ORİJİNAL ARAŞTIRMA / *ORIGINAL RESEARCH*

The Comparison of The Signal Intensity of TMJ Disc and Mandibular Condyle Bone Marrow by Digital Analysis of Magnetic Resonance Images in Bruxism and Non-Bruxism Patients with Temporomandibular Joint Disorders

TEMPOROMANDİBULAR EKLEM BOZUKLUĞUNA SAHİP BRUKSİZM GÖRÜLEN VEYA GÖRÜLMEYEN HASTALARDA TME DİSK VE MANDİBULAR KONDİLİN KEMİK İLİĞİ SİNYAL İNTENSİTELERİNİN, MANYETİK REZONANS GÖRÜNTÜLERDE DİJİTAL ANALİZ YOLUYLA KARŞILAŞTIRILMASI

Kaan ORHAN, Dt, MD,[a] Metin ŞENÇİMEN, Dt, MD[b]

[a]Department of Oral Diagnosis and Radiology, Ankara University Faculty of Dentistry,
[b]Department of Oral and Maxillofacial Surgery, Gülhane Military Medical Academy, ANKARA

Abstract

Objective: The aim of this paper was to evaluate and compare the signal intensity of Temporomandibular Joint (TMJ) disc and mandibular condyle bone marrow by digital analysis of magnetic resonance (MR) images in bruxism and non-bruxism patients with TMJ disorders.

Material and Methods: This study involved 72 TMJs in 36 patients who referred for evaluation of their condition about TMJ to Gülhane Military Medical Academy. Twenty of the patients with TMD symptoms and signs have bruxing behavior while 16 of them did not have such a behavior. All patients underwent bilateral MR imaging. DICOM 3.0 formatted MR images were sent to the DICOM server and downloaded to a personal computer where the evaluation and measurement were made. Firstly, TMJs were divided into Normal, Anterior Disc Displacement with Reduction (ADDwR), Anterior Disc Displacement without Reduction (ADDwoR) groups based on MR images. Secondly, the signal intensity of disk and mandibular condyle were measured via drawing circular region of interests (ROIs) on T1, T2, and proton-weighted MR images using with a special software package (Osiris 4.09, University Hospital of Geneva, Geneva, Switzerland). The signal intensity of the TMJ disk were measured both from anterior and posterior band TMJ disc. The correlations among the groups of TMJs with-without bruxing behavior and signal intensities were statistically analyzed by using Bonferroni/Dunn multi-comparison method test.

Results: The classification of the TMJs with the help of MRI, in patients with bruxing behavior was; 18 were Normal, 9 exhibited ADDwR, 13 ADDwoR whereas the TMJs of the patients without bruxing behavior showed 11 Normal, 10 ADDwR, 11 ADDwoR. There were no statistical difference between signal intensity of the posterior and anterior bands, and in the patient groups of with and without bruxism ($p > 0.05$). There was a statistical difference between the bruxing and non-bruxing groups related to signal intensity of mandibular condyle bone marrow ($p < 0.05$).

Conclusions: It was demonstrated that the signal intensity of mandibular condyle bone marrow in patients with bruxing behavior was found to be higher than in patients without bruxing behavior. It can be also conclude that bruxism can constitute bone marrow alterations in mandibular condyle.

Key Words: Temporomandibular joint, magnetic resonance imaging, internal derangement, parafunctional habits, computer assisted analysis

Özet

Amaç: Bu çalışmanın amacı, Temporomandibular eklem (TME) disk ve mandibular kondil kemik iliği sinyal intensitelerinin manyetik rezonans (MR) görüntülerde dijital analiz yoluyla bozukluğuna sahip bruksizm görülen veya görülmeyen hastalarda karşılaştırılması incelenmesi ve karşılaştırılmasıdır.

Gereç ve Yöntemler: Bu çalışmaya, TME eklem şikâyeti ile Gülhane Askeri Tıp Akademisine başvuran 36 hastanın 72 TME'i dâhil edildi. Otuz altı hastanın 20'sinde bruksizm alışkanlığı var iken 16'sında bu alışkanlık tespit edilmedi. Bütün hastalardan çift taraflı MR görüntüler elde edildi. Elde edilen DICOM 3.0 formatında ki bu görüntüler DICOM server'a gönderildi ve takiben kişisel bir bilgisayara aktarıldı. İlk olarak, eklemler MR görüntülerine göre; normal, redüksiyonlu anterior disk deplasmanı (ADDwR), redüksiyonsuz anterior disk deplasmanı (ADDwoR) olarak sınıflandırıldı. İkinci olarak, disk ve mandibular kondilin kemik iliği sinyal intensiteleri T1, T2 ve proton-ağırlıklı MR görüntülerde, özel bir yazılım yardımıyla (Osiris 4.09, University Hospital of Geneva, Geneva, Switzerland) sirküler ilgi alanları çizilerek (ROIs) ölçüldü. TME disk sinyal intensiteleri hem anterior hem de posterior bandın ikisi de olacak şekilde ölçüldü. Bruksizm alışkanlığı olan ve olmayan bireylerden elde edilen sonuçların istatistiksel değerlendirmesi için Bonferroni/Dunn çoklu-karşılaştırman testi kullanıldı.

Bulgular: Bruksizm alışkanlığı olan hastaların eklemlerinde yapılan sınıflamada; 18'i normal, 9'unda ADDwR iken 13'ü ADDwoR idi. Bruksizm alışkanlığı olmayanlarda ise; 11'i normal, 10'u ADDwR, 11'i ADDwoR idi. TME diskin anterior ve posterior band sinyal intensiteleri arasında her iki grupta fark yok iken ($p > 0.05$), bruksizm alışkanlığı olan ve olmayan hastaların mandibular kemik iliği sinyal intensiteleri arasında anlamlı bir fark bulundu ($p < 0.05$).

Sonuç: Bu çalışma sonucunda, bruksizm alışkanlığı olan hastalarda mandibular kemik iliği sinyal intensiteleri, bu alışkanlık olmayan hastalara göre daha fazla olduğu gözlenmiştir. Bu çalışma ile ayrıca bruksizm alışkanlığının mandibular kondil kemik iliğinde değişimler oluşturduğu sonucuna varılmıştır.

Anahtar Kelimeler: Temporomandibular eklem, manyetik rezonans görüntüleme, internal derangement, parafonksiyonel alışkanlıklar, bilgisayar destekli analiz

Turkiye Klinikleri J Dental Sci 2006, 12:31-36

Geliş Tarihi/*Received:* 14.07.2005 **Kabul Tarihi/*Accepted:*** 09.02.2006

This study was presented at 13th International congress of Turkish Association of Oral and Maxillofacial Surgery, Antalya-Turkey, 29 May 2005.

Yazışma Adresi/*Correspondence:* Dr. Kaan ORHAN
University of Ankara, Faculty of Dentistry
Department of Oral Diagnosis and Radiology, ANKARA
call52@yahoo.com

Temporomandibular joint (TMJ) internal derangement describes an abnormal positional relationship between the articular disc and the mandibular condyle and the articular eminence.[1-5] The disorder has been associated with characteristics clinical findings such as pain, joint sounds, and irregular or deviating jaw function.[3-5] There are numerous factors that can contribute to TMJ internal derangement. Factors that increase the risk of internal derangement are called predisposing factors, factors that cause the onset of internal derangement called initiating factors, and factors that interfere with healing or enhance the progression of internal derangement are called perpetuating factors. Trauma, abnormal functional loading and degenerative joint disease are the main causes (initiating factors) of internal derangement. Along this, changes in the activities of masticatory system can be initiating and perpetuating factors which are called as parafunctional activities which include clenching, bruxism and various oral habits.[2]

Magnetic resonance imaging (MRI) has been used to obtain information regarding articular disc position within the TMJ in patients.[4] It provides a direct form of soft tissue visualization with excellent spatial and contrast resolution on sagittal and coronal MR images of the TMJ.[6,7] It also offers the advantages of being non-invasive, painless, of minimal risk potential, and free of ionizing-radiation exposure. In addition, MRI of the TMJ can also provide essential information about position[4], morphology[15,19] and signal intensity characteristics of the TMJ structures[4,8-12] There has been increasing interest in MR signal intensity alterations that may be found in the joint compartments and in the condylar bony changes of both asymptomatic and symptomatic TMJs.[12,23] However, there is lack of information about the effect of bruxism on TMJ disk and mandibular condyle bone marrow.

Hence, the aim of this paper was to evaluate and classify TMJ internal derangements in symptomatic TMJ patients and compare the signal intensity of TMJ disc and mandibular condyle bone marrow by digital analysis of magnetic resonance images in bruxism and non-bruxism patients with TMJ internal derangements.

Material and Methods

This study was based on MR images of 72 joints from 36 patients having signs and symptoms of internal derangement, which were referred to Gülhane Military Medical Academy due to TMJ complaints. Twenty-four females (mean age 38.7 years) and 12 males (mean age 35.3 years) were included in this study group. The clinical inclusion criteria were one or more of the following complaints; pain in the TMJ region; limitation or deviation in mandibular range of motion; and bruxism. Exclusion criteria for the study group were systemic diseases, dentofacial deformity, jaw trauma, previous TMJ surgery and previous steroid injection in the TMJ. Of all patients, 20 of them have bruxing behavior while 16 of them did not have such a behavior. Signs of bruxism were diagnosed clinically as abrasion of the incisor and occlusal surfaces of the teeth and obtained from the patients' history given on their first visit including clenching, bracing, gnashing, and grinding of the teeth. The duration of the bruxism also obtained from the patient's history and the patient who had bruxism at least one-year or more included the study.

All joints were studied with a 1.5-T Magnet (Gyroscan Intera, Philips Medical Systems, Washington,USA) using a dual phased array surface coil (6x8cm). All patients underwent imaging in axial, coronal and sagittal planes using fast-spin echo sequences (FSE). Imaging parameters were as in Table 1. DICOM 3.0 formatted MR images were sent to the DICOM server and downloaded to a personal computer (MS Windows XP, PIV 2.0 Ghz). The images were evaluated with a special software package for interactive display and manipulation of medical images using density functions (Osiris 4.09, University Hospital of Geneva, Geneva, Switzerland). A radiologist without knowledge of the prevailing clinical conditions evaluated all images and twice the operator interpreted these images after 1-month later. If the assessments were different, the final diagnosis was obtained by repeating the evaluation. The TMJs were classified according to the following MR criteria in Table 2.

The SI of the posterior band and anterior band of TMJ disc were measured with an circular region of interest (ROI) on T1, T2, and proton-weighted images MR images. ROIs were selected as follows; first the outlines of the articular disc, then the mid-

Table 1. Scanning parameters for MR imaging.

Image	Scanning time
Axial localizer TR/TE: 300 msec/16 msec/ NEX:0.5 FOV:18cm Thickness:3mm Matrix:256x128	25 sec
Sagittal, closed mouth TR/TE: :2000 msec/19-80 msec NEX:0,5 FOV:10-12cm Thickness:3 mm Matrix: 256x128	3 min, 15 sec
Sagittal, open mouth TR/TE: :1500 msec/19-80 msec NEX:0,75 FOV:10-12cm Thickness:3 mm Matrix: 256x128	3 min
Coronal, close mouth TR/TE: :2000 msec/19-80 msec NEX:0,5-0,75 FOV:10-12cm Thickness:3 mm Matrix: 256x128	4 min, 10 sec

Table 2. Criteria for classification of the status of the TMJ with respect to the articular disc position.

Normal superior disc position (Normal)
Disc located with its posterior band superior to the condyle The inferior aspect of the central thin zone of the articular disc Articulates against the anterior prominence of the condyle Normal condyle/disc relationship on open mouth images No evidence of medial or lateral displacement
Anterior Disc displacement with reduction (ADDwR)
Disc located anterior, medial, or lateral to the normal position on top of the condyle in the closed-mouth position Normal condyle/disc relationship on open mouth images
Anterior Disc displacement without reduction (ADDwoR)
Disc located anterior, medial, or lateral to the normal position on top of the condyle during all mandibular movements

point on the most anterior bulge of the anterior band, and finally the midpoint on the most posterior bulge of the posterior band were defined. Three lines were then drawn; one vertical line through the center of the head of the condyle (L1) and others from the center point to the midpoint on the most bulging points of the posterior band (L2) and anterior band (L3) of the disc. Similar methods from previous studies were used for the assessment of the disc position.[13,14] After these, we drew circular ROIs 3 mm in diameter, tangent to the lines of the posterior (L2) and anterior bands (L3), and these ROIs were localized inside the anterior and posterior band of the discs (Figure 1). Meanwhile ROI from the center of the mandibular condyle was also drawn and measured. The center of the circular coil and the center of the head of the condyle was the same. As mentioned above 3mm ROIs was also drawn for this region (Figure 2). The correlations among the groups of TMJs with-without bruxing behavior and SI were statistically analyzed by using Bonferroni/Dunn multi-

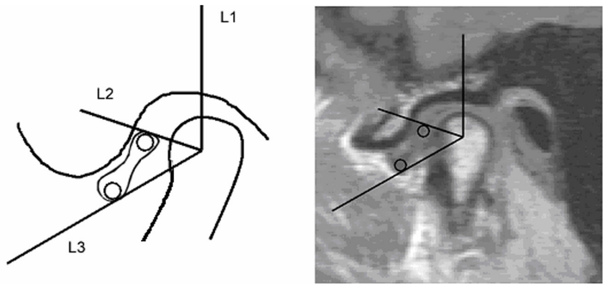

Figure1. The ROI measurement of posterior and anterior bands of TMJ disc.

Figure2. The ROI measurement of mandibular condyle.

Table 3. The distribution of TMJs according to bruxism and non-bruxism patients groups.

	With bruxism	Without bruxism	Total
Normal	18	11	29
ADDwR	9	10	19
ADDwoR	13	11	24
Total	40	32	72

comparison method test with a probability of less than 0,05 was considered statistically significant.

Results

Of all the joints with bruxing behavior studied with the help of MRI, 18 were Normal, 9 exhibited ADDwR, 13 ADDwoR. The patients without bruxing behavior showed 11 Normal, 10 ADDwR, 11 ADDwoR. (Table 3). The measured signal intensity of the posterior and anterior bands in the groups of with and without bruxism showed no statistical significance. There was a statistical significant difference between groups of with and without bruxism about mandibular condyle bone marrow SI ($p < 0,05$). Below in the Figures the average values of SI of anterior band and posterior band can be seen. There is no statistical significance both anterior and posterior band of the discs in patients with-without bruxing behavior groups (Figure 3, 4). The SI of the mandibular condyle bone marrow also investigated according to TMJ disc displacements. The signal intensities of the mandibular condyle bone marrow was as follows; normal with bruxism- 1.003, normal without bruxism-1.115, ADDwR with bruxism-2,720, ADDwR without bruxism-1.476, ADDwoR with bruxism-2.811, ADDwoR without bruxism-1.483.

The results showed that the average SI of the ADDwR group mandibular condyle bone marrow is higher in patients with bruxing behavior than the ADDwR group mandibular condyle bone marrow SI in patients without bruxing behavior (Figure 5). In addition to these SI of the ADDwoR group are lower in patients with bruxing behavior than the ADDwR group mandibular condyle bone marrow SI in patients without bruxing behavior (Figure 6).

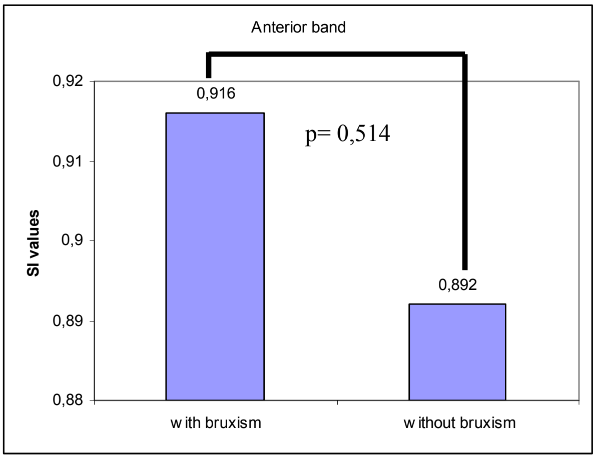

Figure 3. The comparison of anterior band signal intensity between with and without bruxism patients.

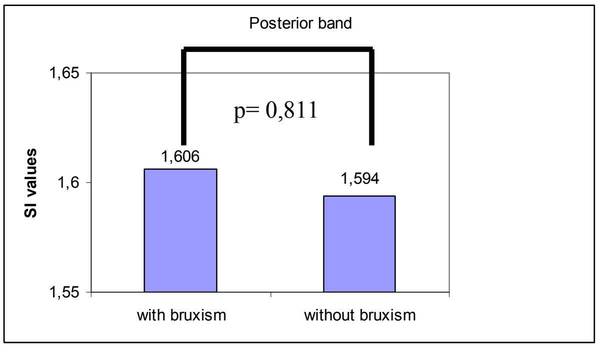

Figure 4. The comparison of posterior band signal intensiy between with and without bruxism patients.

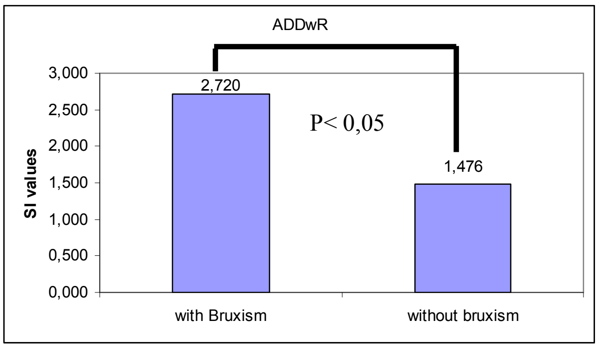

Figure5. The comparison of mandibular condyle bone marrow signal intensity between with and without bruxism patients in ADDwR.

Discussion

MR imaging of TMJ and TMJ disorders has been fully discussed. These structures have a degree of hydration that is easily seen with MR imag-

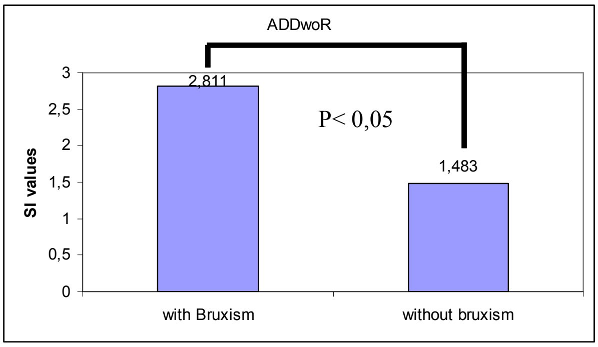

Figure 6. The comparison of mandibular condyle bone marrow signal intensity between with and without bruxism patients in ADDwoR.

ing. Besides visualization of TMJ structures, it can also examine the signal intensity characteristics.[4,8-12] Throughout this study we examined signal intensity characteristic of TMJ disc and mandibular condyle in patients with and without bruxing behavior. Since this is a preliminary study, no attempt was done in order to correlate between bruxism and internal derangement but effort to correlate SI of the TMJ structures and bruxism. We know from the previous studies that both in ADDwR and ADDwoR, condylar changes occur for the patients with bruxism.[3] Furthermore an investigator named Capurso[20] examined degenerative changes of the TMJ in 19.6% of 406 patients. He detected in the cases, bruxism played a part in its multifactorial etiology.

Previous studies indicated that increased pain associated with bone marrow alterations such as bone marrow edema, and osteonecrosis is well established for other joints such as femoral head, knee, wrist, and shoulder.[21,22] Abnormalities of the mandibular condyle similar in appearance to osteonecrosis in the femoral head have now been described in a number of MRI studies. This has led to the assumption that osteonecrosis can also affect the mandibular condyle.[23,24] It was concluded in a recent study intense pain in the TMJ may indicate marrow edema in the mandibular condyle, and that this condition itself may be precursor condition for osteonecrosis.[25] The results of MR imaging and measurement of SI in the present study showed that there is no significant change for anterior and posterior bands of TMJ disc in patients with and without bruxism. From another word, bands of the TMJ disc is affected as same as for both with and without bruxing behavior. It was found that mandibular condyle bone marrow SI increased significantly with the progress of internal derangement in the following order; normal, ADDwR, ADDwoR both in patients with bruxism and non-bruxism patients. It was also revealed that for all groups of TMJs, the signal intensity of condyle bone marrow in patient with bruxism are higher than the SI values of with bruxism patients which shows decreased signal on T1 and proton-weighted images but increased signal on T2-weigted images. The results mean that in patients with bruxism bone marrow alteration such as bone marrow edema of the mandibular condyle occurs which can be seen as high intensity areas in T2-weighted and proton-weighted images.

In conclusion, It was found that there were no difference for signal intensity of TMJ disc between in patients with-without bruxing behavior groups whereas the signal intensity of mandibular condyle bone marrow in patients with bruxing behavior was found to be higher than in patients without bruxing behavior. It can be conclude that bruxism effect condyle instead of disc and can constitute bone marrow alterations in mandibular condyle. Further studies have to be done with the inclusion of clinical data such as pain and clicking to clarify this connection.

REFERENCES

1. Dolwick MF, Katzberg RW, Helms CA: Internal derangements of temporomandibular joint: fact or fiction? J Prosthet Dent 49:415, 1983
2. Okeson JP: Management of Temporomandibular Disorders and occlusion. St.Louis, Mosby Inc, 1998,s.234-239, 355.
3. Güler N, Yatmaz PI, Ataoglu H, Emlik D, Uckan S: Temporomandibular internal derangement: correlation of MRI findings with clinical symptoms of pain and joint sounds in patients with bruxing behaviour. Dentomaxillofac Radiol 32:304, 2003.
4. Şener S, Akgünlü F: MRI characteristics of anterior disc displacement with and without reduction. Dentomaxillofac Radiol 33:245, 2004.
5. Westesson PL, Rohlin M: Internal derangement related to osteoarthrosis in temporomandibular joint autopsy specimens. Oral Surg Oral Med Oral Pathol 57:17, 1984.

6. Sano T, Westesson PL: Magnetic resonance imaging of the temporomandibular joint. Increased T2 signal in the retrodiskal tissue of painful joints. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 79:511, 1995.
7. Brooks SL, Westesson PL: Temporomandibular joint: value of coronal MR images. Radiology 188:317, 1993.
8. Cirbus MT, Smilack MS, Beltran J, Simon DC: Magnetic resonance imaging in confirming internal derangement of the Temporomandibular joint. J Prosthetic Dent 57:488,1987.
9. Tasaki MM, Westesson PL, Isberg AM, Ren YF, Tallents RH: Classification and prevalence of temporomandibular joint disc displacement in patients and symptom-free volunteers. Am J Orthod Dentofacial Orthop 109:250, 1996.
10. Katzberg RW: Temporomandibular joint imaging. Radiology 170:297, 1989.
11. Takaku S, Sano T, Yoshida M: Long term magnetic resonance imaging after temporomandibular joint discectomy without replacement. J Oral Maxillofac Surg 58:739-745, 2000.
12. Katzberg RW, Westesson PL, Tallents RH, Drake CM: Anatomic disorders of the temporomandibular joint disc in asymptomatic subjects. J Oral Maxillofac Surg 54:147-153, 1996.
13. Silverstein R, Dunn S, Binder R, Maganzini A: MRI assessment of the normal temporomandibular joint with the use of projective geometry. Oral Surg Oral Med Oral Pathol 77:523-530, 1994.
14. Ruf S, Pancherz H: Does bite-jumping damage the TMJ? A prospective longitudinal clinical and MRI study of Herbst patients. Angle Orthod 70:183-199, 2000.
15. Helms CA, Kaban LB, Mcneill C, Dodson T: Temporomandibular Joint: morphology and signal intensity characteristics of the disc at MR imaging. Radiology 172:817-820, 1989.
16. Katzberg RW: Temporomandibular joint imaging. Radiology 170:297-307,1989.
17. Schellhas KP, Fritts HM, Heithoff KB, Jahn JA, Wilkes CH, Omlie MR: Temporomandibular Joint: MR fast scaning. Cranio 6:209-216, 1988.
18. Rees AL: The structure and function of the mandibular joint. Br Dent J 96:125-133, 1954.
19. Taskaya-Yılmaz N, Ögutcen-Toller M: Magnetic resonance imaging evaluation of temporomandibular joint disc deformities in relation to type of disc displacement. J Oral Maxillofac Surg 59:860-865, 2001.
20. Capurso U: Clinical aspects of craniomandibular disorders. I. Analysis of a sample group of patients and diagnostic classification. Minerva Stomatol 45:311-320, 1996.
21. Zanetti M, Bruder E, Romero J, Hodler J: Bone marrow edema pattern in osteoarthritic knees: Correlation between MR imaging and histologic findings. Radiology 215:835-840, 2000.
22. Lecouvet FE, van de Berg BC, Maldague BE: Early irreversible osteonecrosis versus transient lesions of the femoral condyles: prognostic value of subchondral bone and marrow changes on MR imaging. AJR Am J Roentgenol 170:71-77, 1998.
23. Sano T: Recent developments in understanding temporomandibular joint disorders. Part 1: bone marrow abnormalities of the mandibular condyle Dentomaxillofac Radiol 29:7-10, 2000.
24. Schellhas KP: ınternal derangement of the temporomandibular joint: radiologic staging with clinical, surgical, and pathologic correlation. Magn Reson Imaging 152:551-560, 1989.
25. Morimoto Y, Tanaka T, Masumi S, Tominaga K, Shibuya T, Kito S, et al: Significance of frequency-selective fat saturation T2-weigted MR images for the detection of bone marrow edema in the mandibular condyle. Cranio 22:115-123, 2004.