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Is there an association between temporomandibular joint effusion and arthralgia?

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Abstract

Purpose—Literature on joint effusion (JE) and its association with clinical and radiological variables in patients with temporomandibular disorders (TMD) is inconsistent and is characterized by multiple methodological limitations. The primary aim of this investigation was to evaluate the association between magnetic resonance imaging (MRI) identified JE and TMJ arthralgia. The secondary aim of this investigation was to determine the association between JE and other clinical and MRI identified soft tissue characteristics.

Methods—A retrospective cohort study was conducted. Clinical and soft-tissue imaging assessments were carried out following the Diagnostic Criteria for Temporomandibular Disorders

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guidelines. The dependent variable was JE and primary independent variable was arthralgia. The secondary independent variables comprised of TMJ-pain associated characteristics, and magnetic resonance identified variables. When applicable either Pearson Chi-square or T-test was used to determine the statistical associations between JE and clinical characteristics, and between JE and MR identified variables. Furthermore, generalized estimating equations (GEE) model was conducted to determine which of the independent clinical and MR identified variables were associated with JE.

Results—Data for 158 participants, representing 312 joints was extracted. The mean age of the female sample (59.4 %) was 31 ± 11.1 years and of the male sample (40.6 %) was 29.8 ± 9.7 years. No association was found between JE and arthralgia. However, statistically significant associations were found between JE and lateral disc rotation ($p = .001$) and between disc position in the coronal and sagittal planes ($p = .001$). The GEE model suggested that disc displacement with reduction ($OR = 2.5$) was statistically significant contributing factors for JE in the absence of DJD.

Conclusion—Results indicate that JE is associated with the position of the disc in sagittal plane. No association was found between JE and arthralgia, or TMJ-pain associated clinical characteristics in patients with TMD.

Introduction

Temporomandibular disorders (TMD) is a collective term, embracing a number of clinical musculoskeletal and neuromuscular conditions that involve the masticatory muscles, the temporomandibular joints, and the associated tissues (1, 2). It is characterized by pain of a persistent, recurring, or chronic nature; limitations or other alterations in the range of mandibular motion; and temporomandibular joint (TMJ) noises, such as, clicking and crepitus (2).

It has been suggested that differential diagnosis of TMDs should be based on information obtained from the patient's history, standardized clinical examination, and when necessary, TMJ imaging procedures (2). Magnetic resonance imaging (MRI) is a non-invasive imaging modality that has shown to have excellent reliability and validity for analyzing soft tissues and fluids within the TMJ complex. It can also be used for the assessment of hard tissues; however, the reliability has been shown to be poor (3–5).

TMJ effusion is defined as a collection of fluid in the TMJ space. It is manifested as areas of high intensity signal in the joint space on T2-weighted magnetic resonance (MR) images (4). Joint effusion (JE) has been suggested to represent an inflammatory process. Clinically, JE has been suggested to be associated with TMJ-pain and arthralgia in patients with TMD. Furthermore, it has often been used as an indication for pharmacological and surgical intervention (6–11). Radiologically, it has been associated with degenerative joint disease (3, 4, 12). In addition, it has been suggested that JE may be associated with morphological and positional soft tissue changes, such as disc deformity or disc displacement with and without reduction (11–14).

Literature on JE and its association with clinical and radiological variables is inconsistent and is characterized by multiple methodological limitations such as the absence of control group (3, 11, 15); non-standardized examination of the TMJ (11, 15); presence of confounding factors, such as inclusion of participants with degenerative joint disease (DJD) (16), or participants on anti-inflammatory medications (17, 18); or lack of information regarding examiner or radiologist reliability (7, 9–11, 15, 19).

The purpose of this study was to determine the clinical and radiological significance of JE in patients with TMD in the absence of methodological limitations and confounding variables. The investigators hypothesized that JE will be associated with the diagnosis of arthralgia, as defined by Diagnostic Criteria for Temporomandibular Disorders (DC/TMD). The primary aim of the study was to determine the association between MRI identified TMJ effusion and arthralgia, as previously defined. The secondary aims of this study were; a) To determine the association between JE and TMJ-pain associated clinical characteristics; and b) To determine the association between JE and MR identified soft tissue characteristics such as disc shape, and disc position in coronal and sagittal planes, in the absence of DJD.

Materials and Methodology

Study Design

To address the research purpose, the investigators designed and implemented a retrospective cohort study that involved de-identified data from two parent studies, “Effect of gender and TMD on mandibular mechanics” (20) and “Joules, Genes, and Behaviors: A multifactorial assessment of TMD risk indicators” (21, 22). For both studies, participants responded to newspaper advertisements or flyers asking for participants with “TMJ problems”, or presented to the TMD and Orofacial Pain Clinics, School of Dental Medicine, University at Buffalo for evaluation and management of TMJ and masticatory muscle disorders between the 2001 to 2015. Recruitment for both studies was carried out at the University at Buffalo, School of Dental Medicine.

To be included in the study sample, participants had to be consenting adult. Participants were excluded as study subjects if they were pregnant or had systemic rheumatological disease(s), as determined by medical history. In addition, participants with TMJ DJD, based on cone-beam computed tomography (CBCT) scan, or computed tomography (CT) scan (see below) were also excluded.

These parent studies (20–22) were approved by the Health Sciences Institutional Review Board (HSIRB) of the State University of New York at Buffalo, and are in compliance with the Helsinki Declaration. Informed consent was obtained from each participant. This de-identified historical cohort study was designated as exempt by the HSIRB.

Data collection methods

Clinical assessment—In both parent studies, clinical assessment was carried out using similar guidelines. In the initial clinical visit, an examiner explained the study, obtained informed consent, and reviewed the participant’s medical history. In the following visit, a calibrated examiner who had undergone formal training and calibration for performing

Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) examination protocol (23) conducted the DC/TMD clinical examination. The reliability level of the examiner was acceptable (ranging from K = 0.90 – 1).

Arthralgia: The protocol used to establish the diagnosis of arthralgia was based on the DC/TMD guidelines and definition (23).

TMJ-pain associated clinical characteristics consisted of three surrogate severity indexes (i) Functional pain index, (ii) Palpation pain index, and (iii) Total pain index.

Functional Pain Index (FPI): Functional pain index was defined as a cumulative score that indicates the presence of TMJ-pain during any range of mandibular motion. It consists of five movements; namely, maximum unassisted opening (MUO), maximum assisted opening (MAO), ipsilateral and contralateral excursion, and protrusion. Each painful TMJ movement is equivalent to score of 1. Functional pain index score ranges from 0 (no TMJ pain during any movement) to a maximum score of 5 (TMJ pain during every movement). For each joint, the functional pain index was calculated using the presence of pain in the ipsilateral TMJ. The presence of TMJ-pain in FPI was not required to be familiar, unlike for the diagnosis of arthralgia, as defined by DC/TMD.

Palpation Pain Index (PPI): Palpation pain index was defined as a summary score indicating presence of TMJ-pain during palpation of the TMJ. It consists of two palpations, palpation of lateral pole, and palpation around the pole. Each painful palpation is equivalent to score of 1. Palpation pain index score ranges from 0 (no TMJ pain during any palpation) to a maximum score of 2 (TMJ pain during palpation of both lateral and around the pole). The presence of TMJ-pain on palpation was not required to be familiar, unlike for the diagnosis of arthralgia, as defined by DC/TMD.

Total Pain Index (TPI): Total pain index was defined as TMJ-pain that occurred during range of motion and palpation of the TMJ. It is considered as an indicator of overall TMJ associated pain. It consists of seven items: 1) TMJ-pain during maximum unassisted opening (MUO); 2) maximum assisted opening (MAO); 3) ipsilateral excursion; 4) contralateral excursion; 5) protrusion; 6) pain during palpation of lateral pole; and 7) pain during palpation around the pole. Each positive response is equivalent to a score of 1. The score can range from 0 (no TMJ-pain during any movement or palpation) to 7 (TMJ-pain during every movement and palpation). The presence of TMJ-pain was not required to be familiar, unlike for the diagnosis of arthralgia, as defined by DC/TMD.

Radiographic assessment

Hard-tissue Assessment: Participants of “Effect of gender and TMD on mandibular mechanics” underwent CT scans, while subjects of “Joules, Genes, and Behaviors: A multifactorial assessment of TMD risk indicators” underwent CBCT scans. However, in both studies participants were prepared using same guidelines and the same radiologist did the evaluations.

Participants were instructed to put their back teeth completely together in the position where they fit the best. All the images were obtained in multidetector CT or CBCT and reconstructed in a hard-tissue algorithm. Minimums of 12 sections of each condyle (1 mm thick slices) were generated in sagittal and axial corrected coronal views with closed-mouth position.

A calibrated radiologist who was a participant of the RDC-validation project conducted in 2009 reviewed the CBCT and CT images (4). The radiologist was unaware of the participant's clinical diagnosis or findings. All of the CT and CBCT images were evaluated according to the guidelines proposed by DC/TMD (23). TMJs were categorized as negative, indeterminate, or positive for DJD. The reliability of participating radiologist to perform hard-tissue analyses was good ($K = .71$). To determine the valid association between TMJ effusion and MRI determined features of TMJ disc, participants categorized as indeterminate or positive for DJD were excluded.

Soft-tissue Assessment—In both parent studies, MRI was acquired using similar guidelines. For acquiring the MRI in closed-mouth position, participants were instructed to put their back teeth together in the position where they fit the best. To prepare for the open-mouth MRI, participants were instructed to open as wide as they could tolerate. The technologist then placed a mouth-opening device (Burnett Bidirectional TMJ Device, Medrad, Pittsburgh, PA) between participant's teeth and set the opening to the maximum that participant could tolerate. The closed-mouth MR images were acquired in proton density (PD) and T2 algorithm by using a dedicated TMJ surface coil. For open-mouth MR images, only PD images were acquired. Minimums of 6 slices of each joint were obtained in sagittally and axially corrected coronal views.

A calibrated radiologist who was a participant of the validation project conducted in 2009 reviewed the MR images (4). The radiologist was unaware of the participant's clinical diagnosis or findings. All of the MR images were evaluated according to the guidelines proposed by the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) (23). For analysis of nonosseous components, such as disc shape and disc position in coronal and sagittal planes using MRI, the reliability of the radiologist was excellent ($K = 0.78$). The reliability of the radiologist for diagnosing joint effusion based on T2-weighted MR images was good ($K = 0.68$) (4).

Joint Effusion: Joint effusion was coded as positive or negative. A positive finding of effusion was produced when in the closed mouth sagittal T2-weighted images there was presence of high intensity signal in the superior or inferior joint spaces (23).

Disc Shape: Disc shape was coded as normal or deformed. A normal finding of disc shape was produced when the disc in the closed mouth sagittal MRI view had a biconcave shape (23).

Disc position in the sagittal plane: Disc position in the sagittal plane was coded as normal, disc displacement with reduction (DDwR), or disc displacement without reduction

(DDwR) using closed and open mouth sagittal MRI views based on the guidelines proposed by the DC/TMD (23).

Disc position in the coronal plane: Disc position in the coronal plane was coded as normal orientation, medial rotation, or as lateral rotation using closed mouth coronal MRI views, as suggested by the DC/TMD (23).

Data Analysis

All the data analysis was conducted in SPSS v. 22 (IBM Corp., Armonk, NY). Each TMJ was identified as a separate unit for the purpose of statistical analysis. If any observation was missing, it was excluded from the analysis.

A multistep analytic approach was exercised for the statistical analysis. In the first step, the Pearson Chi-square test was used to determine the statistical association between JE and arthralgia (as defined by DC/TMD). Similarly, where appropriate T-tests and Pearson Chi-square were used to determine the association between TMJ effusion and FPI, PPI, TPI, disc shape, and disc position in coronal, and sagittal plane. Lastly, generalized estimating equation analysis was used to determine which of the independent clinical and MRI identified soft-tissue variables were associated with JE. Where it was appropriate, Fisher's least significant difference (LSD) post-hoc test was conducted to determine subgroup differences.

Results

There were 158 participants, representing 312 joints. The mean age of the female sample (59.4 %) was 31 ± 11.1 years and of the male sample (40.6 %) was 29.8 ± 9.7 years. No statistical difference was found between the genders for age (independent t-test, $P = .05$).

Seventy-two (23.1 %) joints were given the diagnoses of arthralgia, as defined by DC/TMD. Functional Pain Index (FPI), Palpation Pain Index (PPI), and Total Pain Index (TPI) were calculated for all the joints and were found to be statistically associated with the diagnosis of arthralgia (Table 1).

TMJ effusion was found in 80 (25.6 %) TM joints. The severities of TMJ-pain associated indexes were not associated with the MRI diagnosis of joint effusion (Table 2). Two hundred and sixty four (88.3 %) TMJ discs had a normal biconcave shape. The association between TMJ effusion and disc shape was found to be not statistically significant (Table 2). Two hundred and thirty (74.4 %) TMJ discs were in normal orientation in the coronal plane. Disc position in the coronal plane was found to be significantly associated with an MRI diagnosis of effusion. Post hoc testing indicated that the prevalence of JE in TMJs with lateral disc rotation was significantly higher than the prevalence in the normal disc orientation, or the medial disc rotation ($P_{\text{Normal}} = .003$ and $P_{\text{Medial}} = .001$) (Table 2). In the sagittal plane, 160 (54.1 %) TMJs had a normal disc position. A statistically significant association was found between TMJ effusion and sagittal disc position. The prevalence of TMJ effusion in the DDwR, and in the DDwoR was significantly higher than in the normal disc position (P_{DDwR}

.01 and $P_{DDwoR} = .03$). No statistically significant difference was found in the prevalence of TMJ effusion between DDwR and DDwoR (Table 2).

The association between JE and the diagnosis of arthralgia was statistically not significant (Table 3). Generalized estimating equation analysis suggested that the disc displacement with reduction [OR = 2.5 (1.2, 5.2)] was the only independent characteristic among the tested clinical and other MR identified characteristics to be associated with JE (Table 4).

Discussion

A retrospective cohort study was planned and executed. The purpose of this study was to determine the clinical and radiological significance of JE among patients with TMD, using standardized examination and assessment guidelines and in the absence of methodological limitations. The working hypothesis of the investigators was that JE is associated clinically with the diagnosis of arthralgia, as defined by DC/TMD. The primary aim of this study was to determine the association between JE and diagnosis of arthralgia. In addition, to determine association between JE and TMJ-pain associated clinical characteristics (FPI, PPI, and TPI), and between JE and MR determined characteristics (disc shape and disc position in the coronal and sagittal planes), in absence of DJD. Statistically significant associations were found between JE and disc position in the coronal and sagittal planes. Generalized estimating equation analysis suggested that disc displacement with reduction was statistically significant contributing factors for JE in the absence of DJD.

Temporomandibular JE has been suggested to be a surrogate for an inflammatory process and used as an indicator for pharmacological and surgical intervention (3, 6, 24, 25). It has been proposed that JE may activate or sensitize nociceptive afferent neurons within the joint (3, 24), as well as, result in increased articular pressure, which may cause mechanical trauma. Together this would result in induction of other inflammatory mediators and TMJ-pain (6, 25). However, in the present investigation, the associations between TMJ effusion and arthralgia, or between TMJ effusion and TMJ-pain associated clinical characteristics were not statistically significant. These results are similar to those reported earlier (12, 17, 18, 24, 26). Nevertheless, some investigations have reported significant associations between JE and TMJ-pain, and JE and TMJ-pain associated characteristics (3, 7, 11, 15, 27–31). A possible explanation for these associations may be due to quantification of JE. It has been concluded that a relatively high grade of effusion is associated with TMJ pain (8, 15, 18, 32). However, none of these investigations reported the reliability and validity of the radiologist to determine quantification or intensity of effusion. This limits the utility of this measure and may have resulted in a false-positive association. Furthermore, among the studies reporting quantification of effusion, the results were not consistent, which may be an indication of poor validity and reliability of this measure. Similarly, investigations reporting an association between joint effusion and TMJ-pain consisted of multiple methodological limitations such as absence of a control group (3, 11, 15), failure to apply a standardized clinical examination for the assessment of TMJ-pain (3, 7, 11, 15, 27–31), or failure to report the reliability of clinical examiners and radiologists (7, 9–11, 15, 19).

The occurrence of JE was found to be associated with TMJ disc position in the coronal and sagittal planes. In the present investigation, prevalence of medial and lateral disc orientation in the coronal plane was established to be 17.6 and 9.8 %, respectively. These figures are similar to those reported in previous investigations (33, 34). It has been suggested that medial rotation of the disc may be a physiological variation in the positioning of the disc due to its relatively high occurrence in the asymptomatic joints (33, 34). Furthermore, it has been reported that upon opening, in asymptomatic joints, the TMJ disc further orients medially. Conversely, lateral disc rotation has been associated with JE and clinical symptoms such as TMJ pain (8). In the present investigation, the prevalence of JE was found to be statistically higher in the TM joints with lateral disc rotation than in the TM joints with either normal disc orientation or medial disc rotation.

In the sagittal plane, DDwR and DDwoR were found to be statistically associated with JE. Several investigations have reported associations between JE and disc displacement (11–14). However, there is discrepancy in the magnitude of association, with respect to the type of disc displacement. Some investigators have reported significantly greater prevalence of JE in DDwR than in DDwoR (11, 35), while others have reported the opposite (12, 13, 29). In addition, it has also been reported that no statistically significant differences in occurrence of JE were present between DDwR and DDwoR (12). These variations in reporting may be attributed to inadequate and diverse methodological approaches, such as no control group (3, 11), failure to determine reliability of clinical examiners and radiologists (3, 11, 28, 31), variable criterion for characterization of JE, or quantitative characterization of JE (18, 24, 36).

In the generalized estimating equation analysis, DDwR in sagittal plane was found to be statistically significant contributing characteristics for JE. These results are similar to those reported earlier (8, 12). A proposed pathophysiological mechanism for the association between JE and disc displacement is that a displaced disc may result in abnormal mechanical stresses and induction of inflammatory mediators within the TMJ, which may lead to JE (8, 13, 14). However, it is assumed that if inflammatory mediators are present, there should be pain associated with either joint movement or palpation. In this study, associations between JE and arthralgia, as defined by DC/TMD, or TMJ-pain associated characteristics were not statistically significant.

It has been suggested that JE may be a pooling of synovial fluid with no direct relationship to inflammation (14). It has been proposed that due to the abnormal shaped disc during disc displacement, there may be interfere in the physiological circulation of the synovial fluid, which may result in a localized collection of fluid (13, 14). However, in the present investigation, disc shape was not found to be statistically associated with JE. Nonetheless, based on the results of our investigation, it can be theorized that a reducible displaced disc (DDwR) will not allow equalization of the synovial fluid within the TMJ complex due to its changeable spatial relationship with the condyle. A process not appreciable in DDwoR because of relatively stable anteriorly displaced position of the disc, with respect to the position of condyle in the sagittal plane.

The biggest strength of the present investigation is the utilization of standardized guidelines (DC/TMD) for evaluation and classification of clinical and radiographic characteristics, such as arthralgia, disc shape and position in coronal and sagittal planes. Moreover, multiple confounding variables, such as presence of participants with DJD or lack of information regarding the reliability of the clinical examiners and radiologist that were identified in previous investigations were avoided. Nevertheless, there were some limitations also present in the current study. Pain was not categorized on the basis of intensity. However, evaluating pain intensity within a single muscle, or joint sites to diagnose TMD has been eliminated from the DC/TMD examination. Furthermore, we used two pain indexes, FPI and TPI, to characterize the association of effusion with TMJ pain. Similarly, JE was not quantified. Previously, it has been concluded that a relatively high grade of effusion is associated with TMJ pain (8, 15, 18, 32). However, none of these investigations reported the reliability and validity of their quantification or intensity of effusion. This limits the utility of this measure and may have resulted in a false-positive association.

In summary, based on the findings of this retrospective-cohort study, the association between MRI diagnosis of joint effusion and arthralgia as defined by DC/TMD was not determined. However, a statistically significant correlation was reported between JE and disc position in the coronal and in the sagittal plane. In addition, generalized estimating equation analysis suggested that disc displacement with reduction in the sagittal plane was statistically significant contributing factor for JE in the absence of DJD. These results suggest that effusion is not necessarily associated with pain in patients of TMD. The understanding of the physiological role of JE in the TMJs is limited and warrants further investigation using standardized and validated guidelines.

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Table 1

Association between TMJ Arthralgia and TMJ-pain associated clinical characteristics

	Diagnosis of Arthralgia		Total	
	Yes	No		
Functional Pain Index	1.6 ± 1.6	.14 ± 0.45	.49 ± 1.1	P 0.001
Palpation Pain Index	1.5 ± .67	.3 ± .62	.58 ± .80	P 0.001
Total Pain Index	3.1 ± 1.7	.43 ± .86	1.1 ± 1.6	P 0.001

Table 2

Association between TMJ Effusion and TMJ-pain associated clinical and MRI identified articular disc characteristics

		TMJ Effusion		
		Yes	No	Total
Functional Pain Index		.56 ± 1.1	.46 ± 1.0	.49 ± 1.1 <i>P</i> = 0.461
Palpation Pain Index		.54 ± .78	.57 ± .80	.56 ± .80 <i>P</i> = 0.729
Total Pain Index		1.1 ± 1.7	1.0 ± 1.6	1.1 ± 1.6 <i>P</i> = 0.750
Disc Shape	Normal	60/73	204/226	264
	Deformed	13/73	22/226	35
Coronal disc position	Normal	54/79	168/230	230
	Medial	9/79	47/230	56
	Lateral ¹	16/79	15/230	31
	Normal	26/73	134/223	160
Sagittal disc position	DDwR ²	38/73	73/223	111
	DDwoR ²	9/73	16/223	25
				<i>P</i> = 0.001

¹LSD post hoc test indicated that the prevalence of TMJ effusion was statistically significantly higher in the lateral disc orientation group than in the normal (p = .003) and medial disc orientation groups (p = .001).

²LSD post-hoc test indicated that the prevalence of TMJ Effusion was statistically significantly higher than the prevalence in normal disc position group (p = 0.05).

DDwR: Disc Displacement with Reduction, DDwoR: Disc Displacement without Reduction.

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Table 3

Association between TMJ Effusion and TMJ Arthralgia

	TMJ Effusion		Total	<i>P</i> = 0.759
	Yes	No		
Diagnosis of Arthralgia	17/80	55/232	72	
	63/80	177/232	240	

Table 4

Generalized estimating equation model using clinical and MR identified characteristics.

Study Variable ^a	β Coefficient	Odds Ratio	95 % Confidence interval		<i>P</i> Value
			Lower bound	Upper bound	
DDwR	.92	2.50	1.19	5.23	0.015

^aTMJ Effusion is the dependent variable.