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ARTICLE in JOURNAL OF MANIPULATIVE AND PHYSIOLOGICAL THERAPEUTICS · JUNE 2009
Impact Factor: 1.48 · DOI: 10.1016/j.jmpt.2009.04.003 · Source: PubMed

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Influence of the Temporomandibular Joint on Range of Motion of the Hip Joint in Patients With Complex Regional Pain Syndrome

Michael J. Fischer, MD, a,b Kathrin Riedlinger, MD, b Christoph Gutenbrunner, MD, PhD, a and Michael Bernateck, MD c

Abstract

Objective: This study evaluated if patients with complex regional pain syndrome (CRPS) would have an increase in range of motion (ROM) after myofascial release and a similar ROM decrease after jaw clenching, whereas in healthy subjects these effects would be minimal or nonexistent.

Methods: Documentation of patients with CRPS (n = 20) was established using the research diagnostic criteria for CRPS, questionnaires, average pain intensity for the past 4 weeks, and the temporomandibular index (TMI). Healthy subjects (n = 20, controls) also underwent the same testing. Hip ROM (α angle) was measured at 3 time points as follows: baseline (t1), after myofascial release of the temporomandibular joint (t2), and after jaw clenching for 90 seconds (t3). Comparison of the CRPS and control groups was made using t tests.

Results: Mean TMI total score and mean pain reported for the last 4 weeks were significantly different between the 2 groups (P < .0005). Hip ROM at t1 was always slightly higher compared to t3, but t2 was always lower in value compared to t1 or t3 for both groups. The differences of all hip ROM values between the groups were significant (P < .0005). Moreover, the difference between t1 or t3 and t2 was significantly different within the CRPS group (t1 = 48.7°; t2 = 35.8°; P < .0005).

Conclusions: The results suggest that temporomandibular joint dysfunction plays an important role in the restriction of hip motion experienced by patients with CRPS, which indicated a connectedness between these 2 regions of the body.

(J Manipulative Physiol Ther 2009;32:364-371)

Key Indexing Terms: Complex Regional Pain Syndromes; Temporomandibular Joint Disorders; Range of Motion, Articular; Hip

Temporomandibular dysfunction (TMD) is a multifactor syndrome that can involve myofascial pain, disk displacements, and arthralgia or osteoarthritis of the temporomandibular joint (TMJ). 1 Although it is generally acknowledged that there is a degree of connectedness between various parts of the body and the TMJ, in particular neural and musculoskeletal involvement, 2,3 the nature and mechanisms of these connections are not all that clear because they have not been systematically studied. In addition, the contribution of malocclusion or TMD to the etiology of chronic pain syndromes due in part to myofascial dysfunction remains unclear, controversial, and needs research investigation. For example, postural disorders, 4,5 lumbosacral pain, 6 cervical spine disorders, 7 and general musculoskeletal symptoms 8 have all been linked to craniomandibular disorders or TMJ dysfunction, and better definition of the involvement might lead to improved treatments.

Ciancaglini et al 9 investigated the relationship between TMD and neck pain in a northern Italian population and concluded that it was significantly related. Wiesinger et al 10 also reported that there was a significant association between long-term back pain and musculoskeletal disorders involving the jaw and face. Although it is suspected that TMD can give rise to pain in different parts of the body, especially the trunk and the arms, for patients who have neuromuscular diseases, it appears there might be a common mechanism that is responsible for development of pain in specific body regions, which is connected with the masticatory system. 11 John et al 12 also reported that in women, widespread pain was a risk factor for the development of TMDs, which indicates that the reverse situation might be possible, that is, the common mechanism can work both ways through ascending
and descending neural pathways. The work of Miyahara et al.\textsuperscript{13} may also support this concept, which showed that oral motor activity can exert a strong influence on the motor activity of other parts of the body. In addition, these investigators also demonstrated that voluntary teeth clenching can affect the soleus H reflex, modulated by descending influences from the cerebral cortex, as well as peripheral afferent impulses from the oral-facial region.

In a recent study, we noted a strong association of TMD with complex regional pain syndrome (CRPS), although different kinds of myopathies also seem to have a notable connection with TMD.\textsuperscript{11} Complex regional pain syndrome is a common complication after trauma or operation with a prevalence of 0.03% in which subjects experience a severe neuropathic deep pain in the involved limb with distal accentuation and often hyperalgesia or allodynia (brush-evoked pain).\textsuperscript{14} The current diagnostic guidelines distinguish between CRPS without or with obvious nerve lesions (CRPS type 1 and type 2, respectively).\textsuperscript{15} Based on our clinical experience, reduced range of motion (ROM) (particularly hip joints) is a common occurrence in many painful musculoskeletal disorders and also appears to be another hallmark of CRPS type 1.\textsuperscript{16-18} For example, Veldman et al.\textsuperscript{18} found that 88% of patients had a limited active range of movement of the affected extremity.

Currently there are no specific and validated tests that can diagnose the interference of the TMJ on ROM testing in chronic pain conditions. Moreover, attempts to use the leg-length inequality and internal foot rotation test in dental kinesiology to identify potential masticatory dysfunctions have been deemed unreliable.\textsuperscript{19} Therefore, we sought to develop a procedure that would demonstrate the involvement of the TMJ in ROM measurements in patients with CRPS. Because 2 previous studies\textsuperscript{20,21} and our clinical experience had suggested that patients with various painful musculoskeletal disorders had restricted ROM in the hip joint, standard examination techniques of the hip joint exist, and ROM is easy to measure, we chose ROM of the hip as the outcome measure. Our approach was to measure this parameter at baseline and then quantify the effect of applying traction to the TMJ so as to achieve myofascial release then create maximum stress on the TMJ structures for a short period to simulate dysfunction. Our hypothesis was that in patients with CRPS, we would observe an increase in ROM after myofascial release and a similar ROM decrease after jaw clenching, whereas in healthy subjects, these effects would be minimal or nonexistent.

**Methods**

**Patients**

Patients with CRPS (the CRPS group) were recruited using a university referral center of physical and rehabilitation medicine database and were assessed for disease-specific conditions, adjuvant therapy, sociodemographic variables, age, and sex. Patients were included into the study if the Research Diagnostic Criteria (RDC) for CRPS according to the IASP were fulfilled. The disease characteristics were based on the modified research criteria proposed by Bruehl et al.\textsuperscript{22} in which a patient must have at least one symptom in each of the following categories: sensory (presence of hyperesthesia or allodynia), vasomotor (temperature asymmetry, skin color changes, or skin color asymmetry), sudomotor/edema (edema, sweating changes, or sweating asymmetry), and motor/trophic (decreased ROM; motor dysfunction; and trophic changes to the hair, nails, or skin), with at least one sign at the time of evaluation in 2 or more of the previously described categories and no other diagnosis that better explains the signs and symptoms. The questionnaire used was a standardized sign/symptom checklist of 3 categories with 22 items used at the clinic, which incorporated the modified research criteria proposed by Bruehl et al.\textsuperscript{22} Healthy subjects were also recruited for a control group.

**Inclusion and Exclusion Criteria**

The minimum entry age was 18 years for both groups. For the patient group, the inclusion criteria were diagnosis of CRPS using the revised RDC for CRPS and pain duration greater than 3 months; for the control, group there were no additional criteria.

Subjects (both groups) were excluded if diagnosed with osteoarthritis, fibromyalgia, fever, and respiratory decompensation or if they were unable to speak, read, and write German or fill out the patient questionnaire. One of us (KR) collected completed questionnaires.

Patients gave written consent to participate in the study. The study was conducted at the Department of Neurology, Friedrich Baur Institute, Ludwig Maximilians University (Munich, Germany), in accordance with the ethical principles of the Declaration of Helsinki with the Edinburgh revision and according to current good clinical practice guidelines and was approved by the local ethics committee. The trial was registered with the Bavarian chamber of physicians (trial registration no. 5111).

**Design**

This was a single-center, prospective, experimental intervention study.

**Examination**

The examiner (MJF) was trained by an experienced dentist in the diagnosis of TMD and in the use of the temporomandibular index\textsuperscript{23} (TMI). The examiner also underwent more than 50 hours of education, training, and calibration in the use of the TMI and was blinded to both the patient’s diagnosis and reported pain measures. He
also collected the RDC/TMD (Research Diagnostic Criteria for Temporomandibular Disorders) and TMI data for both groups.

**Outcome Measures**

Questionnaires contained information on localization and duration of pain. A 0 to 10 eleven-point numerical rating scale was used by the patients to rate their perceived level of pain in which 0 denotes “no pain” and 10, “pain as bad as it could possibly be.” Patients (both groups) were also asked to rate their average pain intensity during the last 4 weeks.

Part of the RDC/TMD instrument was used for a standardized examination and history taking according to Dworkin and LeResche. In addition, assessment of the TMI was performed for both groups. The TMI is composed of 3 subindices as follows: the function index, the muscle index, and the joint index.

The hip ROM was measured at 3 time points (t1, t2, and t3). After placing the patient in a supine position with feet slightly apart, the examiner (MJF) immobilized the pelvis by

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**Fig 1.** Assuring that the pelvis is leveled using an orthopedic spirit level (step 1).

**Fig 2.** Flexing the leg at 90° with respect to the hip before abduction of the leg (step 2).

**Fig 3.** Passive abduction of the leg to the end of its motion and measurement of the angle between the table surface and the femur using a standard goniometer (step 3).

**Fig 4.** Applying traction to the mandible in an anterior-distal direction for 90 seconds at the barrier of joint play to achieve a myofascial release.
applying pressure to the contralateral anterior superior iliac spine. The first step was assurance of a level pelvis, which was conducted using an orthopedic spirit level (Nivello, Tip Therm GmbH, Brüggen, Germany) by an assistant examiner (KR) (Fig 1). In the second step, the right leg and knee was then flexed by the examiner to reach a 90° angle with respect to the hip (measured using a goniometer; all subjects reached 90°; Fig 2). In the third step, the leg was then passively abducted to the end of its motion by the examiner, and the angle between the table surface and the femur was then measured using a standard goniometer by the assistant examiner (Fig 3). This constituted t1—the pretest value of

Fig 5. Flow chart of subject enrolment.
the femoral angle. The procedure was then iterated for the left leg (steps 1-3).

Traction was then applied to the mandible in an anterior-distal direction for 90 seconds at the barrier of joint play to achieve a myofascial release (Fig 4). During this time, the patient was instructed not to speak, bite, or swallow, as this would interfere with the process. During this process, the patient’s legs were lying flat on the table. Steps 1 to 3 were then repeated to measure the femoral angles in both legs (t2). Finally, the patients were instructed to clench their teeth 3 times and then hold the bite while the femoral angles were again measured for both legs (t3).

Statistical Analysis

SPSS version 15 (SPSS Inc, Chicago, Ill) was used for statistical analysis. A significance level of 0.05 was chosen, with all tests performed as 2-sided. t Tests were used to compare the mean age, total TMI score, and mean pain reported for the last 4 weeks between the 2 groups. A χ² test was used to compare the sex composition of both groups. t Tests were also used to compare the means between groups of t1, t2, and t3, as well as the differences between t1 and t3, and t2 and t3. In addition, a repeated measures general linear model was created for the CRPS group to analyze the interactions between the covariates age, total TMI score, and pain score (last 4 weeks), and the variables t1, t2, and t3.

RESULTS

Thirty-four patients were screened in the CRPS group, but only 20 patients were enrolled because of failure to meet inclusion criteria, failure of contact, and refusal to participate in the study (Fig 5). Of the 20 healthy individuals screened, 20 were enrolled in the study.

The dominant pain complaint as reported by the patients with CRPS was the hand or foot, but pain in other parts of the body was also frequently encountered.

The age of the 2 groups was significantly different (CRPS group: mean age, 49.8 years; SD, 14.81; control group: mean age, 37.0 years; SD, 10.40; t = 3.163; df = 38; P < .003). However, the sex composition of both groups was not significantly different (CRPS group: 15 women, 5 men; control group: 12 women, 8 men). Both the TMI total score and the mean pain reported for the last 4 weeks were significantly different between the 2 groups (TMI score: CRPS group, mean, 0.542; SD, 0.211; control group, mean, 0.092; SD, 0.063; t = 9.146; df = 22.35; P < .0005; mean pain last 4 weeks: CRPS group, mean, 6.25; SD, 1.673; t = 9.702; df = 38; P < .0005).

The pattern of femoral angles for t1, t2, and t3 was the same in both groups with t1 always being slightly higher compared to t3 (Fig 5). However, whereas t2 was always lower in value compared to t1 or t3, this difference was far more pronounced in the CRPS group compared to the control group (Table 1; Fig 6). For example, for the right leg, the mean difference between t2 and t3 was 10.83° (SD, 6.002) for the CRPS group and 0.75° (SD, 2.447) for the control group. Using the paired t test, although the differences between t1 and t3 were not significant in the CRPS group, they were significant between t1 and t2, and t2 and t3 for both legs (P < .0005) (Table 2; Fig 6).

The femoral angle differences between legs were negligible for both groups. However, in all cases, the differences for the femoral angles at t1, t2, and t3 between the groups were significant for both legs (Table 2, Fig 5). Multivariate tests associated with the general linear model of the CRPS group showed that none of the covariates (age, mean TMI total score, and mean pain in the past 4 weeks) had significant interactions with t1, t2, and t3.

DISCUSSION

The chief goal of our study was to determine whether in patients with CRPS we would observe an increase in hip abduction after myofascial release and a similar abduction decrease after jaw clenching. The authors hypothesized that in healthy subjects these effects would be minimal or nonexistent. Our secondary goal was to quantify the effect of the temporomandibular system on the ROM of other parts of the body.

The experimental design quantified the effect of 2 manipulations of the TMJ after establishing a baseline measurement. The first was to apply traction to the joint in such a manner as to achieve myofascial release, which is a basis for much physical therapy in musculoskeletal disorders and chronic pain syndromes, and the second was to create a situation in which maximum stress on the structures of the TMJ system (i.e., the joint itself, and the associated tendons, muscles, and fascia) could occur for a short period, thus, stimulating possible dysfunction.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>CRPS group (n = 20)</th>
<th>Control group (n = 20)</th>
<th>L</th>
<th>R</th>
<th>L</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>t1</td>
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<td>49.2</td>
<td>10.436</td>
<td>10.310</td>
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<td></td>
</tr>
<tr>
<td>t2</td>
<td>35.6</td>
<td>36.1</td>
<td>8.893</td>
<td>11.188</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t3</td>
<td>45.8</td>
<td>46.94</td>
<td>10.744</td>
<td>10.729</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t1-t2</td>
<td>11.9</td>
<td>12.5</td>
<td>5.724</td>
<td>5.491</td>
<td></td>
<td></td>
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<tr>
<td>t3-t2</td>
<td>10.3</td>
<td>10.8</td>
<td>5.550</td>
<td>6.002</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

L indicates left leg; R, right leg.

Table 1. Mean and SDs for femoral angles at t1, t2, and t3
As expected, there was little change (1.5°) in the control group after manipulations, and the mean baseline femoral angle was 19.5°. However, the mean baseline femoral angle in the CRPS patients was 48°, demonstrating that this group had a severe restriction regarding hip abduction. The angle was also reduced by 12.6° (26%) after myofascial release, indicating that the TMD, documented in this group by TMI total score and average pain in the last 4 weeks, played a substantial role in restricting the hip abduction. Moreover, a short period jaw clenching, which stimulated dysfunction, created almost the same amount of restricted motion measured at baseline. Taken together, these results suggest a strong involvement of the TMJ system with hip abduction in CRPS patients, which imply a connectedness between the two. Therefore, one has to postulate how this might occur.

Afferent inputs via Aβ, Aδ, and C-fibers from the periphery and deep structures of the body that convey various sensory kinds of information converge on the neurons of the spinal or trigeminal dorsal horns, and the information is then relayed to the medial and lateral tract thalamic nuclei and other cortical regions for further processing.\(^\text{26}\) In addition, there is increasing evidence from studies suggesting that these integrated inputs at the brainstem level may play a role in trigeminal motor function, which may then explain the common involvement of TMD with chronic pain syndromes.\(^\text{27-30}\) Finally, the reticular formation can be seen as a possible communication system between the trigeminal and spinal system and perikarya of jaw muscle spindles located in the trigeminal mesencephalic nucleus, which have been shown to project caudally to the medial border of the descending trigeminal nucleus and

**Table 2. Statistical testing of differences between the femoral angles at t1, t2, and t3 for both groups using t test**

| Parameter          | t   | df * | t   | df *
|--------------------|-----|------|-----|------
|                    | L   | R    | L   | R    |
| Between groups     |     |      |     |      |
| t1                 | 9.537 | 9.563 | 37 | 37   |
| t2                 | 6.166 | 6.017 | 36 | 36   |
| t3                 | 8.699 | 8.815 | 36 | 36   |
| Within CPRS group  |     |      |     |      |
| t1-t2              | 6.799 | 7.851 | 26.49 | 22.02 |
| t3-t2              | 7.229 | 6.647 | 19.35 | 22.02 |

Differences were significant between the 2 groups (n = 20 for each group) for t1, t2, and t3, and within the CRPS group for t1-t2 and t2-t3 (P < .0005). * In some instances the df value are not whole numbers because Levene's test for equality of variances was significant, and the t test was then calculated using this basis.

**Fig 6. Influence of the TMS on ROM testing (t1 indicates before traction of the mandible; t2, after traction of the mandible; t3, after clenching of the jaw; bars represent SD).**
adjacent reticular formation. In theory, therefore, these central nervous system pathways may permit communications of nociceptive and other types of information between the TMJ and other parts of the body and vice versa, which may be a role in the development of various pain syndromes such as CRPS.

Although we thus suggest connectedness of the TMJ and hip region is responsible for the results of our study in the CRPS group, we do not know if that connection is strictly neural or whether other components are involved. Moreover, a variety of other musculoskeletal disorders appear to include TMD dysfunction, which suggests that work done in these fields to alleviate the dysfunction may have some applicability to patients with CRPS. For example, the use of occlusal splints has been found to be of use in TMD, and in a recent randomized controlled trial, we found that such devices used for 7 weeks improved signs and symptoms of TMD pain in CRPS although it had no impact on CRPS-related pain. Our clinical experience demonstrated that such devices increase hip abduction, and therefore, this may be another subject for exploration because jaw clenching clearly caused a reduction in hip abduction.

Myofascial release theory suggests that when the fascia of the affected parts of the body are “untangled” through massage or other techniques, that release can be transmitted in part via the fascial system because it is all connected, but concrete evidence elucidating this mechanism is lacking. Nevertheless, our study indicates that myofascial release in the jaw does improve hip abduction, although we do not know how long this effect lasts. Further research objectives, therefore, might include determination of the effect duration with the goal of assessing this treatment as part of a physiotherapeutic regimen for patients with CRPS.

This study used a small group of subjects, so our conclusions must be tentative. In addition, because the mean age of the CRPS group was significantly older that the control group, this factor might have influenced the conclusions we have made. Finally, ROM studies about chronic pain syndromes are lacking in the literature, so it will be incumbent to further explore the technique in both healthy and comorbid patients to establish norms and better elucidate the involvement of TMD.

CONCLUSION

The results suggest that TMJ dysfunction plays an important role in the restriction of hip motion experienced by patients with CRPS, which indicates a connectedness between these 2 regions of the body.

ACKNOWLEDGMENTS

The authors thank Gerhard Marx, MD; Anton Schmidt, MD, DDS; and Martin Würl for their contributions to the conduct of this research project. This study was supported by a research grant from the German Society of Manual Medicine—(FAC) Forschungsgemeinschaft für Arthrologie und Chirotherapie.

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