Ultrasound assessment of increased capsular width in temporomandibular joint internal derangements: relationship with joint pain and magnetic resonance grading of joint effusion

Burcu Bas, DDS, PhD, Nergiz Yılmaz, DDS, PhD, Erkan Gökce, MD, and Hüseyin Akan, MD
Samsun, Turkey
ONDOKUZ MAYIS UNIVERSITY AND OSMAN GAZI UNIVERSITY

Objective. The relationship between radiologic evidence of effusion in the temporomandibular joint (TMJ) and the occurrence of clinical symptoms (e.g., pain) is still unclear. Increased capsular width (CW) measured in ultrasonographic imaging (USI) of the TMJ was considered to be an indirect marker of TMJ effusion. The purpose of this study was to evaluate the relationship between the grades of magnetic resonance imaging (MRI)–depicted joint effusion (JE), increased CW measured in USI, and joint pain in TMJ internal derangement (ID) patients.

Study design. During a 4-year period, 91 patients clinically diagnosed with TMJ ID according to the Research Diagnostic Criteria for Temporomandibular Disorders classification were included in the study. Those with mainly myogenic complaints were excluded. In clinical examination, the severity of pain was assessed by visual analog scale (VAS, 0 to 10). All TMJs (n = 182) were evaluated to detect the presence of joint effusion by means of USI and MRI. MRI-depicted effusion was classified as no effusion, moderate effusion, and severe effusion. Receiver operating characteristic curve analysis was performed to depict the critical cutoff value for TMJ CW. USI sensitivity was evaluated by means of MRI effusion, and a cutoff value was depicted that was considered to be the threshold to discriminate the TMJs with and without effusion. The relationship between the joint pain and USI and MRI findings of effusion were evaluated with Friedman and Wilcoxon tests.

Results. The average VAS scores of the TMJs without effusion was found to be 2.55, with moderate effusion 2.92, and with severe effusion 4.80. A significant positive correlation was found between the VAS scores and the intensity of MRI JE (P < .003). The most accurate cutoff value of CW is found to be 1.65 mm. The average VAS score with CW < 1.65 was found to be 2.10 and the average VAS score with CW > 1.65 was found to be 3.75. A significant positive correlation was found between the clinical pain scores and CW measured in USI (P = .001).

Conclusions. Both MRI-depicted effusion and USI assessment of CW were found to be related to the pain in TMJ ID patients.

Pathologic collection of temporomandibular joint (TMJ) fluid in the joint space is called joint effusion (JE) and typically appears as a bright signal on T2-weighted magnetic resonance imaging (MRI). Several studies have suggested the possible relationship between the TMJ effusion and joint pain, TMJ disk derangement, degeneration of the mandibular bone marrow, inflammation, and external injuries. The relationship between radiologic evidence of JE and the occurrence of clinical symptoms (e.g., pain) is still unclear. Some authors have shown strong correlation between JE and TMJ pain. However, others suggest that MRI detection of high signal intensity in the closed-locking did not directly correlate with the presence of TMJ pain.

The use of MRI is often limited by its cost and availability. Therefore, the need has arisen for alternative radiologic techniques that have good diagnostic accuracy and reliability that are inexpensive, quick, and noninvasive. Recent studies have suggested ultrasonography (US) as a noninvasive, dynamic, and simple imaging technique in diagnosing TMJ internal derangement (ID). There have been encouraging findings in diagnostic agreement of US imaging (USI).
and MRI for JE. In USI, the presence of JE may be detected by direct visualization of a hypoechoic area within the articular space or indirectly by measuring an abnormal articular capsule width (CW). CW was measured as the distance between condylar laterosuperior surface and the articular capsule with the subject in the closed-mouth position. A preliminary study by Manfredini et al. reported good agreement (80%) between clinical and US diagnosis of JE. There has been only 1 report in the literature assessing the relationship between joint pain and effusion findings of USI.

The aim of this study was to find the most accurate cutoff value of CW in USI that was able to discriminate joints with and without MRI effusion and whether these findings are correlated to TMJ pain.

**MATERIAL AND METHOD**

Patients seeking treatment for temporomandibular disorder (TMD) at the Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Ondokuz Mayis University, were entered in a prospective, randomized, double-blind study. Under the guidelines published by Uysal et al., the design of this study is considered to be exempt from specific Ethical Board approval and only required informed written consent from each patient. Subjects were informed about the study procedure before getting consent forms. One trained maxillofacial surgeon and 1 trained radiologist performed the clinical and radiologic examination. Ninety-one patients diagnosed with TMJ ID in ≥1 joint according to Research Diagnostic Criteria for TMDs criteria (RDC-TMD) were included in the study and referred to the Department of Radiology, Faculty of Medicine, Ondokuz Mayis University, for radiographic examination. USI of each joint (n = 182) was performed on the same day as the clinical assessment by an experienced radiologist who was blind to the clinical diagnoses. MR examination was conducted by the same radiologist within 2-3 weeks. The MRI images were classified by means of effusion after all MRI images were taken from 91 subjects, without knowing the patients name and USI results.

**Clinical assessment**

Clinical examination, including patient history, the presence or absence of joint sounds and pain, palpation of intraoral and extra oral masticatory muscles, and measurement of the range of mandibular motion, was performed by 1 trained investigator who was blind to the results of MRI. The severity of pain during mandibular movements was assessed by visual analog scale (VAS, 0-10). Two VAS scores were obtained for each patient. TMD diagnosis was classified using RDC-TMD. Patients were divided into 3 groups as follows: group I, muscle disorders; group II, disk displacement;
and group III, arthralgia, osteoarthritis, and osteoarthrosis. Patients falling into group II were included in the study. In patients who had unilateral TMJ ID, contralateral healthy joints showing no symptoms of ID were considered to be normal.

MRI assessment

MRI was interpreted by 1 trained radiologist who was blind to the clinical diagnoses. For the MRI examination, a 0.5 Tesla scanner (Signa; General Electric, Milwaukee, WI) with bilateral circular-polarized TMJ coil was used. At closed and maximum-opening mouth positions, sagittal and coronal plane gradient T2-weighted (TR 440, TE 25, flip angle 30) images were obtained. It was positioned to pass through the disk. Data were composed of 256 × 128 matrix volume, 12 × 12 cm field of view, 3 mm slice thickness, and 0.5 mm slice distance.

All TMJs (n = 182) were evaluated to detect the presence of JE. On T2-weighted images, JE was identified as an area with homogeneous and high signal intensity in the joint space. MRI JE was classified as follows: no effusion, no area of high signal intensity; moderate effusion, lining or a thin band of high signal intensity in a limited area along the articular surface; and severe effusion, collection with pooling in the compartment (Fig. 1).

USI assessment

The ultrasonographic examination was carried out with a Toshiba Powervision 7000 (SSA-380) instrument with a 10-MHz high frequency transducer. The sonograms were performed by a single radiologist experienced in USI of the head and neck region. All trials were conducted in a dark room with the patients in supine position. The transducer was positioned over the TMJ perpendicular to the zygomatic arch in a transverse and longitudinal plane and tilted out until the best visualization was achieved. Condyle, disk, and articular eminence were identified in USI (Fig. 2). CW was measured by the technique of Manfredini et al. The articular capsule was identified as a hyperechoic line running parallel to the surface of the mandibular condyle. CW was measured as the distance between that line and the condylar laterosuperior surface with the subject in closed mouth position (Fig. 3). All the USA and MRI assessments were performed by the same trained blinded radiologist without knowing the patients’ names and results.

Statistical analysis

Receiver operating characteristic (ROC) curve analysis was performed to depict the critical cutoff value for TMJ CW. US sensitivity for showing effusion was evaluated by means of MRI, and a cutoff value was depicted that was considered to be the threshold to discriminate the TMJs with and without effusion. The relationship between the clinically depicted pain and USI and MRI findings of effusion were evaluated with Friedman and Wilcoxon tests. The statistical significant level was determined to be $P < .05$.

RESULT

Data were collected from 91 patients. There were 17 men and 74 women with an overall mean age of 25 years. In clinical examination, 90 joints (49%) revealed pain, with a mean VAS score of 3 (range 0-10, SD 3-10). Of the 182 joints, 40 joints were clinically diagnosed as normal and 142 joints as ID. In MRI examination, 67 joints (36%) were evaluated as having moderate effusion and 32 joints (17%) as having severe effusion. No effusion was seen in 83 TMJs (45%). The average VAS scores of the TMJs without effusion was found to be 2.55, with moderate effusion 2.92, and with severe effusion 4.8 (Table I). A
significant positive correlation was found between the clinical pain scores and the grades of MRI JE ($P$/H11005.003). Of the normal disk position joints, 21 (11%) showed JE. Sixteen (76%) of them were evaluated as having moderate effusion and 5 (23%) as having severe effusion. Of these 21 joints, 5 joints had pain symptoms and 16 joints were pain free.

The values of CW ranged from 0.8 to 2.8 mm (mean 1.7, SD 0.31). Table II presents the relationship between the different levels of CW and the grades of MRI findings of effusion. An ROC curve was created and the false positive rate ($1 - \text{specificity}$) and true positive rate ($\text{sensitivity}$) were calculated for the different cutoff values (Fig. 4). The area under the ROC curve was equal to 0.83, meaning that the diagnostic accuracy of USI for detecting MRI JE is quite good. Optimum sensitivity and specificity obtained from the ROC curve corresponded to the cutoff value of 1.65 mm, which was considered as the threshold to discriminate the TMJs with and without effusion. The average VAS score under the value of 1.65 was found to be 2.1 and the average VAS score over the value of 1.65 was found to be 3.75 (Table I). A significant positive correlation was found between the clinical pain scores and USI-depicted CW ($P$/H11005.001). Figure 5 represents the regression analysis of the CW and VAS scores of the patients ($R^2 = 0.137; \Delta R^2 = 0.370$). The mean VAS scores at the different grades of effusion in MRI and USI are presented in Table I.

**DISCUSSION**

MRI evidence of TMJ fluid was first recognized in 1985 by Harms et al.,$^{18}$ and since then several authors have studied the relationship between MRI-depicted effusion and TMJ pain and dysfunction.$^{2-9,19,20}$ The relationship between JE and TMJ pain is still controversial. Schellhas reported strong association between painful joints and MR evidence of JE in a study consisting of 100 patients.$^{2,9,19,20}$ Westesson and Brooks confirmed this association with a large series of 390 patients and asymptomatic volunteers.$^{2}$ In 1995, Sano and Westesson found a positive relationship between pain and the T2 signal intensity from the retrodiscal tissue on MRI.$^{7}$ However, Adame et al.,$^{21}$ in their study of a sample of 123 TMJs, found no

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**Table I.** Mean visual analog scale (VAS) scores at different grades of effusion detected in magnetic resonance imaging (MRI) and in lower and higher levels of critical cutoff value (1.65) of capsular width (CW) measured in ultrasonographic images (USI)

<table>
<thead>
<tr>
<th>Effusion</th>
<th>No effusion</th>
<th>Moderate effusion</th>
<th>Severe effusion</th>
<th>CW &lt;1.65</th>
<th>CW &gt;1.65</th>
</tr>
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<tr>
<td>Mean VAS score</td>
<td>2.55</td>
<td>2.92</td>
<td>4.8</td>
<td>2.1</td>
<td>3.75</td>
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**Table II.** Cross-tabulation of ultrasound capsular width (CW) and the grades of effusion evaluated in magnetic resonance imaging (MRI)

<table>
<thead>
<tr>
<th>CW</th>
<th>None</th>
<th>Moderate</th>
<th>Severe</th>
<th>Total</th>
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<td>0</td>
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<td>1.00</td>
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<td>1</td>
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<td>1</td>
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<td>0</td>
<td>1</td>
<td>5</td>
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<td>1.30</td>
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<td>1</td>
<td>0</td>
<td>8</td>
</tr>
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<td>1.40</td>
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<td>19</td>
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<td>1.60</td>
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<td>11</td>
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association between TMJ pain and effusion. They depicted TMJ effusion as being related to the MRI findings of ID and osteoarthritis. The difference between the results may be related to the diagnostic approach to TMD- and TMJ-related pain applied in these studies. In the present study, a significant positive correlation was found between the clinical pain scores and the intensity of MRI-depicted JE.

MRI is the preferred examination method for TMJ soft tissue pathology. However, it is an expensive technique, because of the cost of the equipment, facilities, staffing, and replacement cryogens for the magnet. Several authors have advocated USI as a noninvasive, low-cost, and easy-to-perform technique for the visualization of the disc-condyle relationship. However, very few studies have evaluated the accuracy of USI in detecting TMJ effusion. Jank et al. evaluated 200 joints and reported the accuracy of USI to detect TMJ effusion as 95%. Manfredini et al. reported the diagnostic accuracy of USI to detect MRI depicted TMJ effusion as good. In a study of 41 patients, Tognini et al. reported fairly good agreement between USI and MRI in the diagnosis of TMJ effusion. Jank et al. performed an ROC curve analysis to assess the most accurate cutoff value of CW that was able to discriminate between joints with and without MRI-depicted effusion. They revealed that the critical area is around the value of 2 mm for TMJ CW. In the present study, we performed the same method and found the critical area to be around the value of 1.65 mm. In our opinion, the difference between these 2 results is due to the difficulty of standardization of the examination. One of the major shortcomings of USI is that accuracy mainly depends on the operator’s training. These findings need to be refined by further studies assessing the smallest detectable difference in CW.

Fig. 5. The association between pain scores and capsular width measured in ultrasonography. \(cw\), capsular width; \(vas\), visual analog score.
CONCLUSIONS
For screening patients with TMJ pain and suspected JE, we suggest USI as a simple and less expensive method. According to our results, painful joints are more likely to demonstrate high grades of JE in MRI and increased CW in USI. The main disadvantage of the USI is that it is substantially an operator-dependent procedure. Further studies, including larger series of TMJ should address the standardization of the parameters adopted to detect JE.

REFERENCES

Reprint requests:
Burcu Bas
Department of Oral and Maxillofacial Surgery
Dental Faculty of Ondokuz Mayis University
Samsan
Turkey
burcubas@omu.edu.tr