.05$

Table 4. Temporomandibular joint variables in symptomatic group according to gender

	Groups	N	Mean ± Sd	Median (Min-Max)	*p* value
Superior space (mm)	Female	15	2.84 ± 0.71	2,80 (1.40-4.25)	0.154
	Male	13	3.26 ± 0.83	3.05 (1.95-5.10)	
Anterior space (mm)	Female	15	2.83 ± 0.66	2.75 (1.80-4.50)	0.782
	Male	13	2.91 ± 0.65	2.75 (2.25-4.80)	
Posterior space (mm)	Female	15	2.38 ± 0.86	2.30 (1.15-4.55)	0.855
	Male	13	2.33 ± 0.50	2.25 (1.65-3.65)	
Articular eminence inclination	Female	15	37.50 ± 7.64	39.25 (23.25-45.90)	0.094
	Male	13	41.94 ± 5.49	43.90 (30.90-48.40)	

Max: Maximum, Min: Minimum, N: Number of patients, Sd: Standard deviation

Discussion

Various imaging methods are utilized in research on the TMJ. Even though magnetic resonance imaging is considered the gold standard for visualizing the soft tissue structures of the TMJ, CBCT has its own advantages. CBCT is more widely available, less expensive, and more accurate in demonstrating the hard tissue components of the TMJ.[9] Consequently, it has become a widely accepted imaging technique for assessing the TMJ.

The location of the mandibular condyle inside the glenoid fossa is an important element in TMJ problem diagnosis. Numerous studies in the literature have investigated the association between eccentric condyle location within the glenoid fossa and TMJ disorders.[18,19] In this study, we focused on two groups of asymptomatic and symptomatic patients. In CBCT images, anterior space, superior space, posterior space, and articular eminence inclination were evaluated together. Likewise, unlike the literature, measurements were made only in Angle Class I patient.

Ikeda et al.[20] conducted a study in which they assessed the condyle position on CBCT images of 22 asymptomatic patients with a mean age of 18 years. They reported that the superior, anterior, and posterior joint spaces were 2.5 ± 0.5 mm, 1.3 ± 0.2 mm, and 2.1 ± 0.3 mm, respectively. It is worth mentioning that variations in mean age and racial features across the research groups may explain for the disparities in joint range values seen between our study and theirs in asymptomatic individuals.

There are studies in the literature evaluating the existence of a relationship between condyle position and gender.[21-23] Solberg et al.[21] reported a significant gender difference in condyle width in patients with TMJ disorders. Al-Koshab et al.[22] also found that condyle width was greater in male than in female in CBCT studies. Similarly, in the CBCT study of Yasa et al.[23] significant differences were observed between joint space and articular eminence inclination and gender. However, no significant difference was found between the genders in our study. This may be due to differences in study populations or sample sizes.

There are also studies evaluating the condyle position with computed tomography and magnetic resonance imaging in patients with TMJ disorders.[24,25] In a study conducted by Christiansen et al.[24], the condylar position was evaluated using computed tomography in 25 patients, and they observed that the superior and anterior joint spaces were larger than normal in TMJs with internal disorders. The findings of our study, which also aimed to assess the condylar position using CBCT, are in agreement with the literature, as the anterior joint space value was significantly higher in symptomatic patients. In the study by İncesu et al.[25], which examined 122 TMJs of 61 patients with TMJ disorders, the posterior condyle position was identified as the main feature of TMJs with mild to moderate anterior disc displacement. Similarly, in our study, the posterior joint space value was found to be significantly higher in symptomatic patients, consistent with the literature.

Imanimoghaddam et al.[16] conducted a study using CBCT to evaluate 50 patients, 25 of whom were controls and 25 of whom had TMJ disorders. The study found an increase in the anterior joint space in patients with TMJ disorders. In our study, it was observed that the anterior space value was significantly higher in symptomatic patients, in line with the findings reported in the literature, despite the differences in populations.

This study has several limitations. CBCT images of a limited number of patients were studied. With this, not all patients in the symptomatic patient group had the same complaints. Additionally, two observers made the measurements. It can be studied with a large and homogeneous patient group with more observers.

Consistent with previous studies, the findings of this study indicate that articular eminence inclination is more prominent in patients with TMJ disorder than in asymptomatic individuals. These findings suggest that TMJ disorder may be related to the position of the condyle in the joint. The data presented in this study may improve our understanding of the anatomical variations between individuals without TMJ disorder and those with TMJ disorders.

Conclusion

As supported in the literature, significant changes in condyle position were observed in patients with TMJ disorder in this study. CBCT imaging provides valuable information that can be used to diagnose patients with TMJ disorder. However, further advanced studies with larger populations are needed to generalize and improve the results.

Conflict of Interest

The authors declare no conflict of interest.

Compliance with Ethical Statement

Ethical approval of this study was obtained from Nuh Naci Yazgan University Ethics Committee prior to initiation of the research work (2022/8843).

Author Contributions

FA, SMTF, RA: Hypothesis; FA, RA: Design; FA, SMTF, RA: Project Development; FA, SMTF, RA: Literature Review; FA, SMTF, RA: Analysis; FA, RA: Writing; FA, SMTF, RA: Critical Review.

References

1. Weffort SYK, de Fantini SM. Condylar displacement between centric relation and maximum intercuspation in symptomatic and asymptomatic individuals. Angle Orthod. 2010;80(5):835-842. doi: 10.2319/090909-510.1
2. Bonilla-Aragon H, Tallents RH, Katzberg RW, Kyrkanides S, Moss ME. Condyle position as a predictor of temporomandibular joint internal derangement. J *Prosthet Dent.* 1999;82(2):205-208. doi: 10.1016/s0022-3913(99)70157-5
3. İlgüy D, İlgüy M, Fişekçioğlu E, Dölekoğlu S, Ersan N. Articular eminence inclination, height, and condyle morphology on cone beam computed tomography. *Scientific World Journal*. 2014;2014:761714. doi:10.1155/2014/761714
4. Arieta-Miranda JM, Silva-Valencia M, Flores-Mir C, Paredes-Sampen NA, Arriola-Guillen LE. Spatial analysis of condyle position according to sagittal skeletal relationship, assessed by cone beam computed tomography. *Prog Orthod.* 2013;14:36. doi:10.1186/2196-1042-14-36
5. Schiffman E, Ohrbach R, Truelove E, et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: recommendations of the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group. *J Oral Facial Pain Headache.* 2014;28(1):6-27. doi: 10.11607/jop.1151
6. Ren Y-F, Isberg A, Westesson P-L. Condyle position in the temporomandibular joint: Comparison between asymptomatic volunteers with normal disk position and patients with disk displacement. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 1995;80(1):101-107. doi: 10.1016/s1079-2104(95)80025-5
7. Kurita H, Ohtsuka A, Kobayashi H, Kurashina K. A study of the relationship between the position of the condylar head and displacement of the temporomandibular joint disk. Dentomaxillofac *Radiol.* 2001;30(3):162-165. doi: 10.1038/sj/dmfr/4600603
8. Rodrigues AF, Fraga MR, Vitral RWF. Computed tomography evaluation of the temporomandibular joint in Class II Division 1 and Class III malocclusion patients: condylar symmetry and condyle-fossa relationship. *Am J Orthod Dentofacial Orthop*. 2009;136(2):199-206. doi: 10.1016/j.ajodo.2007.07.033
9. Ahmad M, Hollender L, Anderson Q, et al. Research diagnostic criteria for temporomandibular disorders (RDC/TMD): development of image analysis criteria and examiner reliability for image analysis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2009;107(6):844-860. doi: 10.1016/j.tripleo.2009.02.023
10. Pinto CA, da Rosa Caetano GF, Andrade MEA, et al. Dosimetric evaluation for temporomandibular joint cone beam computed tomography exams using different field of view. *Biomed Phys Eng Express.* 2021;7(6):065013. doi: 10.1088/2057-1976/ac240a
11. Wang Y-H, Ma R-H, Li J-J, et al. Diagnostic efficacy of CBCT, MRI and CBCT–MRI fused images in determining anterior disc displacement and bone changes of temporomandibular joint. *Dentomaxillofac Radiol.* 2022;51(2):20210286. doi: 10.1259/dmfr.20210286
12. Sümbüllü M, Çağlayan F, Akgül H, Yilmaz A. Radiological examination of the articular eminence morphology using cone beam CT. *Dentomaxillofac Radiol.* 2012;41(3):234-240. doi: 10.1259/dmfr/24780643
13. Ahmed J, Sujir N, Shenoy N, Binnal A, Ongole R. Morphological Assessment of TMJ Spaces, Mandibular Condyle, and Glenoid Fossa Using Cone Beam Computed Tomography (CBCT): A Retrospective *Analysis. Indian J Radiol Imaging.* 2021;31(1):78-85. doi: 10.1055/s-0041-1729488
14. Moscagiuri F, Caroccia F, Lopes C, et al. Evaluation of articular eminence inclination in normo-divergent subjects with different skeletal classes through CBCT. *Int J Environ Res Public Health.* 2021;18(11):5992. doi: 10.3390/ijerph18115992
15. Dowrkin S. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. *J Craniomandib Disord*. 1992;6:301-355.
16. Imanimoghaddam M, Madani AS, Mahdavi P, Bagherpour A, Darijani M, Ebrahimnejad H. Evaluation of condylar positions in patients with temporomandibular disorders: A cone-beam computed tomographic study. Imaging Sci Dent. 2016;46(2):127-131. doi: 10.5624/isd.2016.46.2.127
17. Cohen L. Measurement of Life Events; Cohen, LH, Ed.; Life Events and Psychological Functioning. Sage: Newbury Park, CA, USA; 1988.
18. Dalili Z, Khaki N, Kia SJ, Salamat F. Assessing joint space and condylar position in the people with normal function of temporomandibular joint with cone-beam computed tomography. *Dent Res J (Isfahan).* 2012;9(5):607-612. doi: 10.4103/1735-3327.104881
19. Martin D, Rozencweig S, Maté A, Valenzuela J. The importance of condyle position in the diagnosis, treatment and prevention of TMD. *Orthod Fr.* 2015;86(2):125-149. doi: 10.1051/orthodfr/2015018
20. Ikeda K, Kawamura A. Assessment of optimal condylar position with limited cone-beam computed tomography. *Am J Orthod Dentofacial Orthop.* 2009;135(4):495-501. doi: 10.1016/j.ajodo.2007.05.021
21. Solberg W, Hansson T, Nordström B. The temporomandibular joint in young adults at autopsy: a morphologic classification and evaluation. *J Oral Rehabil*. 1985;12(4):303-321. doi: 10.1111/j.1365-2842.1985.tb01285.x
22. Al-koshab M, Nambiar P, John J. Assessment of condyle and glenoid fossa morphology using CBCT in South-East Asians. PloS *One.* 2015;10(3):e0121682. doi: 10.1371/journal.pone.0121682
23. Yasa Y, Akgül HM. Comparative cone-beam computed tomography evaluation of the osseous morphology of the temporomandibular joint in temporomandibular dysfunction patients and asymptomatic individuals. *Oral Radiol.* 2018;34(1):31-39. doi: 10.1007/s11282-017-0279-7
24. Christiansen EL, Thompson JR, Zimmerman G, et al. Computed tomography of condylar and articular disk positions within the temporomandibular joint. *Oral Surg Oral Med Oral Pathol.* 1987;64(6):757-767. doi: 10.1016/0030-4220(87)90182-4
25. Incesu L, Taşkaya-Yılmaz N, Öğütcen-Toller M, Uzun E. Relationship of condylar position to disc position and morphology. *Eur J Radiol.* 2004;51(3):269-273. doi: 10.1016/S0720-048X(03)00218-3