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Association between arthralgia and imaging findings of effusion in the temporomandibular joints: a systematic review

Abstract

Aims: A systematic review was conducted to determine if there is an association between joint effusion and self-reported TMJ-pain during examination and between joint effusion and arthralgia as defined by the Research Diagnostic Criteria for Temporomandibular Disorders (RDC-TMD).

Methods: Four reviewers separately identified observational studies evaluating a possible association between ipsilateral joint effusion, identified by MRI T2-weighted images, and TMJ pain by systematically searching three databases.

Results: A total of 67 articles were identified with the search strategy. However, 32 met the inclusion criteria for the systematic review.

Conclusion: Based on the review of 32 articles, published on this topic, body of literature was unable to provide evidence to support or refute the association between joint effusion and self-reported TMJ-pain, and between joint effusion and arthralgia as defined by RDC-TMD.

Keywords: temporomandibular disorders, joint effusion, MRI, arthralgia, pain

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Abbreviations: MRI, magnetic resonance imaging; JE, joint effusion; RDC/TMD, research diagnostic criteria for temporomandibular disorders; VGIR, visually guided TMJ irrigation; ID, internal derangement; DJD, degenerative joint disease; DDwR, disk displacement with reduction; DDwoR, disk displacement without reduction; OA, osteoarthrosis; CDC/TMD, clinical diagnostic criteria for temporomandibular disorders; OR, odds ratio; VAS, visual analogue scale; ICC, interclass correlation coefficients; SSI, symptom severity index

Introduction

The temporomandibular disorders (TMD) encompass a group of musculoskeletal and neuromuscular conditions that involve the temporomandibular joints (TMJs), the masticatory muscles, and associated tissues.[1] Common manifestations of TMD consist of pain of a persistent, recurring, or chronic nature in the TMJ, masticatory muscles, or in the adjacent structures; limitation or other alterations in the range of mandible motion; and TM joint noises.[2] It has been suggested that differential diagnosis of TMDs should be based primarily on information obtained from the patient's history, clinical examination, and when TMJ imaging procedures indicated.[1] Magnetic resonance imaging (MRI) is an example of such imaging procedures. It provides excellent representation of soft tissues in anatomical and semi-functional relationships. In addition, it may also be used for detection of the presence of joint effusion with acceptable levels of reliability.[3] Some authors have also suggested use of MRI for assessment of hard tissues; however the reliability has been shown to be poor.[3–5] Joint effusion is defined as a collection of fluid in the joint space. It is manifested as areas of high intensity signal in the TMJ space, on T2-weighted images.[3–5] It has been suggested that this accumulation of fluid could be a surrogate of an inflammatory process that may activate or sensitize nociceptive afferent neurons within the joint.[4–6] Alternatively, it could result in increased intra-articular pressure, which may cause mechanical trauma, leading to hypoxia and other inflammation induced changes within the joint space, and eventually leads arthralgia.[7] Several studies have been conducted on the association of joint effusion and TMJ pain associated with TMD. However, the results have been inconsistent. While the majority of studies have reported a statistically significant association,[4–26] others have reported inconclusive findings.[5–30] Due to this difference in reporting, a systematic review was conducted to determine if there is an association between joint effusion and self-reported TMJ-pain during examination, as well as between joint effusion and arthralgia as defined by the Research Diagnostic Criteria for Temporomandibular Disorders (RDC-TMD).[31]

Materials and methods

The clinical question: "Is there an association between MRI identified temporomandibular joint effusion and self-reported TMJ-pain?" was utilized to guide the review.

a. Inclusion Criteria: Observational studies evaluating a possible association between ipsilateral joint effusion, identified by MRI T2-weighted images, and TMJ pain were included. Manuscripts were limited to the English language only, published from inception till January 2017.

b. Exclusion Criteria: All investigations that included participants with rheumatologic diseases, or joint fractures were excluded. In addition, publications such as literature reviews and case-reports were also excluded from the review.

c. Literature Search: Four reviewers separately identified the pertinent literature by searching PubMed, MEDLINE and Cochrane databases under the inclusion criteria of all studies that have been conducted to determine an association between joint effusion and pain in the TMJ. The MeSH terms included TMJ, effusion, MRI, pain and arthralgia.

d. Procedure: Literature review was performed in accordance to PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).Four reviewers independently read the title and the abstract of all publications that matched the MeSH search terms. The reviewers met and developed a final list of publications to be read by consensus. Two reviewers read all the papers (SKN, RFGM); the other two reviewers (HC, YG) equally divided the number papers so that each paper was evaluated independently by three reviewers (Figure 1). Articles were reviewed based on the aim of the study, demographics, methodology, diagnostic criteria, MRI protocol, results, and conclusions.

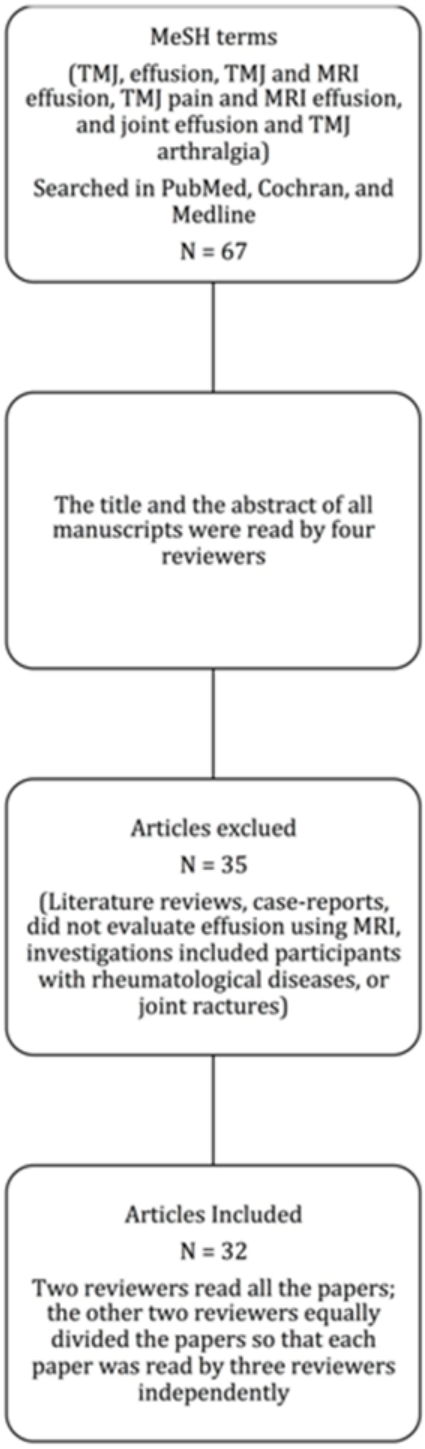

Figure 1 Flow chart summarizing the process of literature search.

Results

Three databases (PubMed, Cochran, and Medline) were systematically searched for articles. A total of 67 articles were identified with the search strategy. Thirty-two met the inclusion criteria, and all were observational studies. Thirty-five publications were excluded because they did not evaluate the association of TMJ effusion with TMJ pain, did not use MRI to evaluate effusion, were case-reports, or literature review studies. The summary of 32 included articles is provided in Table 1. The majority of the included studies reported a statistically significant association between joint effusion and self-reported TMJ-pain. However, during the review of these studies, several methodological limitations were identified. For example: absence of control group;[4–32] lack of information about examiner or radiologist reliability;[10–26] failure to report details regarding the clinical examination;[4–32] joint pain assessed by self-report (history) only without a clinical examination;[15] or inappropriate statistical analysis.[25] Among the studies that failed to find an association between TMJ effusion and self-reported TMJ-pain, several methodological limitations were also present. These include inappropriate control groups;[5–30] lack of information about the evaluation of TMJ pain, or evaluation using a non-standardized examination;[6–30] or lack of information regarding examiner and radiologist reliability.[6–30]

Table 1 Summary of the studies included in the systematic review on the association of TMJ effusion and TMJ pain

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Khawaja et al.[8]	Aim: To determine the clinical and radiological significance of JE in patients with TMD.	N= 158 ; 312 TMJs 59.4 % ♀ age: 31±11.1 yrs. 40.6 % ♂ age: 29.8±9.7 yrs.	Study group: Participants underwent DC/TMD examination by calibrated examiners	T2-weighted sagittal sequences (1.5 T, 3mm thick cuts) JE defined: presence of any high intensity signal in the superior or inferior joint spaces. Radiologist was calibrated.	T-test, Pearson Chi-Square, Generalized estimating equation analysis	No association was determined between JE and TMJ arthralgia. Statistical association was determined between JR and dis position in the coronal and in the sagittal plan. GEE suggested that disc displacement with reduction in the sagittal plan was statistically significant contributing factor for JE.	Pain was no categorized on basis of intensity.
Oliveira et al.[4]	Aim: To evaluate the association between condylar bone changes and presence of TMJ effusion in symptomatic patients	N= 74 ; 148 TMJs 68.9 % ♀ age: 40.4±14.5 yrs. 31.1 % ♂ age: 35.9±11.2 yrs.	Study group: Participants reported at least one sign or symptom of TMD during clinical examination	T2-weighted sagittal sequences (1.5 T, 3mm thick cuts) JE defined: any high signal intensity in the articular space. Two radiologist, diagnosis by consensus	Prevalence Fisher's exact test	Osteoarthritic changes were associated with JE. Prevalence of JE in symptomatic patients was 10 %.	No control group Clinical examination was not adequately described. Reliability of clinical examiners and radiologists was not described.

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Lamot U et al.[14]	Aim:	N= 104 ; 288 TMJs		T2-weighted sagittal sequences (1.5 T, 20 slices)	Prevalence	Morphological changes associated with symptoms of TMJ dysfunction. Prevalence of JE in symptomatic joints was 14.6 %	Clinical examination was not adequately described.
	a. To determine correlation between MRI and clinical findings associated with TMD.	75.7 % ♀ ; 24.3 % ♂	Study group: Participants had unilateral or bilateral presence of TMJ pain, noises/clicking, limited movement and headache. Study group was divided into 3 sub-groups based on type of ID.	JE defined: any high signal intensity in anterior or posterior recess, or large amount in superior or inferior joint space.	Fisher's exact test	Younger age group was associated with JE	Reliability of clinical examiners and radiologists was not described
	b. To assess the impact of gender and age, on this correlation.	Total sample age: 39.4 yrs. (12 – 81 yrs.).			T-Test		Radiologists were not blind to the clinical diagnosis
Santos et al.[20]	Aim: To assess the association between changes of the articular eminence and the condyle, articular disc changes, and the presence of TMJ effusion in symptomatic patients.	N = 71 ; 142 TMJs		T2-weighted sagittal sequences (1.5 T, 3mm thick cuts)	Prevalence	Association was present between: 1) disc form and its position; 2) condylar form and an anterior portion of disc; and 3) articular eminence form and disc form.	No control group
		69 % ♀ ; 31 % ♂	Study group: Participants reported at least one sign or symptom of TMD during examination	JE defined: any hyper-signal in the articular space.	Pearson's Chi-Square test	Prevalence of JE in symptomatic joints was 23.9 %.	Clinical examination was not adequately described.
		Total sample age: 38.7 yrs. (13 – 69 yrs.).		Two radiologist, diagnosis by consensus	Fisher's exact test		Reliability of clinical examiners and radiologists was not described

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Park et al.[18]		N = 100 ; 200 TMJs	Study group: Participants underwent RDC/ TMD examination.	T2-weighted sagittal sequences (1.5 T)	Cohen's Kappa	Cohen's Kappa showed no agreement to moderate agreement between MRI and Group II diagnosis based on RDC/TMD	No information if radiologists were blind to the clinical diagnosis
	Aim: To investigate the value of MRI in the diagnostic process based on the RDC/TMD.	68.0 % ♀ with	Study group was divided into 3 distinct Group II diagnoses based on RDC/TMD.	JE defined: any high intensity signal in articular surface or compartment.	Chi-Square test	JE and ipsilateral pain were significantly associated.	Reliability of clinical examiners and radiologists was not reported.
		age: 25.3±13.12 yrs.		Two radiologist, diagnosis by consensus		43.4 % of joints with pain had JE while 28.7 % of non-painful joints had JE	
		32 % ♂ with mean age: 31.9±12.3 yrs.		Radiologist underwent calibration.			
Bas et al.[9]		N = 91 ; 182 TMJs	Study group:	T2-weighted sagittal sequences (0.5 T, 3mm thick cuts)	Receiver Operating Characteristic curve	Cutoff value for CW was calculated to be 1.65 mm	No control group
	Aim: To evaluate the relationship between the grades of MRI depicted JE, increased capsular width (CW) measured in Ultrasonographic Imaging (USI), and joint pain.	81.3 % ♀	Participants underwent	JE defined: area of homogenous and high signal intensity.	Friedman Test	Statistically significant association was found between VAS score and intensity of MRI- JE.	Reliability of clinical examiners and radiologists was not described
		18.7 % ♂	a. RDC/TMD examination.	JE was characterized into moderate and severe effusion.	Wilcoxon Test	JE absent: 2.55 VAS	
		Total sample	b. VAS to measure pain intensity.	CW was assessed by USI		Moderate JE: 2.92	
		age: 25 yrs.				Severe JE: 4.80	

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Kaneyama et al.[13]	Aim: To determine the association between JE and various soluble cytokine receptors in the synovial fluid.	N = 55 ; 55 TMJs	Study group: Participants had diagnosis of TMD based on	T2-weighted sagittal sequences (1.5 T, 3mm thick cuts) JE defined: area of high intensity signal in superior compartment. JE was characterized into grade I, II, and III based on the quantity of signal.	Mann-Whitney U test	The mean concentration of cytokine receptors in the synovial fluid were significantly higher in joints with JE than in joints without JE.	Gender and age demographics not provided.
			a. Clinical symptoms and MRI.	Three radiologist, diagnosis by consensus.	Spearman's correlation	JE was reported in 55.5 % joints.	Clinical examination was not adequately described.
			b. VAS used to measure ipsilateral joint pain intensity.			No statistically significant difference was observed between severity of JE and VAS.	Reliability of clinical examiners and radiologists was not described.
							High signal in the inferior TM joint compartment was not considered as indicative of JE.
Nakaoka et al.[32]	Aim: To investigate the changes of JE on the MRI and pathology observed in arthroscopy after VGIR.	N = 56 ; 56 TMJs	Study group: Participants underwent clinical examination.	T2-weighted sagittal sequences (0.3 T)	Wilcoxon signed-rank sum test	JE was reported in 65 % of joints.	Gender demographics not provided.
	a. To correlate these findings with clinical variables.	40 participants completed the study	Study group had a clinical diagnosis of unilateral chronic closed lock.	JE defined: area of high signal intensity.	Mann-Whitney U test	JE was significantly higher in the group with poor surgical outcome.	No control group.
		Total sample		JE was characterized into grade I, II, and III.	Spearman's correlation	No statistical correlation between JE and synovial lining score.	Clinical examination was not adequately described.
		age 43 yrs.		Three radiologist, diagnosis by consensus			Reliability of clinical examiners and radiologists was not described.

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
							High signal in the inferior TM joint space was not considered as indicative of JE.
Costa et al.[10]	Aim: To assess the correlation of TM joint ID in patients with the presence of headache, bruxism, and joint pain using MRI.	N = 58 ; 58 TMJs	Study group: Participants underwent	T2-weighted sagittal sequences (2 T, 1.5 mm thick cuts)	Chi-square test	Participants with TMD and headaches had significantly more ID than the control group.	Reliability of clinical examiners and radiologists was not described.
			a. RDC/TMD examination by a calibrated examiner.	JE defined: area of high signal intensity in the region of upper and lower joint spaces.	Fisher's exact test	JE was statistically more prevalent in group with TMD and headaches	Tables and text do not match.
		TMD group: 42 participants, 83.3 % ♀, 16.7 % ♂. Age range of 16-83 yrs.	b. Headache assessment by a trained neurologist.			Participants with JE had statistically higher prevalence for joint pain.	
		Control group: 16 participants, 68.8 % ♀, 31.2 % ♂. Age range of 26-37 yrs.					
Farina et al.[28]	Aim: To evaluate the association between conventional and enhanced MRI findings, and TMJ pain.	N = 38 ; 78 TMJs	Study group: Participants had TMD pain and dysfunction.	T2-weighted sagittal sequences (1.5 T, 3 mm thick cuts)	Chi-square	33.3 % joints with pain had JE.	Age information of the participants not provided.
		81.6 % ♀, 18.4 % ♂	Control group: Participants did not have any TMD pain or dysfunction.	JE defined: presence of high signal intensity within joint space in open- or closed-mouth images.	T-test	21.7 % of joints without pain had JE.	Clinical examination was not adequately described.
					Multivariate logistic regression analysis.	Statistical correlation between TMJ pain and JE was not observed.	Reliability of clinical examiners and radiologists was not described.
						Odd's ratio that painful TMJ had JE was 1.2	34.2 % joints had been on NSAID before MRI.

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Limchaichana et al.[5]	Aim: To evaluate the association between MRI findings and clinical symptoms of TMD.	N = 60 ; 120 TMJs	Study group: Participants underwent RDC/ TMD examination by a calibrated examiner.	T2-weighted sagittal sequences (1.5 T)	T-test	18 % of joints with myofascial pain only, had JE.	Overlapping of diagnosis – both groups had masticatory muscle pain.
		78.3 % ♀, 21.7 % ♂	Divided into	JE defined: area of more than a line or dots of high signal intensity in the region of superior or inferior joint space.	Fisher's exact test	33 % of joints with myofascial pain and arthralgia/OA had JE.	
		No difference between the groups in age and gender was found.	a. Myofascial pain only.	Radiologist had inter-observer agreement of 0.69 for JE	Chi-square test	No statistical difference between two groups in prevalence of JE.	
			b. Myofascial pain with Arthralgia/OA.		Kappa statistic		
Guler et al.[29]	Aim: To determine the association between JE, protein concentration in synovial fluid, and TMJ pain.	N = 31 ; 31 TMJs	Study group: Participants underwent	T2-weighted sagittal sequences (1.5 T, 3 mm thick slices)	Chi-square	7.7 % joints in control group had JE.	Reliability of clinical examiners and radiologists was not described.
		Study group: 81.3 % ♀, 18.7 % ♂.	a. RDC/TMD examination.	JE defined: high-signal area in the upper and lower joint spaces.	Spearman's rank correlation	75 % joints in study group had JE.	
		age: 31 yrs. (17-57 yrs.)	b. VAS to measure pain intensity.	JE was characterized into 4 levels depending on quantity of joint fluid.		No significant association was observed between level of pain and JE.	
		Control group: 66.7 % ♀, 33.3 % ♂.	Participants were divided into:				
		age: 28 yrs. (17-42 yrs.)	a. DDwoR, with arthralgia and OA.				
			b. DDwoR without any pain-related TMD diagnosis.				

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Yano et al.[26]	Aim: To evaluate the association between joint fluid and various disk pathological conditions.	N = 17 ; 34 TMJs	Study group: Participants were diagnosed as having ID of either one or both TMJs.	T2-weighted sagittal sequences (1 T/ 1.5 T, 3 mm thick cuts)	Chi-square test	85.3 % of joints had JE	Small sample size.
		87.5 % ♀, 12.5 % ♂		JE defined: high-signal area in the upper and lower joint spaces.		No significant difference observed between quantity of joint fluid and grade of ID.	Mean age of the participants is younger than the mean age of patients with TMD.
		age of total sample was 20.5 yrs. (12 – 31 yrs.)		JE was characterized into 4 levels depending on quantity of joint fluid.		Significant difference was observed between presence of pain and the quantity of joint fluid	Clinical examination was not adequately described.
							Reliability of clinical examiners and radiologists was not described.
Emshoff et al.[33]	Aim: To evaluate the association between TMD sub-groups and MRI diagnosis of TMJ ID, osteoarthritis, JE, and bone marrow edema.	N = 164; 164 TMJs	Study group: Participants underwent (CDC/ TMD) examination.	T2-weighted sagittal sequences (1.5 T, 3 mm thick cuts)	Chi-square test	Significant association was present between TMJ pain and the MRI diagnosis of TMJ ID for the ID type I group, Capsulitis/ Synovitis group, the ID type III group and DJD group.	DJD diagnosis was diagnosed using a clinical examination.
		TMJ pain group: 86.4 % ♀, 13.6 % ♂.	Intra-examiner reliability was between K ≥ .75 and K = 1.0.	Intra observer reliability was determined (K ≥ .75 – K = 1.0)	Multiple logistic regression analysis	JE was present in 30.4 % of normal joints.	
		age: 36.9 yrs. (12-69 yrs.)		JE defined: area of more than one high signal intensity line in the region of joint space, evident in at least two consecutive sections.		JE is associated with TMJ pain in joints with DJD.	
		Control group: 67.4 % ♀, 32.6 % ♂.					
		age: 38.3 yrs. (15-64 yrs.)					

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Emshoff et al.[34]	Aim: To evaluate whether the MRI variables of TMJ ID, OA, and/or JE may predict the presence of TMJ pain.	N = 42 ; 84 TMJs	Study group: Participants underwent CDC/ TMD examination.	T2-weighted sagittal sequences (1.5 T, 3 mm thick cuts)	Chi-square test	TMJ ID type-III were significantly associated with high rate of TMJ ID.	Primarily clinical symptoms used without confirming the diagnosis of arthralgia.
		95.2 % ♀, 4.8 % ♂.		JE defined: area of more than one high signal intensity line in the region of joint space, evident in at least two consecutive sections.	Multiple logistic regression analysis	A statistically significant association was found between JE and TMJ pain.	Reliability of radiologists was not described.
		age of the sample: 38.8 yrs. (16 -77 yrs.)				JE was observed in 45.2 % of TMJs with pain, while 14.3 % of TMJs without pain had JE.	
Guler et al.[11]	Aim: To correlate MRI findings of JE, disc displacement, condylar bone changes and disc form with clinical findings of pain and sounds in patients with bruxing behavior.	N = 94 ; 188 TMJs	Study group: Participants underwent examination for	T2-weighted sagittal sequences (1.5 T, 3 mm thick cuts)	Chi-Square	Significantly higher prevalence of condylar bony changes present in joints with displaced disks in the study group.	Data of the subjects included in the analysis were meeting the exclusion criteria.
		Study (bruxing) group: 86.7 % ♀ and 13.3 % ♂.	a. TMJ pain and dysfunction.	JE defined: area of high signal intensity in the region of the upper and lower joint spaces.		Significant association was present between JE and TMJ pain.	Reliability of clinical examiners was not described.
		age: 29 yrs. (13 – 63) yrs.	b. Bruxism.			30 % of painful joints in the study group, and 59 % of the painful joints in the control group had JE.	
		Control group: 86.7 % ♀, 13.3 % ♂.	c. VAS to measure pain intensity.				
		age: 26 yrs. (14 – 50 yrs.)					

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Yamamoto et al.[25]	Aim: To evaluate the association between quantity of JE and TMD associated pain and dysfunction.	N = 293; 577 TMJs	Study group: Participants had TMD pain and dysfunction.	T2-weighted sagittal sequences (1 T/ 1.5 T)	Kruskal-Wallis test	Statistically significant difference was present for JE, between painful and non-painful joints in the DDwoR group.	Clinical examination was not adequately described.
		82.6 % ♀, 17.4 % ♂.		JE defined: high-signal area in the upper and lower joint spaces.	Scheffe test	No statistically significant difference was present in painful and non-painful joints of normal, DDwR, or OA groups.	Radiologists were not blind to the clinical diagnosis
		age: 31.4 yrs. (10-78 yrs.)		JE was characterized into 4 levels.	Wilcoxon rank sum		Reliability for the quantification criteria for JE not provided.
							Inappropriate statistical analysis
							Radiologists were not blind to the clinical diagnosis.
Emshoff et al.[35]	Aim: To determine if MRI findings are predictive of TMJ pain.	N = 169; 338 TMJs.	Study group: Participants underwent CDC/ TMD examination.	T2-weighted sagittal sequences (1.5 T, 3 mm thick cuts).	Chi-square test	In multiple logistic regression analysis, ID was significantly associated with TMJ pain; however, OA, JE, and bone marrow edema were statistically not significant.	According to multiple logistic model, JE is not associated with TMJ pain, while according to Chi-square test it is.
		85.2 % ♀, 14.8 % ♂.	Intra-examiner reliability was between $K \geq .75$ and $K = 1.0$.	Intra observer reliability was determined ($K \geq .75 - K = 1.0$).		JE was observed in 44.2 % of painful TMJs, and 28.3 % non-painful TMJs	
		age of the sample: 36.9 yrs. (15 -86 yrs.)		JE defined: area of more than one high signal intensity line in the region of joint space, evident in at least two consecutive sections.	Multiple logistic regression analysis	A statistically significant correlation was present between TMJ pain and JE.	

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Manfredini et al.[16]	Aim: To evaluate the predictive value of clinical symptoms for MRI findings of JE.	N = 61	Study group: Participants underwent	T2-weighted sagittal sequences (0.5 T, 3 mm thick cuts)	Multiple logistic analysis	Except for pain during joint play and pain in the TM joint during dynamic tests, rest of the clinical variables were included in the logistic regression analysis.	Gender demographics were not provided.
			a. RDC/TMD examination.	JE defined: area of high signal intensity inside the joint space.	Goodness-of-fit test	Among single parameters, presence of pain in the TMJ with lateral palpation provided good diagnostic accuracy of 76.2 %.	No control group.
			b. Additional clinical examination (pain in TMJ during posterior palpation, dynamic tests).		Model Chi-square test		Reliability of radiologists was not described.
Emshoff et al.[36]	Aim: To evaluate the association between MRI findings of OA, and/or JE, and TMJ pain.	N = 112 ; 224 TMJs.	Study group: Participants underwent CDC/TMD examination.	T2-weighted sagittal sequences (1.5 T, 3 mm thick cuts)	Chi-square	88.4 % of joints with TMJ-Pain, and 66.1 % of joints without TMJ-Pain had OA.	Reliability of clinical examiners and radiologists was not described.
		86.6 % ♀, 13.4 % ♂		JE defined: area of more than one high signal intensity line in the region of joint space, evident in at least two consecutive sections.	Kappa statistic test	48.2 % of joints with TMJ-Pain, and 19.6 % of joints without TMJ-Pain had JE.	
		age: 38.2 yrs. (15-78 yrs.)				TMJ-Pain was statistically associated with OA, and JE.	
						Kappa value for association of TMJ-Pain and JE was 0.29 (poor).	

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Segami et al.[30]	Aim: To evaluate the association between JE and synovial fluid constituents in patients with ID and OA.	N = 108; 108 TMJs	Study group: Participant underwent	T2-wighted sagittal sequences (1.5T, 3 mm thick slices).	Mann-Whitney U test	No statistically significant difference was observed in pain intensity among study groups.	Control group only had ♂.
		Study group: 90 % ♀, 10 % ♂.	a. MRI	JE defined: high-signal area in the upper and lower joint spaces. It was further characterized into 4 levels depending on quantity of joint fluid.		Joints with JE had significantly higher total protein concentration, and Interleukin – 6 levels than joints without JE.	Clinical examination was not adequately described.
		age: 34.9 yrs. (13-73 yrs.)	b. VAS to measure pain intensity.	Grade 0 and 1 were excluded.			30 % participants in study group were on NSAID.
		Control group: All ♂.	Study group had ID or OA, with or without JE.				Reliability of clinical examiners and radiologists was not described.
		age 30 yrs.	Control group were symptom free.				
Tanaka et al.[23]	Aim:	N = 200 ; 400 TMJs	Study group: Participants underwent RDC/ TMD examination.	FS T2-weighted sagittal sequences (1.5 T, 3 mm thick cuts).	Chi-square test	Detection rate of JE by FS was significantly greater than by T2-weighted MRI.	Clinical examination was not adequately described.
	a. To compare JE evaluation between T2-weighted MRI and Fat saturation (FS) MRI.	76.5 % ♀, 23.5 % ♂.		T2-weighted sagittal sequences (1.5 T, 3 mm thick cuts).	Kappa statistic test	Statistically significant association between JE and TMJ pain.	Reliability of radiologists was not described.
	b. To determine association between JE and MRI findings.	age of case group: 29.3 yrs. (17-52 yrs.)		JE defined: area of high signal intensity greater than a moderate amount of fluid.		Kappa test indicates good agreement between pain and JE (K = 0.66).	
		20 participants were in control group.				FS indicates 70 % of painful joints and 3 % of pain-free joints having JE.	
		65 % were ♀, 35 % ♂.					
		age of control group: 23.3 yrs. (18-35 yrs.)					

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Haley et al.[12]	Aim: To investigate the association between TMJ-Pain and clinical and MRI findings.	N = 85; 170 TMJs.	Study group: Participants underwent standardized clinical examination.	T2-weighted sagittal sequences (1.5 T).	Chi-square test	69 % of joints with pain had JE (p = .001). OR for this association was 3.8.	All participants were ♀.
		All participants were female.	Examiners had acceptable levels of reliability.	JE defined: area of high signal intensity area within either joint space in open and closed position.	OR	80 % of joints with pain had ID (p = .332). OR for this association was 1.8.	
		Age: 16-49 yrs.		Radiologist had acceptable levels of reliability.		84 % of joints with pain had reported experiencing pain at the onset of study (p = .001). OR for this association was 49.	
Rudisch et al.[19]	Aim: To investigate the association between TMJ-Pain and MRI findings of ID and JE.	N = 41 ; 82 TMJs.	a. Study group: Participants underwent CDC/ TMD examination.	T2-weighted sagittal sequences (1.5 T, 3 mm thick cuts)	Chi-square	80.5 % of joints with pain and 46.3 % of joints without pain had ID.	Reliability of clinical examiners and radiologists was not described.
		78 % ♀, 22 % ♂.		JE defined: area of more than one high signal intensity line in the region of joint space, evident in at least two consecutive sections.	Kappa statistical test	58.5 % of joints with pain and 26.8 % of joints without pain had JE.	
		age: 39.1 yrs. (17-78 yrs.)				ID and JE were statistically associated with TMJ-Pain. TMJ-Pain and ID had a K value of 0.34 (poor). TMJ-Pain and JE had a K value of 0.32 (poor).	

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Segami et al.[6]	Aim: To characterize JE with arthroscopic findings	N = 47 ; 47 TMJs	Study group: Participants underwent	T2-wighted sagittal sequences (1.5T, 3 mm thick slices).	Mann-Whitney U test	68.1 % of joints had JE.	Control group only had ♂.
		93.6 % ♀, 6.4 % ♂	1. Clinical examination.	JE defined: high-signal area in the upper and lower joint spaces.	Spearman's correlation co-efficient	VAS score had no statistical correlation with the presence of JE.	Clinical examination was not adequately described.
		age: 39 yrs. (13-76 yrs.)	2. VAS to measure pain intensity.	JE was characterized into 4 levels.			Reliability of clinical examiners and radiologists was not described.
				Grade 0 and 1 were excluded.			No information provided regarding the type of treatment participants were involved in before undergoing MRI.
Shaefer et al.[7]	Aim:	N = 30 ; 30 TMJs	Study group: Participants underwent	T2-weighted sagittal sequences	Sensitivity and Specificity	85 % of subjects with TMJ arthralgia had JE.	All subjects were ♀.
	a. To evaluate the association between TMJ arthralgia and JE.	100 % ♀	a. RDC/TMD examination, Modified SSI for severity of symptoms.	JE defined: presence of any high intensity signal within either joint space.	T-test	72 % of subjects without any TMJ pain had JE.	The criterion for TMJ arthralgia was not consistent with RDC/TMD specifications.
	b. To evaluate the validity of 1 pound of palpating pressure for diagnosing arthralgia.	age of study group: 31.3±9 yrs.	b. Examiners were calibrated.	Reliability of the radiologist to determine JE was $K = 0.85$.	Paired t-test	MRI effusion sensitivity was 85 %, and specificity was 28 %.	Use of the most painful joint instead of both or an average.
		age of control group: 31.6±6 yrs.				Sensitivity and specificity of 1 pound of palpating pressure was 27 % and 100 %, respectively.	

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Suenaga et al.[21]	Aim: To evaluate the association between JE, contrast enhancement of JE, nitric oxide present in the joint, and TMD symptoms.	N = 77 ; 154 TMJs	Study group: Participants underwent	T2-weighted sagittal sequences (1.5 T, 5 mm thick cut).	Chi-square test	56 % of symptomatic TMJs and 9 % of non-symptomatic TMJs had JE.	Reliability of clinical examiners and radiologists was not described.
		84.6 % ♀, 15.4 % ♂.	a. Clinical examination.		Spearman's rank correlation	JE was significantly associated with pain, and joint sounds.	Clinical diagnosis was based on non-standardized examination.
		Age range was 14 – 70 yrs.	b. VAS to measure pain intensity.	Post-contrast T1-weighted oblique sagittal sequence (1.5 T, 5 mm thick cut).		Contrast enhancement of JE was significantly higher in the symptomatic groups than T2-weighted images.	High signal in the inferior TM joint space was not considered as indicative of JE.
				JE defined: area of high signal intensity in the region of the superior space.			
Larheim et al.[15]	Aim: To evaluate the association between JE and MRI diagnosis of TMJ ID, bone marrow abnormalities, and pain.	N = 523	Study group: Participants underwent evaluation by a questionnaire.	T2-weighted sagittal sequences (1.5 T, 3 mm thick cuts).	T-test	13.4 % TMJs were diagnosed as having JE.	Clinical evaluation of TMJs was carried out by a questionnaire.
				JE defined: area of high signal intensity greater than a moderate amount of fluid.	Fisher's exact test	Compared to pain-free TMJs, joints with pain had statistically more cases of JE, ID, and cortical bone abnormalities.	Reliability of questionnaire and radiologists was not described.
						Regression analysis indicated that TMJ-Pain side difference was positively dependent on JE and condyle marrow abnormalities.	Prevalence of pain in joints with JE was not provided.
					Regression analysis		

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
Takahashi et al.[22]	Aim: To investigate the association between JE, joint pain, and protein levels in joint lavage fluid of patients with ID and OA.	N = 26 ; 38 TMJs	Study group: Participants underwent clinical examination.	T2-weighted sagittal sequences (1.5 T, 5 mm thick cut).	Fisher's exact test	80 % of TMJs with pain and 38.5 % of pain-free TMJs had JE ($p < .05$).	Reliability of clinical examiners and radiologists was not described.
		84.2 % ♀, 15.8 % ♂		JE defined: area of high signal intensity in the region of the superior or inferior joint space.	Student's t-test	Total protein concentration was statistically higher in the group without TM joint pain than in the group with pain.	Clinical examination was not adequately described.
		age: 43.2 yrs. (16 – 67 yrs.)					High signal in the inferior TM joint space was not considered as indicative of JE.
							Definition of the control group was not clear.
Adame et al.[27]	Aim: To correlate JE with clinical and MRI findings.	N = 142 ; 169 TMJs	Study group: Participants underwent clinical examination.	T2-wighted sagittal sequences (0.5T, 5 mm thick slices).	Pearson's Chi-square test	65 % of participants with JE had TM joint pain.	Clinical examination was not adequately described.
		88.9 % ♀, 11.1 % ♂		JE defined: hyper-intensity signal in either joint space, seen in two consecutive image cuts.		69.6 % of participants without JE had TM joint pain.	Reliability of clinical examiners and radiologists was not described.
		age: 25.4 yrs. (14-74 yrs.)				TMJs with effusion had significantly lower incidence of TM joint clicking than control group.	Data presented in table does not match the text.
Murakami et al.[17]	Aim: To investigate the association between TMJ pain levels and JE.	N = 19 ; 19 joints	Study group: Participants underwent	T2-weighted sagittal sequences (1.5 T).	Paired t-test	52.6 % of participants had JE.	All participants were ♀.
		All participants were ♀ and were diagnosed as having disk displacement without reduction.	a. Clinical examination.	JE defined: area of more than a line of high signal intensity in the region of superior or inferior joint space.		No statistically significant difference was observed between the groups for VAS pain score, pain questionnaire scores, and total pain score.	Clinical examination was not adequately described.

Table Continued...

Author and Year	Study aim	Demographics	TMJ pain assessment methodology	Imaging assessment methodology	Statistics	Conclusion	Limitations
		age: 39.1 yrs. (14-61 yrs.)	b. VAS and Pain level questionnaire to measure intensity of pain.				Reliability of clinical examiners and radiologists was not described
Westesson et al.[24]	Aim: To investigate the association between JE and clinical symptoms of TMJ pain, and MRI diagnosis of ID and OA.	N = 390 ; 780 TMJs	Study group: Participants had TMD pain and dysfunction.	T2-weighted sagittal sequences (1.5 T).	No report on statistical analysis.	7 % of joints with normal disk position had JE.	No demographic details provided.
			Control group: Participants did not have any TMD pain or dysfunction.	JE defined: more than a line of high signal intensity in the region of superior or inferior joint space.		40 % of joints with DDwR had JE.	Clinical examination was not adequately described.
						50 % of joints with DDwoR had JE.	Details for blindness of the radiologist not provided.
						27 % of joints with OA had JE.	Reliability of clinical examiners and radiologists was not described.
						Statistically significant association was present between JE and joints with severe pain.	

Discussion

A systematic review was conducted to determine if there is an association between joint effusion, self-reported TMJ pain and arthralgia of the TMJ. Based on the review of 32 articles published on this topic, the body of literature was unable to provide evidence to support or refute the association between joint effusion and self-reported pain TMJ pain during examination or between joint effusion and arthralgia, as defined by RDC-TMD. Systematic review of the studies indicated that the majority of investigations had reported a statistically significant association between joint effusion and TMJ self-reported pain during examination and joint effusion and arthralgia as defined by RDC-TMD. However, these results need to be interpreted with caution due to the presence of several crucial methodological limitations. Some of these studies failed to apply a standardized clinical examination.[4–36] This may result in failure to identify the true source of pain associated with TMD, or may result in using indeterminate classifications, such as the inclusion of participants with "tenderness" to palpation instead of "pain", or inclusion of participants with pain of muscular origin rather than of the TMJ. Furthermore, some investigations failed to report the reliability of the clinical examiners and radiologists.[10–26] Reliability is the overall consistency of a measure and is considered an important factor in identification of TMD and MRI-based findings since the prevalence of both conditions in the normal population range relatively low,[31] and overlooking reliability may influence the results in favour of a false positive association and inconsistent reporting. Another reason for disparity in reporting may be due to poor consensus among the authors for the operational definition of joint effusion. Some of the investigators defined effusion as presence of a high intensity signal on T2 images only in the superior joint space, while other considered presence of a high intensity signal in the superior or inferior joint space as indicative of joint effusion. Similarly, some authors quantified the joint effusion into multiple relative categories. However, none of these investigations reported the reliability and validity of radiologist to quantify effusion, which limits

the utility of this measure. Nonetheless, among the studies reporting quantification of effusion, the results were not consistent.

Conclusion

In summary, based on the findings of this systematic review, the association between MRI diagnosis of joint effusion and self-reported TMJ-pain as well as between joint effusion and arthralgia, as defined by RDC-TMD, was not determined. This may be attributed to several methodological limitations, and heterogeneity in the operational definition of joint effusion. Investigations using validated and reliable clinical and radiologic criteria with appropriate case and control groups that have been adequately characterized are required. This will help determine, if any, association is present between MRI diagnosis of joint effusion and joint pain, and joint effusion and arthralgia.

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Conflicts of interest

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References

1. Greene CS. Diagnosis and treatment of temporomandibular disorders: emergence of a new care guidelines statement. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2010;110(2):137−139.
2. Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. *J Craniomandib Disord.* 1992;6(4):301−355.
3. Ahmad M, Hollender L, Anderson Q, et al. Research diagnostic criteria for temporomandibular disorders (RDC/TMD): development of image analysis criteria and examiner reliability for image analysis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2009;107(6):844−860.
4. Oliveira JX, Rosa JA, Dutra ME, et al. Assessing joint effusion and bone changes of the head of the mandible in MR images of symptomatic patients. *Braz Oral Res.* 2013;27(1):37−41.
5. Limchaichana N, Nilsson H, Ekberg EC, et al. Clinical diagnoses and MRI findings in patients with TMD pain. *J Oral Rehabil.* 2007;34(4):237−245.
6. Segami N, Nishimura M, Kaneyama K, et al. Does joint effusion on T2 magnetic resonance images reflect synovitis? Comparison of arthroscopic findings in internal derangements of the temporomandibular joint. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2001;92(3):341−345.
7. Shaefer JR, Jackson DL, Schiffman EL, et al. Pressure-pain thresholds and MRI effusions in TMJ arthralgia. *J Dent Res.* 2001;80(10):1935−1939.
8. Khawaja SN, Crow H, Mahmoud RF, et al. Is There an Association Between Temporomandibular Joint Effusion and Arthralgia? *J Oral Maxillofac Surg.* 2017;75(2):268−275.
9. Bas B, Yilmaz N, Gokce E, et al. Ultrasound assessment of increased capsular width in temporomandibular joint internal derangements: relationship with joint pain and magnetic resonance grading of joint effusion. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2011;112(1):112−117.
10. Costa AL, D'Abreu A, Cendes F. Temporomandibular joint internal derangement: association with headache, joint effusion, bruxism, and joint pain. *J Contemp Dent Pract.* 2008;9(6):9−16.
11. Guler N, Yatmaz PI, Ataoglu H, et al. Temporomandibular internal derangement: correlation of MRI findings with clinical symptoms of pain and joint sounds in patients with bruxing behaviour. *Dentomaxillofac Radiol.* 2003;32(5):304−310.
12. Haley DP, Schiffman EL, Lindgren BR, et al. The relationship between clinical and MRI findings in patients with unilateral temporomandibular joint pain. *J Am Dent Assoc.* 2001;132(4):476−481.
13. Kaneyama K, Segami N, Yoshimura H, et al. Increased levels of soluble cytokine receptors in the synovial fluid of temporomandibular joint disorders in relation to joint effusion on magnetic resonance images. *J Oral Maxillofac Surg.* 2010;68(5):1088−1093.
14. Lamot U, Strojan P, Surlan Popovic K. Magnetic resonance imaging of temporomandibular joint dysfunction-correlation with clinical symptoms, age, and gender. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2013;116(2):258−263.
15. 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):104−112.
16. Manfredini D, Tognini F, Zampa V, et al. Predictive value of clinical findings for temporomandibular joint effusion. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2003;96(5):521−526.
17. Murakami K, Nishida M, Bessho K, et al. MRI evidence of high signal intensity and temporomandibular arthralgia and relating pain. Does the high signal correlate to the pain? *Br J Oral Maxillofac Surg.* 1996;34(3):220−224.
18. Park JW, Song HH, Roh HS, et al. Correlation between clinical diagnosis based on RDC/TMD and MRI findings of TMJ internal derangement. *Int J Oral Maxillofac Surg.* 2012;41(1):103−108.
19. Rudisch A, Innerhofer K, Bertram S, et al. Magnetic resonance imaging findings of internal derangement and effusion in patients with unilateral temporomandibular joint pain. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2001;92(5):566−571.
20. Santos KC, Dutra ME, Warmling LV, et al. Correlation among the changes observed in temporomandibular joint internal derangements assessed by magnetic resonance in symptomatic patients. *J Oral Maxillofac Surg.* 2013;71(9):1504−1512.
21. Suenaga S, Abeyama K, Hamasaki A, et al. Temporomandibular disorders: relationship between joint pain and effusion and nitric oxide concentration in the joint fluid. *Dentomaxillofac Radiol.* 2001;30(4):214−218.
22. Takahashi T, Nagai H, Seki H, et al. Relationship between joint effusion, joint pain, and protein levels in joint lavage fluid of patients with internal derangement and osteoarthritis of the temporomandibular joint. *J Oral Maxillofac Surg.* 1999;57(10):1187−1193; discussion 1193−1184.
23. Tanaka T, Morimoto Y, Masumi S, et al. Utility of frequency-selective fat saturation T2-weighted MR images for the detection of joint effusion in the temporomandibular joint. *Dentomaxillofac Radiol.* 2002;31(5):305−312.
24. Westesson PL, Brooks SL. Temporomandibular joint: relationship between MR evidence of effusion and the presence of pain and disk displacement. *AJR Am J Roentgenol.* 1992;159(3):559−563.
25. Yamamoto M, Sano T, Okano T. Magnetic resonance evidence of joint fluid with temporomandibular joint disorders. *J Comput Assist Tomogr.* 2003;27(5):694−698.
26. Yano K, Sano T, Okano T. A longitudinal study of magnetic resonance (MR) evidence of temporomandibular joint (TMJ) fluid in patients with TMJ disorders. *Cranio.* 2004;22(1):64−71.
27. Adame CG, Monje F, Offnoz M, et al. Effusion in magnetic resonance imaging of the temporomandibular joint: a study of 123 joints. *J Oral Maxillofac Surg.* 1998;56(3):314−318.

28. Farina D, Bodin C, Gandolfi S, et al. TMJ disorders and pain: assessment by contrast-enhanced MRI. *Eur J Radiol.* 2009;70(1):25−30.

29. Guler N, Uckan S, Imirzalioglu P, et al. Temporomandibular joint internal derangement: relationship between joint pain and MR grading of effusion and total protein concentration in the joint fluid. *Dentomaxillofac Radiol.* 2005;34(3):175−181.

30. Segami N, Miyamaru M, Nishimura M, et al. Does joint effusion on T2 magnetic resonance images reflect synovitis? Part 2. Comparison of concentration levels of proinflammatory cytokines and total protein in synovial fluid of the temporomandibular joint with internal derangements and osteoarthrosis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2002;94(4):515−521.

31. Schiffman E, Ohrbach R, Truelove E, et al. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications: Recommendations of the International RDC/TMD Consortium Network* and Orofacial Pain Special Interest Groupdagger. *J Oral Facial Pain Headache.* 2014;28(1):6−27.

32. Nakaoka K, Hamada Y, Holmlund AB, et al. The changes of joint effusion on MRI and arthroscopic findings after visually guided TMJ irrigation correlated to the clinical outcome. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2009;108(1):99−104.

33. Emshoff R, Brandlmaier I, Gerhard S, et al. Magnetic resonance imaging predictors of temporomandibular joint pain. *J Am Dent Assoc.* 2003;134(6):705−714.

34. Emshoff R, Brandlmaier I, Bertram S, et al. Risk factors for temporomandibular joint pain in patients with disc displacement without reduction - a magnetic resonance imaging study. *J Oral Rehabil.* 2003;30(5):537−543.

35. Emshoff R, Brandlmaier I, Bertram S, et al. Relative odds of temporomandibular joint pain as a function of magnetic resonance imaging findings of internal derangement, osteoarthrosis, effusion, and bone marrow edema. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2003;95(4):437−445.

36. Emshoff R, Brandimaier I, Bertram S, et al. 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.