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Magnetic Resonance Imaging Assessment of Positional Relationship Between the Disk and Condyle in Asymptomatic Young Adult Mandibular Prognathism

Hatice Gökalp, DDS, PhD[a]

ABSTRACT

The aim of this study was to clarify disk position relative to the condyle and condylar position relative to the glenoid fossa in clinically asymptomatic and orthodontically untreated young adult Class III patients by magnetic resonance imaging (MRI). In addition, the relationship between skeletal Class III morphology and positional changes of the temporomandibular joint (TMJ) components were investigated. The material consisted of 34 bilateral sagittal oblique TMJ MR images (MRIs) and lateral cephalometric radiographs taken in a closed mouth position. The mean age of the patients was 20.71 ± 0.82 years (range 16–29 years). Only clinically symptom-free subjects were included in this study. Measurements made on the MRIs and lateral cephalographs were used to calculate means and minimum and maximum values. The right and left TMJ variables were compared with the Student's *t*-test. Correlation coefficients between bilateral TMJ variables and skeletal variables were calculated. In the right TMJ, the disk was positioned anteriorly and the condyle was positioned posteriorly, whereas the left TMJ was normal. A negative correlation existed between the vertical skeletal morphology and the anterior joint space of the TMJ. A positive correlation was found between the left disk position and the vertical skeletal morphology because of the differentiation of the condylar head angle in each side. As a result, clinically asymptomatic Class III patients may be candidates for TMJ derangements. For this reason, clinical and visual examinations should be performed simultaneously to eliminate diagnostic errors before orthognathic treatment.

KEY WORDS: Class III malocclusion, Mandibular prognathia, MRI, Disk position, Condyle position.

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INTRODUCTION Return to TOC

One of the causative factors of temporomandibular joint (TMJ) internal derangement is the loss of the ideal relationship between the TMJ components. The ideal relationship of the TMJ components is described according to positional changes of the disk and condyle in the glenoid fossa. The position of the disk relative to the condyle is defined by two criteria. First, the central part of the disk is located on the anterolateral aspect of the condyle.[1] Second, the condyle is at a 12 o'clock position[1–4] and centered in the glenoid fossa in centric occlusion.[5,6] Any factor that damages the ideal relationship between the TMJ components may cause TMJ signs and symptoms. Malocclusion is mentioned in the literature as one of the factors causing TMJ internal derangement.

Several investigations have stated that the position of the condyle in the glenoid fossa varies in different malocclusion types.[6–14] One widely held belief is that posterior condylar displacement in Class II malocclusion results from anterior disk displacement.[15,16] It has also been reported that the condyle is located anteriorly in the glenoid fossa in Class III malocclusion.[11] Although a possible correlation between the malocclusion and condylar position has been established in previous studies, changes of the disk position in relation to the condyle in various types of malocclusion have not been considered, and the condyle and disk positions are closely associated with each other. Posterior condylar position has been explained as a displacement resulting from anterior disk displacement.[15,17–19] Consequently, the question arises as to how the disk position is affected by anterior condylar positioning. These ambiguous views in the literature motivated this investigation of disk position associated with condyle position. The purpose of this study was to help clarify answers to the following questions:

- If the condyle is located anteriorly in the glenoid fossa in Class III malocclusion, where should the disk be placed?
- Does a relationship exist between the Class III morphology and the positional changes of TMJ characteristics?
- What is the importance of anatomical structural relationships between the disk, condyle, and glenoid fossa in asymptomatic young adult Class III patients in orthognathic treatment planning?

MATERIALS AND METHODS Return to TOC

The material for this study was composed of a total of 34 bilateral oblique sagittal TMJ magnetic resonance imaging (MRI) in closed mouth obtained from 17 clinically symptom–free and orthodontically untreated young adult prognathic patients. Lateral cephalometric radiographs of the subjects were also obtained to describe skeletal features. The mean age of the patients was 20.71 ± 0.82 years (range 16–29 years). The TMJ function of all subjects was evaluated by a clinical examination. Each patient was questioned about TMJ pain, joint sounds, and limitation of mouth opening, and only clinically symptom-free subjects were included in this study. The MRIs were performed on a 1.5 T MR scanner (GE Medical system, Milwaukee, Wis). Bilateral receiver surface coils with a diameter of 8 cm were used. A transaxial locator sequence was used for patient orientation and positioning. The head was supported by a polyurethane foam head positioner to enable stabilization of the skull so that the midsagittal plane of the imager was perpendicular to the midpoint of the long axis of the condyle. A spin echo technique (repetition time [TR] = 0.5 seconds and echo time [TE] = 21 milliseconds) was used. Five contiguous 3-mm thick parasagittal images with matrix size

256 × 128 were obtained.

Points used on the MRIs and lateral cephalometric radiographs are indicated in Figure 1. Measurements made on the MRIs are shown in Figures 2 and 3. Linear and angular measurements were carried out for both the right and left TMJs on sagittal MRIs to evaluate both the disk position associated with the condyle and the condylar position associated with the glenoid fossa. Linear and angular measurements of the disk position relative to the condyle were made. A line at the 12 o'clock position identified normal position of the disk (Figure 4). A line was drawn through from the center of the condylar (Cc) to the center of curvature of the top surface of the condyle (Ct) and to the posterior margin of the posterior band of the disk (dp) (junction of posterior band and bilaminar zone). The angle between these lines (dp-Cc-Ct) was measured (Figure 2), and the amount of anterior displacement, if any, was quantified in terms of degrees from the 12 o'clock position. Displacement anterior to the 12 o'clock position was termed positive and posterior displacement was termed negative.[2,3] Linear disk displacements (dm-λ) were measured by changes in the position of the central part of the disk (dm) relative to the most prominent anterior aspect of the condyle (Ca) (Figure 2).

The narrowest posterior (Cp-Cp′) and anterior (Ca-Ca′) interarticular distances were measured (Figure 2) to express the condylar position into the glenoid fossa as a percent of anterior and posterior displacements from absolute concentricity (zero) according to the following formula:

$$\frac{\text{posterior joint space} - \text{anterior joint space}}{\text{posterior joint space} + \text{anterior joint space}} \times 100$$

A positive value indicated an anterior condylar positioning, and a negative value indicated posterior condylar positioning. A definite displacement of the condyle was defined as more than 12% deviation from concentricity.[20]

The eminence slope was defined as the angle between the Frankfort horizontal plane and a tangent drawn from the deepest fossa point (f) to the slope of the anterior eminence. Condyle angulations (ø) were also investigated in this study (Figure 3). Lateral cephalometric radiographs were analyzed by conventional methods to describe the skeletal features of the subjects. These angular and linear data are presented in Table 1. All the measurements were made manually using a protractor. The accuracy was set at 0.5 mm for linear measurements and at 0.5° for angular measurements.

Error of method

Measurements were made twice with a 20-day interval to determine repeatability of landmark identification and measurement techniques. All angular and linear variables had a coefficient of intrarater reliability ($r = \Sigma^2\text{total}/\Sigma^2\text{between}$) between 0.82 and 1.00. That means, this error is considered negligible.

Statistical method

The minimum and maximum values, the arithmetic mean, and standard deviation were calculated for each variable. Right and left TMJ variables were compared with Student's *t*-test, and the correlation coefficients between bilateral TMJ and skeletal variables were calculated.

RESULTS Return to TOC

Descriptive statistic of the right and left TMJ variables and comparison of these data are presented in Table 2. Linear position of the disk associated with the condyle (dm-λ) was different from the right TMJ to the left side ($P < .05$), although the angular position of the disk (dp-Cc-Ct) was similar for each side. This contradiction may be the result of a difference in the condylar head angle on the right and left sides. The condylar head angle was increased in the left TMJ with respect to the right side ($P < .05$). The condyle was located in a more concentric position on the left side than the right side ($P < .05$). The slope of the eminence was similar for each side.

Correlation coefficients were calculated between the TMJ MRI variables and lateral cephalometric radiographs. In the right TMJ, negative correlations existed between vertical skeletal linear and angular measurements (ANS-Me; FH-MP; Ar-Go-Me) and anterior joint space (Ca-Ca′) (Table 3). In the left TMJ, a negative correlation also existed between the vertical skeletal angular measurement (Ar-Go-Me) and anterior joint space (Table 4). In the left TMJ, a positive correlation existed between the angular disk position (dp-Cc-Ct) and linear vertical skeletal measurements (ANS-Me; N-Me) (Table 4).

DISCUSSION Return to TOC

The results of this study do not suggest an increased tendency for anteriorly located condyles in young adult Class III patients. The condyle and disk demonstrated an asymmetrical location. The right condyle was located more posteriorly, whereas the left condyle was concentric in the fossa. The right disk was displaced anteriorly, whereas the left disk was positioned close to the 12 o'clock position. Disk and joint derangements in the right TMJ were diagnosed on MRIs despite the absence of any signs or symptoms in the clinical examination. It has been stated that an absence of harmony may exist between the clinical TMJ examination and MRI results.[21] The results of a clinical TMJ functional examination need a controlled visualization technique to eliminate diagnostic errors. MRI is well established as a valuable imaging modality permitting visualization of the disk, condyle, and other joint structures. Therefore, the clinical TMJ examination and the MRIs were gathered concurrently in the present study.

Malocclusions have been reported to change the relationship between the disk and the condyle. Several investigations have reported that the condylar position in the glenoid fossa varies in different malocclusion types.[5–11] The position of the condyle in the glenoid fossa is concentric in Class I malocclusion,[5,11] but a Class II malocclusion with a deep overbite has been reported to cause posterior condylar displacement.[5–9] However, Posselt[10] remarked that a distal relationship of the mandible is not synonymous with posterior condylar displacement. Furthermore, Pullinger et al[6] showed that the condylar position in a Class II malocclusion with overjet is frequently slightly anterior.

Cohlmia et al[11] showed that the condyle was positioned more anteriorly in Class III malocclusions than in other malocclusions. However, the condyle position in the glenoid fossa and the disk position relative to the condyle need to be evaluated simultaneously because condylar position is not a unique factor causing TMJ internal derangement. For this reason, it is very important to evaluate the condylar position associated with the disk position in the glenoid fossa.

According to the current theory of mechanical displacement, disk position is controlled by two mechanisms. One is a direct contraction of the superior head of the lateral pterygoid muscle (SLP) that is attached either directly to the anterior band or underneath the disk, and the other is the occlusion. In previously reported cases of malocclusion, the disk was displaced anteriormedially with tearing of the lateral and posterior attachments.[12,13] When this occurs, the pull of the SLP causes dysfunction and pain.[22,23] It has also been indicated that disk displacement is influenced by direct attachment of the SLP when the disk has undergone trauma with tearing or stretching (or both) of its lateral and posterior attachments. Muscle contraction may maintain the disk in an anteriormedial position, whereas the condyle is retracted by other masticatory muscles.[14] Malocclusion may be a risk factor influencing the attachments of the disk. Furthermore, Class III malocclusion may be a contributing factor to the tearing of the disk in the right TMJ in this study. This might not be observed because of the MRIs being taken in a closed mouth position. Consequently, the SLP might also contribute to disk displacement when the disk or joint derangement had previously existed in the right TMJ.

Some relationships were found between the skeletal morphology and the TMJ data in this study. Posterior rotation of the mandible was associated with an increase in the anterior joint space in the right and left TMJs. However, the condylar head angle was not the same on each side of the TMJ. This might imply that the condylar head angle on one side may be different from that on the other side in the same patient because of functional changes in the stomatognathic system. The positive correlation that exists between the disk position in the left TMJ and increased vertical skeletal dimension may be explained by having a steeper condylar head angle on the left side.

Mandibular prognathism is a facial displasia produced by a growth disharmony of mandibular size, form, and position with respect to the maxilla. It is usually associated with a Class III malocclusion. A common treatment approach is to apply an orthopedic force to the mandible during growth to retard or to redirect the growth of the mandible. On the other hand, an osteotomy of the mandible is performed after skeletal growth is complete. This study was performed on clinically symptom–free and orthodontically untreated young adult Class III patients. Mandibular ramus osteotomies with mandibular set-backs were planned to obtain a favorable esthetic and functional maxillomandibular relationship for these patients. However, the results of this investigation revealed the opposite of what was expected. The right TMJ was a candidate for joint derangement because of the anterior disk displacement and posterior condyle displacement, but the left TMJ was normal. Orthognathic surgery, especially a mandibular ramus osteotomy, might cause changes of the condylar position and produce TMJ dysfunction.[24–27] It has been reported that significant anterior and inferior displacement of the condyle was observed in patients who received an oblique ramal osteotomy for a mandibular set-back.[28,29] Authors state that the pull of the lateral pterygoid muscle and pterygomasseteric sling to the proximal segment might be an important factor in this kind of condylar displacement. This effect may be worthwhile in order to obtain a favorable condyle position in the glenoid fossa when treatment planning in the present study. However, a significant posterior displacement of the condyle has been observed in prognathic patients who received sagittal split ramus osteotomies due to the pull of the temporal and masseter muscles on the proximal segment.[28] As a result, the condyle position in the glenoid fossa is also influenced differently with various mandibular ramus osteotomy techniques because of the possible effects of intracapsular edema and manipulation of the fragments. For this reason, it is important that the clinical evaluation of the TMJ should also include a visualization technique to depict the disk-condyle-glenoid fossa at the beginning of the treatment in order to perform a well-organized treatment plan and obtain a successful result. In this way, undesired condylar and disk positions may be prevented during and after orthognathic treatment.

CONCLUSIONS Return to TOC

Condyle and disk positions were different from right to left sides of TMJ in clinically asymptomatic young adult Class III patients. Whereas the right condyle was located more posteriorly, the left condyle was more concentrically placed.

The disk was positioned anteriorly in the right side. This position may result from the anterior pull of the SLP if the disk had undergone pathosis earlier.

An indirect relationship may exist between Class III morphology and a tendency for TMJ internal derangement.

Visual and clinical evaluations should be performed simultaneously before orthognathic treatment planning to avoid contradictory diagnoses.

REFERENCES Return to TOC

1. Katzberg RW, Westesson P-L. *Diagnosis of the Temporomandibular Joint*. 1st ed. Philadelphia, Penn: WB Saunders; 1993:9.

2. Drace JE, Enzmann DR. Defining the normal temporomandibular joint: closed-, partly open-, and open-mouth MR Imaging of asymptomatic subjects. *Radiology.* 1990; 177:67–71. [PubMed Citation]

3. Drace JE, Young SW, Enzmann DR. TMJ meniscus and bilaminar zone: MR imaging of the structure—diagnostic landmarks and pitfalls of interpretation. *Radiology.* 1990; 177:73–76. [PubMed Citation]

4. Katzberg RW. Temporomandibular joint imaging. *Radiology.* 1989; 170:297–307. [PubMed Citation]

5. Pullinger AG, Solberg WK, Hollender L, Guichet D. Tomographic analysis of mandibular condyle position in diagnostic subgroups of temporormandibular disorders. *J Prosthet Dent.* 1986; 55:723–728. [PubMed Citation]

6. Pullinger AG, Solberg WK, Hollender L, Petersson A. Relationship mandibular condylar position to dental occlusion factors in an asymptomatic population. *Am J Orthod Dentofacial Orthop.* 1987; 91:200–206. [PubMed Citation]

7. Perry HT. Relation of occlusion to temporomandibular dysfunction: the orthodontic viewpoint. *J Am Dent Assoc.* 1969; 79:137–141. [PubMed Citation]

8. Loiselle RJ. Relation of occlusion to temporomandibular dysfunction: the prosthodontic viewpoint. *J Am Dent Assoc.* 1969; 79:145–146. [PubMed Citation]

9. Greene CS. A survey of current professional concepts and opinions about the myofascial pain dysfunction (MDP) syndrome. *J Am Dent Assoc.* 1973; 86:128–135. [PubMed Citation]

10. Posselt U. *The Physiology of Occlusion and Rehabilitation.* 2nd ed. Philadelphia, Penn: FA Davis Company; 1968:39.

11. Cohlmia JT, Ghosh J, Sinha PK, Nanda RS, Currier GF. Tomographic assessment of temporomandibular joints patients with malocclusion. *Angle Orthod.* 1996; 66:27–36. [PubMed Citation]

12. Dubrul EL. The craniomandibular articulation. In: Dubrul EL, ed. *Sicher's Oral Anatomy.* 7th ed. St Louis, Mo: CV Mosby; 1980:107–116.

13. Okeson JP. *Fundamentals of Occlusion and Temporomandibular Disorder*. St Louis, Mo: CV Mosby; 1985:10–14.

14. Wongwatana S, Kronman JH, Clark RE, Kabani S, Mehta N. Anatomic basis for disk displacement in temporomandibular joint (TMJ) dysfunction. *Am J Orthod Dentofacial Orthop.* 1994; 105:257–264. [PubMed Citation]

15. Ireland VE. The problem of "the clicking jaw.". *J Prosthet Dent.* 1953; 3:200–212.

16. Ricketts RM. Abnormal function of the temporomandibular joint. *Am J Orthod.* 1955; 41:435–441.

17. Farrar WB. Differentiation of temporomandibular joint dysfunction to simplify treatment. *J Prosthet Dent.* 1972; 28:629–636. [PubMed Citation]

18. Blaschke DD, Solberg WK, Sanders B. Arthrography of the temporomandibular joint: review of the current status. *J Am Dent Assoc.* 1980; 100:388–395. [PubMed Citation]

19. Bery DC, Watkinson AC. Mandibular dysfunction and incisor relation. A theoretical explanation for the clicking joint. *Br Dent J.* 1978; 144:74–77. [PubMed Citation]

20. Pullinger GA, Hollender L, Solberg KW, Petersson A. A tomographic study of mandibular condyle position in an asymptomatic population. *J Prosthet Dent.* 1985; 53:706–713. [PubMed Citation]

21. Yatani H, Sonoyama W, Kuboki T, Matsuka Y, Orsini MG, Yamashita A. The validity of clinical examination for diagnosing anterior disc displacement with reduction. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 1998; 85:647–653. [PubMed Citation]

22. Gelb H, Bemstein I. Clinical evaluation of two hundred patients with TMJ syndrome. *J Prosthet Dent.* 1983; 49:234–243. [PubMed Citation]

23. Bell WE. Etiology of temporomandibular disorders. In: *Temporomandibular Disorder.* 3rd ed. Chicago, Ill: Yearbook Medico Publisher; 1990:104–108,113–118.

24. Hackney FL, Van Sickels E, Nummikoski PV. Condylar displacement and temporomandibular joint dysfunction following bilateral sagittal split osteotomy and rigid fixation. *J Oral Maxillofac Surg.* 1989; 47:223–227. [PubMed Citation]

25. Ellis E, Hinton RJ. Histologic examination of the temporomandibular joint after mandibular advancement with and without rigid fixation: an experimental investigation in adult Macaca mulatta. *J Oral Maxillofac Surg.* 1991; 49:1316–1327. [PubMed Citation]

26. O'Ryan F, Epker BM. Surgical orthodontics and the TMJ. LI. Mandibular advancement via modified sagittal ramus osteotomies. *Am J Orthod.* 1983; 83:418 [PubMed Citation]

27. Feinerman DM, Piecuch JF. Long-term effects of orthognathic surgery on the temporomandibular joint: comparison of rigid and non-rigid fixation methods. *Int J Oral Maxillofac Surg.* 1995; 24:268–272. [PubMed Citation]

28. Hu J, Wang D, Zou S. Effects of mandibular setback on the temporomandibular joint: a comparison of oblique and sagittal ramus osteotomy. *J Oral Maxillofac Surg.* 2000; 58:375–380. [PubMed Citation]

29. Rosenquiest B, Rune B, Petersson A. et al. Condylar displacement after oblique sliding osteotomy of the mandibular rami. *J Craniomaxillofac Surg.* 1988; 16:301–307.

TABLES Return to TOC

TABLE 1. Descriptive Statistics of the Lateral Cephalometric Radiographs

Variables	Minimum	Maximum	$\bar{X} \pm SD$
SNA (°)	69	86	78.12 ± 1.12
SNB (°)	73	91	81.74 ± 1.17
ANB (°)	−12	−1	3.68 ± 0.69
FH-MP (°)	12	43	32.53 ± 1.94
ANS-Me (mm)	56	91	72.68 ± 2.31
N-S-Ar (°)	115	133	123.94 ± 1.44
S-Ar-Go (°)	130	162	145.85 ± 2.01
Ar-Go-Me (°)	112	145	132.47 ± 1.88
S-Go (mm)	68	90	80.18 ± 1.57
N-Me (mm)	109	151	128.94 ± 2.87
Overjet (mm)	−0	−13	−4.06 ± 1.56
Overbite (mm)	0	10	5.6 ± 1.05

TABLE 2. Descriptive and Comparative Statistics of the Bilateral Temporomandibular Joint (TMJ) Data

	Right TMJ			Left TMJ			
Variables	Min	Max	$\bar{X} \pm SD$	Min	Max	$\bar{X} \pm SD$	P[a]
dm-λ (mm)	0.0	7.5	2.34 ± 0.58	−1.0	2.9	0.73 ± 0.21	*
dp-Cc-Ct (°)	0.0	79.0	21.5 ± 5.23	−10	29.5	8.21 ± 2.91	NS
Ca-Ca′ (mm)	1.5	5.0	2.81 ± 0.26	0.8	4.25	2.11 ± 0.23	*
Cp-Cp′ (mm)	1.0	3.25	2.04 ± 0.19	0.5	4.5	2.72 ± 0.25	*
Condylar position (%)	−64	20	−15 ± 5.0	−60	33	3 ± 5.0	**
Eminence slope (°)	33.0	53.0	41.97 ± 1.45	28.5	60.0	42.68 ± 1.92	NS
Condyle head angle (°)	129.0	173.0	153.3 ± 3.0	131	180	158.35 ± 3.8	*

[a] Significance level—NS, not significant; * $P < .05$; ** $P < .01$.

TABLE 3. Correlations Between the Right Temporomandibular Joint (TMJ) and Craniofacial Morphology[a]

	Right TMJ			
	SNA	FH-MP	ANS-Me	Ar-Go-Me
Ca-Ca′	NS	−0.553*	−0.578*	−0.487*
Eminence slope	0.560*	NS	NS	NS

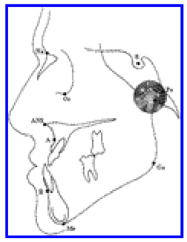
[a] * r 0.05 = 0.481; NS, not significant.

TABLE 4. Correlations Between the Left Temporomandibular Joint (TMJ) and Craniofacial Morphology[a]

	Left TMJ		
	ANS-Me	Ar-Go-Me	N-Me
dp-Cc-Ct	0.662**	NS	0.645**
Ca-Ca′	NS	−0.535*	NS

[a] * r 0.05 = 0.481; ** r = 0.606; NS, not significant.

FIGURES Return to TOC



Click on thumbnail for full-sized image.

FIGURE 1. Points concerning craniofacial structure and temporomandibular joint

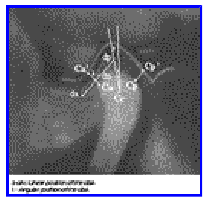


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FIGURE 2. Angular and linear position of the disk relative to the condyle. Ca indicates the anterior edge of functional surface of the condyle; Ca′, projection point drawn perpendicular from Ca point to anterior slope of the glenoid fossae; Cp, posterior edge of functional surface of the condyle; Cp′, projection point drawn perpendicular from Cp point to posterior surface of the glenoid fossae; da, middle point of anterior band of the disk; dm, intermediate region of the disk; dp, middle point of posterior band of the disk; and λ, projection point drawn perpendicular from Ca point to (da-dp) line

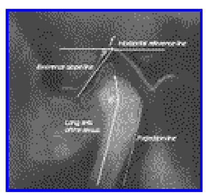

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FIGURE 3. Eminence slope angle; ø: condyle head angle. f indicates the deepest point of roof of the glenoid fossa. Eminence slope line; a line drawn tangent from f point to anterior slope of the glenoid fossa; Long axis of the ramus, a line passed from middle of the ramus and parallel to a projection line that is tangent to the posterior border of the ramus; Horizontal reference line, a line is established as the tangent to f point and parallel to the horizontal plane of the MRI. That line represents Frankfort Horizontal plane

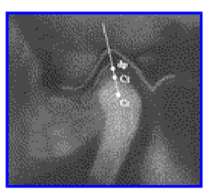

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FIGURE 4. Twelve o'clock position of the disk. dp indicates middle point of posterior margin of the posterior band of the disk; Ct, top of the condyle head; and Cc, center of the condyle head

[a]Department of Orthodontics, School of Dentistry, Ankara University, Ankara, Turkey

Corresponding author: Hatice Gökalp, DDS, PhD, Ankara Universitesi, Dis Hekimliği Fakultesi, Anabilim Dalı 06500, Beşevler, Ankara, Turkiye. (E-mail: haticegokalp@yahoo.com)