



Best MRI Sequences in Detection of Temporomandibular Joint Disorders

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Abstract

Temporomandibular joint involvement is one of the most complications in patients attending dental clinics. Nowadays, MRI is commonly used to diagnose temporomandibular joint pain and movement disorders and this study was performed to compare finding of MRI sequences in distinguishing TMJ disorders. In a prospective design, 44 TMJ of 23 patients (only one TMJ is evaluated in 2 patients) included in the study. After clinical examination by a Facial and Jaw Surgeon, MRI sequences include T1, T2, PD and dynamic (GRE) were obtained and assessed by a skilled radiologist. Evaluation of internal derangement and osteoarthritis were the main objects. Mean \pm SD of age was 40.38 ± 17.87 years. According to disk position and its shape, internal derangement was reported in 21 joints (47.7%) that PD was judicable in 43 joints (97.7%) and T2 in 42 joints (95.5%). Osteoarthritis was observed in 14 joints (31.8%) that T2 and PD were judicable in more than 95% of joints and degenerative changes were seen in 12 joints (27.3%) in T2 study and 11 joints (25%) in PD image. It seems that PD and T2 sequences have high ability to show TM joint structure and surrounding tissues; while T1 and dynamic sequences have less diagnostic value.

Introduction and Objective: The current study aims to investigate the findings of different MRI sequences in the diagnosis of movement disorders and temporomandibular joint pain in patients referring to the dental clinic of Tehran University.

Keywords: MRI, Sequences, Temporomandibular joint, Internal derangement, Osteoarthritis,

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Introduction

Temporomandibular involvement is one of the common problems among patients referring to dental clinics. Various studies have indicated the prevalence of TMJ disorder. In some articles, the prevalence of this disorder has been reported to be up to 28% of the population although these studies have not covered visual findings. The most common reason for TMJ disorder is the placement of internal components of this joint and in fact, the abnormal connection of the disc with the condyle (1).

Despite this prevalence, unfortunately, the diagnosis of disorders of this joint faces a lot of problems. The studies conducted to find the causes and treatment of TMJ disorders should be based on authentic and reliable diagnostic criteria. Although the history and the clinical examination play an important role in the diagnosis of this disorder, the lack of paraclinical methods to confirm the diagnosis has made fundamental challenges for therapists. In the meantime, the imaging methods are of great importance (2).



Besides the clinical findings, imaging of the temporomandibular joint is one of the important steps in diagnosing this joint's disorders. The objective of imaging the temporomandibular joint is to examine the integrity of the joint structure, assess the extent and progress of the disorder, and evaluate the effect of treatment. To achieve these objectives, TMJ should be evaluated in terms of both soft and hard textures (3).

Temporomandibular Joint Disorder (TMJ) is one of the common disorders best examined by the MRI(23,24). The first step in performing an MRI for this joint is the evaluation of its articular disc including the disc and its location in connection with the condyle in the open and closed-jaw states. The location of the disc is of primary importance because the presence of a displaced joint is indicative of a serious disorder in TMJ's performance. However, since disc displacement is repeatedly seen in symptomless patients, the absolute diagnosis of the displaced disk disorder requires other findings. These findings include the thickening of the connection between the external pterygoid muscle, tearing of the retrodiscal layers, and joint effusion. These findings can be categorized as early and indirect symptoms of TMJ disorder. Radiologists need to be able to diagnose its symptoms by the MRI in the first phases of the disease since if they do so, the disease progress to the final and irreversible phase, such as changes in osteoarthritis (flattening of the condyle, osteophyte, etc.) can be avoided. Future studies that include new techniques of MRI can be helpful in the diagnosis of TMJ pain origin and in dealing with any difference between the visual findings and disease symptoms (5).

In a study by Schweighofer et al. to investigate the MRI value in the diagnosis of the normal and abnormal positions (Positional and bone changes) of the temporomandibular joint in the coronal plane (T1 sequence) compared to findings obtained from the cryosection investigations, 22 temporomandibular joints from the non-optional bodies were evaluated. Finally, it was revealed that for a complete examination of TMJ by the MRI, it is required to prepare both sagittal and coronal planes (7). In a study by Brooks & Westesson, the efficiency of MRI coronal plane (T2 and PD sequences) for evaluation of TMJ disc has been investigated. it was revealed in this study that based on the sagittal plane alone, 7

cases of internal or external displacements were not found and the use of the coronal plane adds to the diagnostic power of sagittal plane MRI (8).

Although most of the available studies have indicated the high diagnostic accuracy of the MRI, few studies have dealt with the investigation of the value of different sequences of MRI in the diagnosis of these joint disorders, in detail (8). As a result, the current study aimed to investigate the findings of different sequences of the MRI in movement disorders and TMJ pains among a sample of Iranian patients. Explanation of these findings greatly helps with the improvement of the diagnostic guidelines for TMJ disorders and the selection of the best MRI sequence.

Method and Materials:

The present research is a case-series investigation. The statistical population included all patients with movement disorders and TMJ pains referring to TMJ department.

A convenience sampling method was used. Using the results of similar studies, in the present study, 44 joints in 23 patients (in two patients, only one joint was investigated) were investigated. Using the prospective method, all the patients with movement disorders and TMJ pain who needed an MRI according to the diagnosis of a skilled dentist were included in the study. First, the clinical examinations were performed by the dentist and the patients were checked for Internal Derangement and joint osteoarthritis. Then, all the studied patients were referred to the MRI clinic, and obtained MRI sequences were T1sagittal, T2 sagittal ,coronal T2 and PD sequences with open and closed-jaw positions as well as dynamic sequences. Then, the MRI sequences were evaluated by a skilled radiologist in terms of temporomandibular joint surfaces (temporal and mandibular), joint disc condition (disc shape, disc position, and disc movement), the presence of internal derangement and its type, the presence of degenerative joint changes, indirect joint changes (joint effusion, increased thickness of external pterygoid muscle connections, and rupture of the retrodiscal layers). The data collection instrument was a checklist. All data obtained were analyzed by



SPSS Ver.16 and presented in the form of suitable tables and graphs. The descriptive objectives were presented using central and dispersion indices for any information and result.

Results:

The mean (\pm standard deviation) age of the samples was 40.38 ± 17.87 with a range of 21-73 years. All the samples were female. The clinical examinations indicated Osteoarthritis in 18 joints (40.9%) and internal derangement in 23 joints (52.3%). Investigating each joint, 4 sequences as Dynamic, T1, T2, and PD (opened and closed-jaw) were prepared.

The temporal articular surface could be observed in 35 cases (79.5%) from the Dynamic sequence, 40 cases (90.9%) from the T1 sequence, 43 cases (97.7%) from the T2 sequence, and 41 cases (93.2%) from the PD sequence. Finally, abnormality of the temporal joint surface was observed in all four sequences in only one case (2.3%).

The mandibular articular surface could be observed in 34 cases (77.3%) from the Dynamic sequence, 40 cases (90.9%) from the T1 sequence, 42 cases (95.5%) from the T2 sequence, and 41 cases (93.2%) from the PD sequence. Finally, the abnormality of the mandibular articular surface was observed in 9 cases (20.5%) of the Dynamic sequence, 11 cases (25%) of the T1 sequence, 11 cases (25%) of the T2 sequence, and 9 cases (5/5%) of the PD sequence.

Table 1 compares the results of different MRI sequences in the diagnosis of temporomandibular joint surface disorders.

Articular Surfaces:

Articular Surface Evaluation						
	Temporal			Mandibular		
	Normal feature	Abnormal feature	Undetectable feature	Normal feature	Abnormal feature	Undetectable feature
Dynamic	34(77.3%)	1(2.3%)	9(20.5%)	25(73.5%)	9(20.5%)	10(22.7%)
T1	39(88.6%)	1(2.3%)	4(9.1%)	29(65.9%)	11(25%)	4(9.1%)
T2	42(95.5%)	1(2.3%)	1(2.3%)	31(70.5%)	11(25%)	2(4.5%)
PD	40(90.9%)	1(2.3%)	3(6.8%)	32(72.7%)	9(20.5%)	3(6.8%)

Table 1: Comparison of different MRI sequences in terms of diagnosis of temporal and mandibular joint surface disorders

Articular Disc:

The shape of the articular disc could be observed in 11 cases (25%) from the Dynamic sequence, 22 cases (50%) from the T1 sequence, 42 cases

(95.5%) from the T2 sequence, and 42 cases (95.5%) from the PD sequence, which indicates an abnormality in the shape of the disc in 4 cases (9.1%) from the dynamic sequence, 4 cases (9.1%) from T1 sequence, 14 cases (31.8%) from T2 sequence, and 13 cases (5.5%) from the PD



sequence.

The position of the disc was also observed in 14 cases (31.8%) from the dynamic sequence, 21 cases (47.7%) from the T1 sequence, 42 cases (95.5%) from the T2 sequence, and 43 cases (97.7%) from the PD sequence, and abnormality could be seen in 5 cases (11.4%) from the dynamic sequence, 9 cases (20.5%) from T1 sequence, 20 cases (45.5%) from T2 sequence and 20 cases (45.5%) from the PD sequence.

Disc movement in the open-jaw radiography could be seen in 5 cases (11.4%) from the dynamic sequence and 30 cases (68.2%) from the PD sequence, the results of which indicated abnormality in 1 case (2.3%) of the dynamic sequence, and 16 cases (36.4%) from the PD sequence.

Table 2 compares the results of different MRI sequences in the diagnosis of temporomandibular joint disc disorders.

Table 2: Comparison of different MRI sequences in terms of temporomandibular joint disc disorders

Disk Evaluation									
	Disk Configuration			Disk Movement			Position		
	Normal feature	Abnormal feature	Undetectable feature	Normal feature	Abnormal feature	Undetectable feature	Normal Feature	Abnormal feature	Undetectable feature
Dynamic	7(15.9%)	4(9.1%)	33(75%)	9(20.5%)	5(11.4%)	30(68.2%)	4(9.1%)	1(2.3%)	39(88.6%)
T1	18(40.9%)	4(9.1%)	22(50%)	12(27.3%)	9(20.5%)	23(52.3%)	-	-	44(100%)
T2	28(63.6%)	14(95.5%)	2(4.5%)	22(50%)	20(45.5%)	2(4.5%)	-	-	44(100%)
PD	29(65.9%)	13(29.5%)	2(4.5%)	23(52.3%)	20(45.5%)	1(2.3%)	14(31.8%)	16(36.4%)	14(31.8%)

By comparing the results of clinical examinations and MRI sequences, the following results were obtained: in 20 joints (45.5%), both methods showed the joint to be normal, and in 20 joints (45.5%), both methods showed an internal derangement. Also, in 1 joint (2.3%), the results of normal clinical examinations and MRI showed

Internal Derangement, and in 3 joints (6.8%), clinical examinations indicated Internal Derangement while the results were normal in the MRI. In Table 3, the results of clinical examinations and MRI in the diagnosis of Internal Derangement of the temporomandibular joint are compared.

Table 3: 2x2 table of comparison of results obtained from the clinical examinations and MRI in the diagnosis of internal derangement of TMJ in the case study

		MRI		
		Positive	Negative	Total
Physical Examination	Positive	20 (45.5%)	3 (6.8%)	23 (52.3%)
	Negative	1 (2.3%)	20 (45.5%)	21 (47.8%)



Total	21 (47.7%)	23 (52.3%)	44 (100%)
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T1 sequence, 43 cases from the T2 sequence, and 42 cases (95.5%) from the PD sequence, which allows for judgement. The results of the investigation showed osteoarthritis in 10 cases (22.7%) from the dynamic sequence, 14 cases (31.8%) from the T1 sequence, 12 cases (27.3%) from the T2 sequence, and 11 cases (25%) from the PD sequence, which are compared in diagram 2.

Degenerative Articular Changes:

Finally, based on MRI examinations, osteoarthritis was reported in 14 joints (31.8%). An acceptable quality was observed in 26 joints (59.1%) from the Dynamic sequence, 38 cases (86.4%) from the

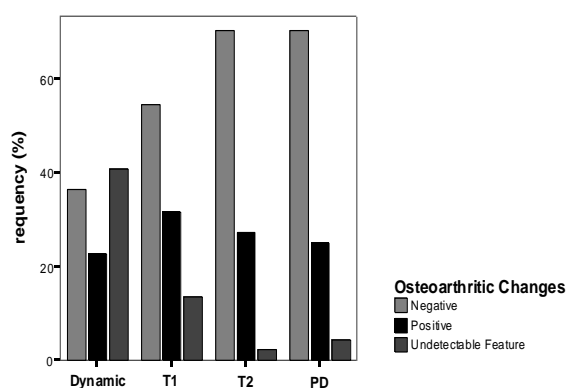


Figure 2: Comparison of different MRI sequences in the diagnosis of degenerative changes of TMJ

(11.4%) from the T2 sequence, and 5 joints (11.4%)) from the PD sequence.

Other Changes in Temporomandibular Joint:

Joint effusion could be observed in 8 cases (18.2%) from the T1 sequence, 33 cases (75%) from the T2 sequence, and 42 cases (95.5%) from the PD sequence. Also, an abnormality was reported in 10 joints (22.7%) from the PD sequence.

The decision about the rupture of the retrodiscal layers could be made in 3 cases (6.8%) from the dynamic sequence, 6 cases (13.6%) from the T1 sequence, 39 cases (88.6%) from the T2 sequence, and 41 cases (93.2%)) from the PD sequence. The results indicated rupture in 1 case (2.3%) in the dynamic sequence, 1 case (2.3%) from the T1 sequence, 11 cases (25%) from the T2 sequence, and 11 cases (25%) from the PD sequence.

An increase in the thickness of the junction of the external pterygoid muscle was observed in 12 cases (27.3%) from the dynamic sequence, 24 cases (54.5%) from the T1 sequence, 43 cases (97.7%) from the T2 sequence and 43 cases (7.7%) 97) from the PD sequence. An abnormality was observed in 1 joint (2.3%) from the Dynamic sequence, 3 joints from the T1 sequence, 5 joints

Table 4 compares the results of different MRI sequences in the diagnosis of indirect changes in the temporomandibular joint.



Table 4: Comparison of different MRI sequences in the diagnosis of indirect changes in the temporomandibular joint

	Indirect Changes of TMJ								
	Joint Effusion			Increased Thickness of LPM Attachment			Rupture of Retrodiskal Layers		
	Normal feature	Abnormal feature	Undetectable feature	Normal feature	Abnormal feature	Undetectable feature	Normal feature	Abnormal feature	Undetectable feature
Dynamic	-	-	44(100%)	11(25%)	1(2.3%)	32(72.7%)	2(4.5%)	1(2.3%)	41(93.2%)
T1	8(18.2%)	-	36(81.8%)	21(47.7%)	3(6.8%)	20(45.5%)	5(11.4%)	1(2.3%)	38(86.4%)
T2	33(75%)	11(25%)	-	38(86.4%)	5(11.4%)	1(2.3%)	28(63.6%)	11(25%)	5(11.4%)
PD	32(72.7%)	10(22.7%)	2(4.5%)	38(86.4%)	5(11.4%)	1(2.3%)	30(68.2%)	11(25%)	3(6.8%)

Discussion:

In the current study, the role of different MRI sequences in a sample of patients with movement disorders and TMJ pain was investigated. The TMJ, in most cases, is an articular and muscular disorder that emerges in the form of pain, joint noise, and abnormal joint function. In most texts, these disorders, their diagnosis method, and their treatment are divided into two basic categories of disc derangement and osteoarthritis of the joint (9).

The studies which have dealt with the investigation of the disc's natural angle to condyle have reported different results (10). Paying attention to the normal variation of this angle to differentiate the patient from the healthy people is of great importance. However, the discovery of disorders in these angles requires a high resolution of the prepared image which depends on the type of the MRI sequence. In our study, similar results were observed between the T2 and PD sequences in the diagnosis of disorders of disc position as during examination with these two sequences, a disc position disorder was observed in 45% of the

joints versus the 20% observation in T1 sequence and 11% observation in the dynamic sequence. Undoubtedly, this difference is due to the higher power PD and T2 in indicating the disc position compared to the T1 and Dynamic sequences (97.7 and 95.5% versus 47.7% and 31.8%). Unfortunately, no similar studies have been conducted in this regard, and existing studies have used the T1, T21, and PD sequences, separately (11, 12, and 13). Comparison of the MRI sensitivity and specificity in the diagnosis of disc displacement disorders in the studies using these sequences also indicates the high diagnostic value of the pF and T2 sequences. For example, in Westesson's study, a sensitivity of up to 86% and a specificity of up to 63% were reported using the T1 sequence (13), while Tasaki, using the PD and T2 sequences, reported a sensitivity of 90% and specificity of 100% (12). The higher specificity in these two sequences led to the differentiation of healthy people from the patients, which reduces the unnecessary medical procedures for them. Unfortunately, the studies' results are indicative of the significant prevalence of disc displacement among symptomless healthy volunteers. Larheim et al. showed that 78% of the patients with symptoms and 35% of symptomless



healthy volunteers had a disc displacement (14), although there were differences between the two groups in terms of the type of displacement disc return to the initial position, which indicates the necessity of the use of more powerful sequences for differentiation of normal variations from the abnormal ones.

Regarding the shape of the disc, our results also indicate the higher efficiency of the PD and T2 sequences as the shape of the disc could be judged in 95% of T2 and PD sequences which resulted in the observation of joint abnormalities up to 31 and 29%, respectively, while only 25% of the dynamic sequences and 50% of the T1 sequences could be judged, and 9% of joint abnormalities could be observed in both sequences. Also, the studies that investigate the diagnostic value of the MRI for the discovery of disc shape disorders are indicative of a 60% diagnostic accuracy with a sensitivity of 83% and specificity of 50% using the T1 sequence (15), and a 95% diagnostic accuracy with a sensitivity of 80% and specificity of 10% using the T2 and PD sequences (12).

Also, paying attention to the PD sequence's ability in showing the disc movement in open and closed-jaw images which led to the diagnosis of 36% of the joint disorders adds to the importance of this sequence in the discovery of TMJ disc disorders. In the open-jaw sequences, in this sequence, the anterior displacement of the abnormal meniscus is increased with the anterior displacement of the condyle, which increases the radiologist's differentiation power (16). On the other hand, using the overall information about the disc position, shape, and movement when opening the jaw, obtained from each sequence, the probability of internal derangement of the articular disc is evaluated. With this explanation and in our study, the internal derangement was observed in 47.7% of the joints and the T2 and PD sequences were helpful in the diagnosis of all cases, while the prevalence of this disorder in the T1 sequence was 20% and in the Dynamic sequence, it was 15% which is due to the 63% difference between the images from PD sequence and Dynamic sequence in clinical judgement power.

Anterior displacement of the meniscus is the most common type of internal derangement that involves the temporomandibular joint, which is in line with our results (17). During any disc displacement, its surrounding soft tissue is also damaged, which due to the high capability of the

MRI in the determination of the soft tissue, can be used as a parameter to improve the diagnostic power. For example, Tomas et al. conducted a quantitative study on the MRI images of 80 patients with TMJ performance disorder and 12 healthy volunteers and showed that (18) the average diameter of the upper and lower LPM connections in the closed-jaw condition is significantly higher in patients than in the control group. In our study, the thickness of the junction of the external pterygoid muscle was measurable in only 27% and 54% of the joints in the Dynamic and T1 sequences, while this rate reached 97% in T2 and PD sequences. Finally, an increase in thickness was reported in 11% of the PD and T2 sequences and only in 2% of the T1 sequences. Another finding that indirectly indicates temporomandibular joint dysfunction is disc perforation. It was possible to decide on disc rupture using the PD sequences in 93% of the cases, the T2 sequence in 88% of the cases, the T1 sequence in 13% of the cases, and the Dynamic sequence in 7% of the cases. It should be noted in this regard that the diagnosis of disc perforation is associated with a high percentage of false positives (19), which increases the necessity for more investigations to isolate and reduce these cases.

Sener et al. (20), despite much debate on the importance of effusion in movement disorders and temporomandibular joint pain, after studying 200 patients, showed a strong correlation between effusion and deformity and degenerative articular changes. It was revealed in other studies that the presence of large amounts of joint effusion is associated with TMJ pain and disc displacement, and it indicates early changes leading to osteoarthritis (13). In the present study, only the PD sequence was able to show joint effusion with a high accuracy (95.5%), followed by the T2 sequence (75%), as a result of which effusion was observed in 22% of the joints.

Degenerative changes in the temporomandibular joint are associated with many clinical symptoms. Yang et al. emphasized the correlation of osteoarthritis with condyle limitations (21). Meanwhile, MRI is a valuable diagnostic tool in evaluating TMJ symptoms related to osteoarthritis (22). In our study, although the T2 and PD sequences were the most powerful in judging joint osteoarthritis (97.7% and 95.5%), the T1 sequence, with a 86% judgment ability, was able to detect 32% of the joints with osteoarthritis, which was comparable to 27% of



the joints in the T2 sequence and 25% in the PD sequence. The results of our study in this regard are in line with a diagnostic accuracy of 94%, a sensitivity of 83%, and a specificity of 100% in the evaluation by Katzberg using the T1 sequence (11), and the diagnostic accuracy of 93%, the sensitivity of 87% and the specificity of 100% in the evaluation by Tasaki using the T2 and PD sequences (12).

Finally, it seems that the PD sequence, followed by the T2, has the greatest ability to diagnose temporomandibular joint disorders and the Dynamic sequence has little value in this regard. It is necessary to pay attention to points such as diagnostic accuracy, cost-effectiveness, length of time to perform the modality, the amount of invasion, and finally the acceptance of the patient while choosing a diagnostic modality. In this regard, the use of PD(opened and closed) and T2 sequences, while maintaining the effectiveness of MRI in the diagnosis of movement disorders and TMJ pain, reduces the costs imposed on the patient and the health system and shortens the MRI time, which results in high patient satisfaction. The results of the present study will pave the way for therapeutic systems to improve the diagnostic guidelines for TMJ disorders and will be a basis for future clinical studies.

Declarations:

- Ethics approval and consent to participate
- Consent for publication

Not applicable

- Availability of data and material

Not applicable

- Competing interests

"The authors declare that they have no competing interests"

- Funding

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- Authors' contributions

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