Original Article

J Babol Univ Med Sci
Vol 17, Issu 11; Nov 2015. P:13-20

Evaluation of Degenerative Changes, Condyle Position and Joint Effusion in Patients with Temporomandibular Joint Disorder via MRI

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Received: Apr 8th 2015, Revised: May 6th 2015, Accepted: Jul 29th 2015

ABSTRACT

BACKGROUND AND OBJECTIVE: Investigation of the relationship between joint sounds and radiographic findings could be helpful in selecting a suitable treatment for internal temporomandibular joint disorder (TMJD). This study aimed to evaluate degenerative changes, condyle position and joint effusion in patients with TMJD using magnetic resonance imaging (MRI) as a gold standard procedure.

METHODS: This cross-sectional study was conducted on 34 patients diagnosed with TMJD via MRI. MRI images were obtained from the sagittal plane of the subjects using 5.0 Tesla Magnetic Resonance Scanner with open and closed mouth. Click sounds were divided into three categories based on the origin of the sound while opening the mouth: premature (<15 mm), intermediate (16-30 mm), and delayed (>31 mm). In addition, effusion volume, condyle-fossa relationship, swelling of the joints and degenerative changes were evaluated in the patients.

FINDINGS: Regarding the condyle position in the fossa, 32 of the examined joints (47.1%) were in central position, 30 (44.1%) were in posterior position, and 6 joints (8.8%) were in the upper position. Moreover, 34 joints (70.8%) had clicks, and 14 joints (70%) had no clicks or symptoms of osteoarthritis. Following that, grade-zero and grade-one effusions accounted for the highest number of examined joints, and there was no significant relationship between effusion volume and type of clicking. In the study group with clicking joints, 10 cases (14.7%) had premature clicks, 20 (29.4%) had intermediate clicks, and 18 joints (26.5%) had delayed clicks.

CONCLUSION: According to the results of this study, presence or absence of premature, intermediate and delayed clicks have no effects on condylar position in the fossa, effusion volume and occurrence of osteoarthritis in MRI.

KEY WORDS: Temporomandibular Joint, Osteoarthritis, Magnetic Resonance Imaging (MRI).

Please cite this article as follows:

Madani AS, Taheri Heravi M, Imanimoghadam M, Chamani A, Javan A, Mirmortazavi A. Evaluation of Degenerative Changes, Condyle Position and Joint Effusion in Patients with Temporomandibular Joint Disorder via MRI. J Babol Univ Med Sci. 2015;17(11):13-20.

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[DOR: 20.1001.1.15614107.1394.17.11.2.9]

[DOI: 10.22088/jbums.17.11.13]

Introduction

Temporomandibular joint (TMJ) is a joint with the ability to move in different directions due to the positioning of the mandibular condyle in the glenoid fossa of the temporal bone (1).

TMJ is associated with three common disorders, including internal, muscular and inflammatory disorders (2, 3), which affect the functionality of the joints (1). Internal disorders occur due to the position of condyle and its incorporating factors, such as disc, or any disturbance in the accordance of these two, such as degenerative changes, which could lead to joint dysfunction. Joint dysfunction is manifested through click sounds and loss of ability to fully open the mouth (1, 4-7). Clinical examinations may not provide complete information about the position and disorders of the joints; in this regard, it is more efficient to evaluate radiographic images after clinical examinations (8).

Various radiographic techniques are used for the assessment of condyle position in the glenoid fossa; for instance, computed tomography (CT), arthrography, magnetic resonance imaging (MRI), cone-beam (CB) CT, and panoramic ultrasound (9-11). Among these techniques, MRI is the most reliable diagnostic method for the detection of internal disorders and is considered as a “gold standard” procedure for TMJ imaging (11). MRI provides information about different parameters, including disc condition (12), shape and position of condyle, synovial fluid, joint effusions and changes in the bone marrow and bone structure, without exposing patients to any radioactive waves (1, 4, 8, 13-15).

Major joint changes are disc movements, and degenerative and inflammatory (effusion) changes in the hard and soft tissues of TMJ (16). Degenerative changes of TMJ are detected in MRI pictures in the presence of factors such as erosions (lack or absence of cortical continuity), sclerosis (significant increase of bone density), flattening (lack of round contour) and osteophytes (marginal hypertrophic bone formation) (4,10,15). When more than one of these changes appear in MRI, it is interpreted as the presence of degenerative or osteoarthritis changes in the joint (12). In one study, Dos Anjos Pontual et al. reported that flattening and osteoarthritis are the most frequent bone changes occurring with age (17). In this regard, one hypothesis declares that osteoarthritis of TMJ is the advanced mode of disc displacement, especially in the irreversible type (4). Furthermore, several researchers have confirmed that degenerative bone changes occur frequently in joints with irreversible disc displacement (4,18,19). However, the relationship between these two conditions remains unclear (4), and there is no agreement on the clinical significance of condyle position in the fossa. Despite the fact that posterior condylar position has been reported to be more common among patients with joint disorders, no evident relationship has been confirmed between the position of condyle in the fossa and radiographic and clinical symptoms of these patients (20). Joint effusion is defined as the presence of high volumes of fluids in the joint space, which normally leads to painful joints and swelling (10, 15).

Today, MRI is the primary option for the detection of TMJ effusions (19). These effusions are detected in MRI pictures of patients with internal disorders of the joints. In their research, Larheim et al. indicated that presence of joint fluids is predominantly associated with disc displacement(21).

Conversely, Koh et al. concluded that reversible or irreversible disc dislocation is not related to radiographic findings regarding the presence of joint effusions (22). This study aimed to evaluate the relationship between different types of joint click sounds and degenerative changes, condyle position and joint effusions by investigating the MRI results of patients with temporomandibular joint disorder (TMJD) referring to the occlusion section of Mashhad Dental School, Iran.

Methods

In this cross-sectional study, 34 patients presented with joint clicks were consecutively examined at the occlusion section of Mashhad Dental School, Iran. Firstly, patients were examined by prosthodontics specialists, and those diagnosed with class I occlusion with posterior dental support were enrolled in the study.

All the patients had click sounds atleast in one of the temporomandibular joints. In addition, 20 patients had one-sided clicks, and 14 had dual

[DOI: 10.22088/jbums.17.11.13]
[DOR: 20.1001.1.15614107.1394.17.11.2.9]

clicks. Types of click sounds based on the place of hearing while opening the mouth are as follows: premature (<15 mm), intermediate (16-30 mm), and delayed (>31 mm) (23). Exclusion criteria of the study were as follows: 1) history of acute trauma; 2) systematic diseases such as scleroderma and rheumatoid arthritis; 3) dental coatings containing iron and cobalt compounds; 4) pregnancy; 5) having heart pacemakers and 6) presence of claustrophobia. In order to evaluate the soft tissues of TMJ disc and condyle position, MRI was used as the gold standard procedure.

Informed consent was obtained from all the patients prior to MRI, and all the images were provided using GE Signa Contour device (GE Medical System, Milwaukee, WI MRI) with 0.5 Tesla and specific surface ring for TMJ. During MRI, patients were lying down, and images were obtained from the sagittal planes with open and closed mouth. We used T_1 pictures with T_E=17 and T_R=500, and T_2 pictures with T_E=90 and T_R=300 in the MRI of the patients. Thickness of each cutting block was allocated to each series of 3-mm images without any space in between, which resulted in 11-12 images in each series. Field of vision for each coronal image was 12 cm, and 12-16 cm for sagittal images.

Each image series was prepared in an approximate time of 4.5 minutes. Images were evaluated by radiologists specialized in jaw and mouth and MRI, and the results were interpreted based on Westesson's criteria for the status of TMJ (24).

If an area had high signals in the upper or lower joint spaces, effusions were confirmed in the joint. Criteria proposed by Roh et al. were used to determine the volume of joint effusion in MRI at four main grades (13), as follows: no areas detected with high effusions (grade zero), one point or line on joint surface with high intensity of signals (grade one) (fig 1), bond of high intensity signals (grade 2) (fig 2), and signals with high intensity in a set of articular components (grade 3) (fig 3). Furthermore, criteria offered by Incesu et al. were used to determine the condyle position in the fossa of TMJ in MRI pictures (11), so that the positioning of condyle was determined by the difference in the narrowest gap between the articular anterior (A) and the articular posterior (P) in the MRI pictures of the mid-sagittal planes (fig4).

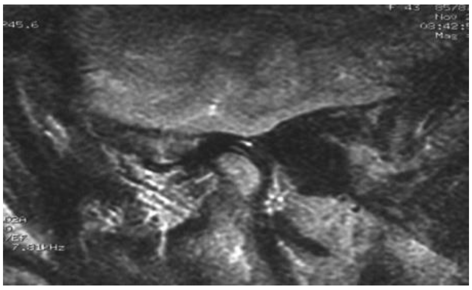

Figure 1. Grade 1 Temporomandibular Joint (TMJ) Effusion in MRI

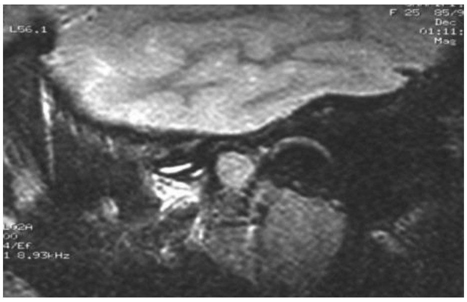

Figure 2. Grade 2 TMJ Effusion in MRI

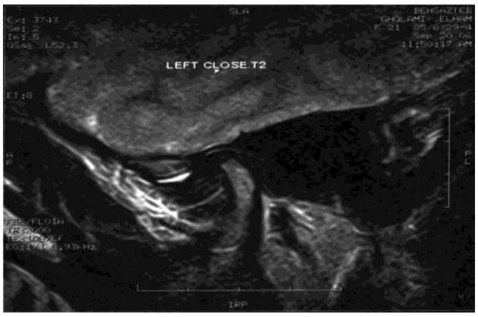

Figure 3. Grade 3 TMJ Effusion in MRI

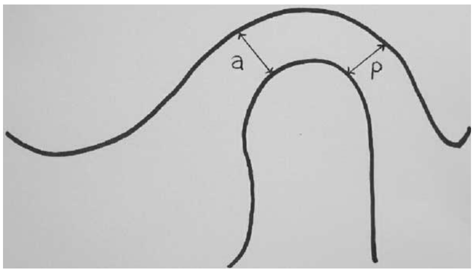

Figure 4. Evaluation of Condylar Position

When the anterior distance was greater than the posterior distance (P<A), the condyle was located in the posterior position of the fossa, and when these two distances were equal (A=P), the condyle was positioned at the center of the fossa (fig 5). On the other hand, when the posterior distance was greater than the anterior (P>A), the condyle was in

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[DOI: 10.22088/jbums.17.11.13]

the anterior position (fig 6). Osteoarthritis and degenerative changes of the TMJ in MRI images were determined based on the criteria of Roh et al., as well as and the presence of factors such as erosions (lack or absence of cortical continuity), sclerosis (significant increase of bone density), flattening (lack of round contour), and osteophytes (marginal hypertrophic bone formation) (fig 7) (13). Data analysis was performed using SPSS, Fisher’s exact test and Chi-square for evaluating the condyle position in MRI and its relationship with the types of click sounds. Moreover, the Kruskal-Wallis test was used to assess the relationship between osteoarthritis and type of joint clicks. Also, Kendall's Tau correlation coefficient was used to evaluate the relationship between effusion volumes and clinical symptoms, and $p<0.05$ was considered significant.

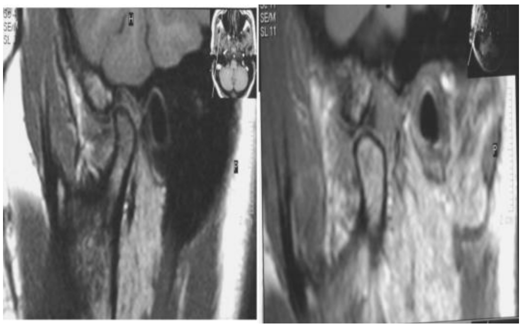

Figure 5. Normal Position of Disc and Condyle in Sagittal MRI

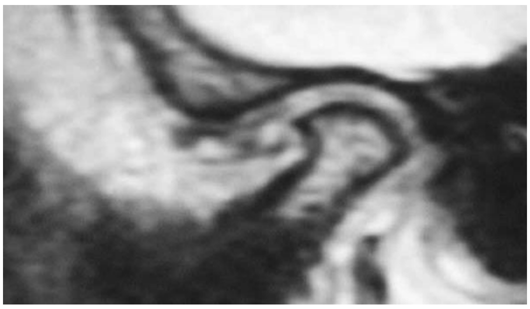

Figure 6. Posterior Condylar Position in TMJ of Fossa in MRI

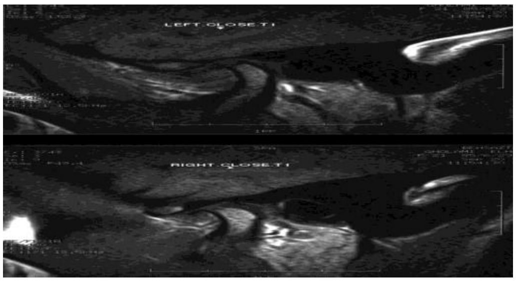

Figure 7. Osteoarthritis in TMJ in MRI

Results

In this study, patients were within the age range of 16-46 years (mean age: 24.4±8.25), including 27 women and 7 men. Out of 68 examined joints (34 patients), 48 joints (70.6%) had click sounds, and 20 joints (29.4%) had no click sounds (table 1). In the study group with clicking joints, 10 cases (14.7%) had premature clicks, 20 (29.4%) had intermediate clicks, and 18 cases (26.5%) had delayed clicks. In total, 9 joints (13.2%) had singular click sounds, while 39 joints (57.4%) had reciprocal clicks (table 2). Position of condyle in MRI images was central in 32 joints (47.1%), posterior in 30 joints (44.1%), and in 6 cases (8.8%), the condyle was located in the upper position, which had the lowest rate. There was no significant difference in the condylar position in MRI and type of clicking sounds. In the evaluation of osteoarthritis in MRI images, there was no statistically significant difference between osteoarthritis and joint clicks (table 2). Accordingly, out of 48 clicking joints, 34 cases (70.8%) had osteoarthritis symptoms, while out of 20 joints without clicks, 14 cases (70%) had osteoarthritis symptoms. In joints with effusions, 20 cases (29.4%) had grade-one effusion, 6 joints (8.8%) had grade-two effusion, and one case (1.5%) had grade-three effusion. Additionally, 41 joints (60.3%) had no effusions (grade zero). No statistically significant difference was observed between the type of joint clicks and grade of effusions (table 2).

Table 1. Frequency of examined joints based on Condylar position and presence of clicks in MRI images

Condylar Position / Click	Central N(%)	Posterior N(%)	Upper N(%)	Total N(%)
Without click	10(50)	7(35)	3(15)	20(100)
With click	22(45.8)	23(47.9)	3(6.3)	48(100)
Total	22(47.1)	30(44.1)	6(8.8)	68(100)

[DOR: 20.1001.1.15614107.1394.17.11.2.9]
[DOI: 10.22088/jbums.17.11.13]

Table 2. Frequency of examined joints based on clicking types and condylar position, presence or absence of osteoarthritis and the level of effusion in MRI images

Clicking Type	Condylar Position			Osteoarthritis		Range of Effusion			
	Central N(%)	Posterior N(%)	Upper N(%)	Presence N(%)	Absence N(%)	Absence N(%)	+ N(%)	++ N(%)	+++ N(%)
Without clicks	10(50)	7(35)	3(15)	6(30)	14(70)	11(55)	9(45)	0	0
Premature	2(20)	7(70)	1(10)	2(20)	8(80)	7(70)	2(20)	0	1(10)
Intermediate	8(40)	11(55)	1(5)	7(35)	13(65)	12(60)	6(30)	2(10)	0
Delayed	12(66.7)	5(27.8)	1(5.6)	5(27.8)	13(72.2)	11(61.1)	3(16.7)	4(22.2)	0
Total	32(47.1)	30(44.1)	6(8.8)	20(29.4)	48(70.6)	41(60.3)	20(29.4)	6(8.8)	1(1.5)

Discussion

In total, 68 joints were examined in the present study, and the condyle was in the posterior position in 70% of the cases with premature clicks and 55% of those with intermediate clicks in MRI images. As for cases with delayed clicks or no clicking, the condyle was more often in a central position, rather than posterior or upper positions. However, there was no statistically significant difference between condylar position in MRI pictures and joint clicks with various grades of ability to open the mouth. Consequently, the position of condyle could not be clearly realized based on the type of clicking. Since abnormal condyle shape was more frequent in cases without joint clicks and those of various types, we could not determine the shape of condyle based on the type of clicking. According to the literature, although TMJ effusion is mostly accompanied with clinical symptoms, evidence is scarce to confirm the relationship between MRI findings and clinical symptoms of joints (12-14).

This is in line with the findings of the present study since effusion in the joints without clicking was positive in 45% of our cases, and in case of joints with clicking sounds, only 37.5% had effusions. Furthermore, out of 68 examined joints in our study, only one had grade-3 effusion, which was of the premature type, while two and four cases of grade-2 effusions were of the intermediate and delayed clicking types, respectively. In cases without clicks, grade 2 and 3 effusions were not detected; however, this finding was not statistically significant and cannot be generalized.In a study conducted by Galhardo et al., out of 67 patients, 44 cases had clinical TMJD, while this diagnosis could not be confirmed in 21 patients via MRI (25). In another study, Manfredini et al. stated that joint sounds could not accurately determine the position of disc and condyle, and a combination of clinical and radiographic methods is necessary for this purpose (26). In their research, Bernhardt et al. reported that clinical examination alone cannot determine the degenerative disorders of joints, and MRI is a necessary complementary method for the accurate diagnosis of such disorders (27). In the current study, out of 20 joints without clicking, 14 cases (70%) had osteoarthritis, while in 35% of the intermediate clicks, there were no signs of osteoarthritis.

This finding highlights the importance of MRI in the evaluation of joint disorders. Although the presence of joint clicks do not indicate a need for treatment, joints with clicking sounds may not function properly, which reveals the pivotal role of diagnostic imaging (8). In their study, Compos et al. emphasized the importance of MRI in the evaluation of the correlation between joint pain and occurrence of degenerative changes, since 46.5% of the studied patients with degenerative changes were observed to have no joint pain (4).

Several studies have confirmed the significance of degenerative changes of the joints as the major mechanisms involved in pain and functional TMJD (28-30). For instance, Milam et al. indicated that individual risk factors associated with genetics, age, gender and systematic diseases play a key role in the occurrence of degenerative changes of joints (31). Although osteoarthritis is one of the most common degenerative diseases of the synovial joints (32), the results obtained by Emshoff et al. denoted the controversy over the impact of osteoarthritis on the onset, progression and termination of TMJ clinical symptoms (33). Findings regarding the identification of a significant correlation between degenerative changes of osteoarthritis in joint structures and related clinical symptoms (e.g., pain and clicks) are

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variable in different studies. This is due to the differences in the prevalence of osteoarthritis symptoms in radiographic images of TMJ without clinical symptoms, which has been reported to be 50-90% in various researches (34-36). The findings of the current study indicated that hearing clicking sounds is not a proper indicator of degenerative changes in TMJ, and degenerative changes without clicks are also detectable in MRI.

Considering the differences in the reported prevalence of osteoarthritis, as well as the lack of clinical and imaging criteria specific to the diagnosis of joint osteoarthritis, further research is required as to invent special clinical and radiographic criteria for evaluating osteoarthritis. Moreover, it is recommended that future studies be conducted on MRI devices with higher power and larger sample sizes. In conclusion, the results of the present study indicated that hearing clicking sounds is not a proper indicator of degenerative changes in TMJ, and these changes are also detectable in MRI without joint clicks. On the other hand, it is possible to identify clicking sounds in cases presented with substantial degenerative and inflammatory changes, such as high effusion rates, while it may not be statistically significant. In addition, premature, intermediate and delayed joint clicks could not be an accurate indicator of the condylar position in the fossa, effusions and their grade, and the presence of osteoarthritis in TMJD patients.

Acknowledgments

Hereby, we extend our gratitude to the Research Deputy of Mashhad University of Medical Sciences, Mashhad Dental School and all the colleagues for assisting us in this project.

References

1.Dergin G, Kilic C, Gozneli R, Yildirim D, Garip H, Moroglu S. Evaluating the correlation between the lateral pterygoid muscle attachment type and internal derangement of the temporomandibular joint with an emphasis on MR imaging findings. J Craniomaxillofac Surg. 2012;40(5):459-63.

2.Barclay P, Hollender LG, Maravilla KR, Truelove EL. Comparison of clinical and magnetic resonance imaging diagnosisin patients with disk displacement in the temporomandibular joint. Oral surg Oral med Oral Pathol Oral Radiol Endod. 1999;88(1):37-43.

3.Madani AS, Shamsian AA, Hedayati-Moghaddam MR, Fathi-Moghadam F, Sabooni MR, Mirmortazavi A, et al. A cross-sectional study of the relationship between serum sexual hormone levels and internal derangement of temporomandibular joint. J oral rehabil. 2013;40(8):569-73

4.Campos MI, Campos PS, Cangussu MC, Guimaraes RC, Line SR. Analysis of magnetic resonance imaging characteristics and pain in temporomandibular joints with and without degenerative changes of the condyle. Int J Oral Maxillofac Surg. 2008;37(6):529-34.

5.Emshoff R, Brandlmaier I, Bosch R, Gerhard S, Rudisch A, Bertram S. Validation of the clinical diagnostic criteria for temporomandibular disorders for the diagnostic subgroup - disc derangement with reduction. J Oral Rehabil. 2002;29(12):1139-45.

6.Madani AS, Mirmortazavi A. Comparison of three treatment options for painful temporomandibular joint clicking. J Oral Sci. 2011;53(3):349-54.

7.Madani AS, Mirmortazavi A, Ghazi N, Ziaee S. The possible role of oral contraceptives in thedevelopment of temporomandibular disorders. Indian J Stomatol. 2010;2(3):149-52.

8.Dias IM, Coelho PR, Picorelli Assis NM, Pereira Leite FP, Devito KL. Evaluation of the correlation between disc displacements and degenerative bone changes of the temporomandibular joint by means of magnetic resonance images. Int J Oral Maxillofac Surg. 2012;41(9):1051-7.

9.Petersson A. What you can and cannot see in TMJ imaging--an overview related to the RDC/TMD diagnostic system. J Oral Rehabil. 2010;37(10):771-8.

10.Taheri Heravi M, Madani AS, Imani moghadam M, Goudarzi M, Habibi Rad A, Mirmortazavi A. Evaluation of disc position in patients with temporomandibular joint clicking using MRI. J Mashhad Dent Sch. 2014;38(2):139-48. [In Persian]

11.Incesu L, Taskaya-Yilmaz N, Ogutcen-Toller M, Uzun E. Relationship of condylar position to disc position and morphology .Eur J Radiol. 2004;51(3):269-73.

12.Park JW, Song HH, Roh HS, Kim YK, Lee JY. Correlation between clinical diagnosis based on

RDC/TMD and MRI findings of TMJ internal derangement. Int J Oral Maxillofac Surg. 2012;41(1):103-8.

13.Roh HS, Kim W, Kim YK, Lee JY. Relationships between disk displacement, joint effusion, and degenerative changes of the TMJ in TMD patients based on MRI findings. J Cranio-maxillo-fac Surg. 2012;40(3):283-6.

14.Tognini F, Manfredini D, Melchiorre D, Zampa V, Bosco M. Ultrasonographic vs magnetic resonance imaging findings of temporomandibular joint effusion. Minerva stomatologica. 2003;52(7-8):365-70.

15.Simmons HC, Gibbs SJ. Anterior repositioning appliance therapy for TMJ disorders: specific symptoms relieved and relationship to disk status on MRI. J Tenn Dent Assoc. 2009;89(4):22-30.

16.Ribeiro-Rotta RF, Marques KD ,Pacheco MJ, Leles CR. Do computed tomography and magnetic resonance imaging add to temporomandibular joint disorder treatment? A systematic review of diagnostic efficacy. J Oral Rehabil. 2011; 38(2): 120-35.

17.dos Anjos Pontual ML, Freire JS, Barbosa JM, Frazao MA, dos Anjos Pontual A. Evaluation of bone changes in the temporomandibular joint using cone beam CT. Dentomaxillofac Radiol. 2012;41(1):24-9.

18.Manfredini D, Basso D, Salmaso L, Guarda-Nardini L. Temporomandibular joint click sound and magnetic resonance-depicted disk position: which relationship? J Dent. 2008;36(4):256-60.

19.Gil C, Santos KC, Dutra ME, Kodaira SK, Oliveira JX. MRI analysis of the relationship between bone changes in the temporomandibular joint and articular disc position in symptomatic patients. Dentomaxillofacial Radiol. 2012; 41(5): 367-72.

20.Cho BH, Jung YH. Osteoarthritic changes and condylar positioning of the temporomandibular joint in Korean children and adolescents. Imaging Sci Dent. 2012;42(3):169-74.

21.Larheim TA, Westesson PL, Sano T. MR grading of temporomandibular joint fluid: association with disk displacement categories, condyle marrow abnormalities and pain. Int J Oral Maxillofac Surg. 2001;30(2):104-12.

22.Koh KJ, Park HN, Kim KA. Relationship between anterior disc displacement with/without reduction and effusion in temporomandibular disorder patients using magnetic resonance imaging. Imaging Sci Dent. 2013;43(4):245-51.

23.Ozawa S, Tanne K. Diagnostic accuracy of sagittal condylar movement patterns for identifying internal derangement of the temporomandibular joint. J Orofac Pain. 1997;11(3):222-31.

24.Westesson PL, Katzberg RW, Tallents RH, Sanchez-Woodworth RE, Svensson SA, Espeland MA. Temporomandibular joint: comparison of MR images with cryosectional anatomy. Radiology. 1987;164(1):59-64.

25.Galhardo AP, da Costa Leite C, Gebrim EM, Gomes RL, Mukai MK, Yamaguchi CA, et al. The correlation of research diagnostic criteria for temporomandibular disorders and magnetic resonance imaging: a study of diagnostic accuracy. Oral Surg Oral Med Oral Pathol Oral Radiol. 2013;115(2):277-84.

26.Manfredini D, Basso D, Arboretti R, Guarda-Nardini L. Association between magnetic resonance signs of temporomandibular joint effusion and disk displacement. Oral Surg Oral Med Oral Pathol Oral Radiol. 2009;107(2):266-71.

27.Bernhardt O, Biffar R, Kocher T, Meyer G. Prevalence and clinical signs of degenerative temporomandibular joint changes validated by magnetic resonance imaging in a non-patient group. Ann Anat. 2007;189(4):342-6

28.Holmlund A, Hellsing G. Arthroscopy of thetemporomandibular joint: occurrence and location of osteoarthrosis and synovitis in a patient material. Int J Oral Maxillofac Surg. 1988; 17(1): 36-40.

29.Israel HA, Saed-Nejad F, Ratcliffe A. Early diagnosis of osteoarthrosis of the temporomandibular joint: correlation between arthroscopic diagnosis and keratan sulfate levels in the synovial fluid. J Oral Maxillofac Surg. 1991;49(7):708-11.

30.Stegenga B, de Bont LG, Boering G. Osteoarthrosis as the cause of craniomandibular pain and dysfunction: a unifying concept. J Oral Maxillofac Surg. 1989;47(3):249-56.

31.Milam SB. Pathogenesis of degenerative temporomandibular joint arthritides. Odontology. 2005;93(1):7-15.

32.Arthur C, Watt K, Nussey DH, Pemberton JM, Pilkington JG, Herman JS, et al. Osteoarthritis of the temporo-mandibular joint in free-living Soay sheep on St Kilda. Vet J. 2015;203(1):120-5.

33.Emshoff R, Brandimaier I, Bertram S, Rudisch A. Magnetic resonance imaging findings of osteoarthrosis and effusion in patients with unilateral temporomandibular joint pain. Int J Oral Maxillofac Surg. 2002;31(6):598-602.
34.Brooks SL, Westesson PL, Eriksson L, Hansson LG, Barsotti JB. Prevalence of osseous changes in the temporomandibular joint of asymptomatic persons without internal derangement. Oral Surg Oral Med Oral Pathol. 1992;73(1):118-22.
35.Ericson S, Lundberg M. Structural changes in the finger, wrist and temporomandiblar joints. A comparative radiologic study. Acta odontol Scand. 1968;26(2):111-26.
36.Westesson PL, Brooks SL. Temporomandibular joint: relationship between MR evidence of effusion and thepresence of pain and disk displacement. AJR Am J Roentgenol. 1992;159(3):559-63.

[DOR: 20.1001.1.15614107.1394.17.11.2.9]
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