Reduction of Clinical Temporomandibular Joint Pain Is Associated with a Reduction of the Jaw-Stretch Reflex

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Aims: *To examine the jaw-stretch reflex after injection of local anesthetic (LA) into painful temporomandibular joints (TMJs), since the functional role of jaw-stretch reflexes in patients with painful temporomandibular disorders is still not well understood.* ***Methods:*** *Thirteen female patients with a clinical diagnosis of disc displacement without reduction and TMJ pain participated in this open study. Reflex responses were evoked by fast stretches at 15% of the maximal voluntary contraction level before and after injection of 1 mL carbocaine into the painful TMJ. Electromyographic (EMG) activity was recorded from the left and right masseter and temporalis muscles, and the mean level of prestimulus EMG activity and peak-to-peak amplitude of the stretch reflex were measured. Visual analog scale ratings of TMJ pain and TMJ pressure pain thresholds (PPTs) were also obtained. Eleven healthy women were examined with the same protocol (except for PPT determinations) before and after injection of LA into the TMJ.* ***Results:*** *In patients, injection of LA reduced the TMJ pain during jaw movements and maximum clenching ($P < .021$) and increased the PPTs in the painful TMJ ($P < .01$). The prestimulus EMG activity in the masseter on the painful side (feedback muscle) was unaffected by the injection of LA ($P > .262$). There were no significant side-to-side asymmetries of latency or amplitude measures of the stretch reflex in the patient group. Both the peak-to-peak amplitude and the normalized peak-to-peak amplitude of the stretch reflex were reduced in the masseter and temporalis muscles on the painful side and in the masseter on the nonpainful side after LA injections ($P < .048$). There were no effects of LA injections into the TMJ in the healthy group on any EMG or stretch parameters.* ***Conclusion:*** *These results do not support the notion of asymmetries in the jaw-stretch reflex in patients with TMJ pain, but they do suggest that the reflex sensitivity can be influenced by nociceptive activity from the TMJ area.* J OROFAC PAIN 2004;18:33–40.

Key words: local anesthesia, pain, pain thresholds, stretch reflex, temporomandibular joint, trigeminal nerve

Temporomandibular disorders (TMD) are characterized by pain or tenderness in the jaw muscles, several types of joint sounds, and/or restriction of mandibular motion.[1–4] The pain is usually described as dull, aching, continuous, and increasing with jaw function and is typically located around the ear, the mandibular angle, and the temporal area. Pain can also be reported in the jaw and diffusely throughout one side of the face. Tenderness of jaw muscles to palpation can be found in the clinical examination of

TMD and is in most cases accompanied by clinically tender neck or shoulder muscles.[5]

The stretch reflex has been previously studied in patients with TMD, with equivocal results.[6] Studies using controlled chin taps to evoke the reflex have reported a significant side-to-side asymmetry in onset latency but no amplitude differences in the jaw-jerk reflex in patients with painful TMD.[7] Other studies have demonstrated bilateral amplitude "imbalance" of the reflex in TMD patients before treatment, as compared to normal subjects and following treatment.[8,9] The asymmetry of the onset latency of the stretch reflex is thought to be the result of facilitation of muscle spindles on the side with muscle pain or tenderness.[10] A significantly longer onset latency and smaller amplitudes of the jaw-stretch reflex (jaw jerk) have been shown on the painful side in TMD patients.[10,11] In contrast to the above findings, other studies have shown different results. The pattern of the complex reflex responses to tooth tapping appears to be similar in patients with different types of TMD symptoms and in healthy subjects when the background electromyographic (EMG) activity is controlled by visual feedback.[12] Furthermore, the jaw-stretch responses are not significantly changed, and bilateral asymmetries cannot be found in TMD patients, as compared with control subjects, when the background EMG activity is controlled and the reflex amplitude is normalized.[13] Discrepancies in methodology and criteria for selection of TMD patients may, in part, explain such divergent findings; therefore, assessment of the jaw-stretch reflex may require highly standardized techniques and protocols to determine the excitability of the trigeminal motoneuron pool in well-defined subgroups of TMD patients.[6,14,15]

In previous human studies, a facilitation of the jaw-stretch reflex during experimentally induced jaw muscle pain has been clearly demonstrated under highly standardized conditions.[16–21] However, the interaction between clinical temporomandibular joint (TMJ) pain and jaw-stretch reflexes pathways is less investigated. Thus, the purpose of the present study was to use injections of local anesthetic (LA) to reduce the pain in patients with painful TMJs to examine whether the sensitivity of the jaw-stretch reflex is influenced by pain in the TMJ region. We also tested the effect on jaw-stretch reflexes of LA injections into nonpainful TMJs in healthy volunteers.

Materials and Methods

Participants

Thirteen female patients (mean age ± SEM: 28.4 ± 2.4 years) participated this study. All patients underwent a history and clinical examination compatible with a diagnosis of disc displacement without reduction and arthralgia according to the Research Diagnostic Criteria for TMD.[1] Magnetic resonance imaging (MRI) is not routinely performed in patients with disc displacement problems in Denmark, and in only 2 patients was the position of an anteriorly displaced disc verified by MRI. The healthy group consisted of 11 women (mean age ± SEM: 25.2 ± 1.2 years) without signs or symptoms of TMD, periodontal or endodontic diseases, or distinct orthodontic abnormalities. All subjects had full dental arches, including the second molars. The study was conducted in accordance with the Helsinki Declaration, and all participants gave written informed consent to the procedures, which were approved by the local ethics committee.

Pressure Pain Thresholds

A pressure algometer (Somedic) was used to measure the TMJ pressure pain thresholds (PPTs). The PPT was defined as the amount of pressure (kPa) that the subject first perceived as painful.[22] The 1-cm-diameter probe was applied perpendicular to the lateral part of the ipsilateral and contralateral TMJ. During the pressure stimulation of the TMJ, each subject was asked to keep her teeth in the intercuspal position with minimum voluntary contraction (EMG was not assessed), stabilize the mandible, and focus attention on the experimental task. The subject pushed a button to stop the pressure stimulation when the threshold was reached. The PPTs were determined twice with a constant application rate of 30 kPa/s. The time between repeated measurements was 1 min. The mean value was used for further statistical analysis.

Jaw-Stretch Reflex Recordings

Stretch reflexes were evoked in the jaw-closing muscles with a muscle stretcher based on that described by Miles et al[23] and previously described in detail by the present authors.[24,25] During the recordings, each participant was instructed to bite on a jaw bar of the stretch device with the incisors. The initial jaw separation for the subject, which was determined by the distance between the maxillary and mandibular bars, was 4.0 mm. The EMG activity was recorded with the use of bipolar disposable surface electrodes (4 × 7 mm recording area, 720-01-k, Neuroline; Medicotest), which were placed 10 mm apart along the central part of the masseter and the anterior temporalis muscles on both sides. The skin over the recording positions was cleaned with alcohol. A ground electrode soaked with saline was attached to the right wrist. The EMG activity was amplified 2,000 to 5,000 times (Counterpoint MK2), filtered with bandpass 20 Hz to 1 kHz, sampled at 4 kHz, and stored for offline analysis.

To obtain the mean EMG value of the maximal voluntary contraction (MVC) in the 4 muscles each participant was initially asked to perform 3 maximal clenches, each lasting up to 3 seconds, by clenching on the bars of the stretch device with the incisors. The EMG-MVC calculated at the start of the experiment was used to construct a window of 10% below and above the target level of 15% EMG-MVC (ie, 13.5% to 16.5%). To help participants achieve this, online calculation of the root-mean-square (RMS) value in 200-milliseconds intervals was performed. The participant received visual feedback from markers on the computer screen that changed from green to red upon crossing the upper and lower limits of the window.[24–26] The program automatically triggered the stretch device when the EMG activity remained within the preset window for more than 400 milliseconds. A total of 300 milliseconds of EMG activity was recorded (100 milliseconds prestimulus and 200 milliseconds poststimulus). Twenty sweeps were recorded in each condition.

A special-purpose computer program (Aalborg University) was subsequently used to analyze the jaw-stretch reflex responses. First, the mean EMG activity in the prestimulus interval (–100 to 0 milliseconds) of the averaged and rectified signal was calculated.[13] The onset latency, duration, and peak-to-peak amplitude of the early reflex component, which appeared as a biphasic potential in the average of the nonrectified recordings, was measured. The peak-to-peak amplitude was then normalized with respect to the mean prestimulus EMG activity[13,24] (Fig 1).

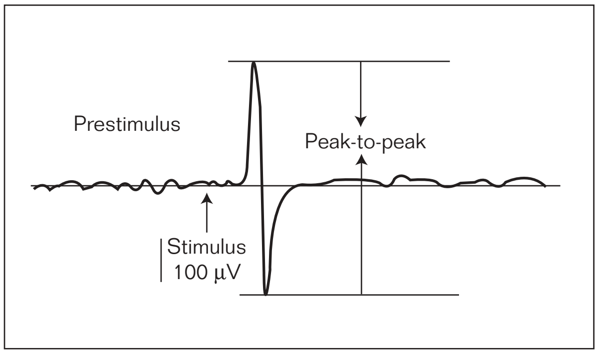


Fig 1 Example of an averaged reflex response (20 sweeps) in the masseter muscle evoked by fast stretch (ramp time: 10 milliseconds) in a single subject. The arrow shows the onset of the stretch stimulus. The amplitude was measured as the peak-to-peak value. The normalized peak-to-peak amplitude was calculated as the peak-to-peak amplitude divided by the prestimulus EMG activity.

Experimental Protocol

Each patient rated her TMJ pain on a 100-mm visual analog scale (VAS) at rest, during maximal clenching in the intercuspal position, during maximal unassisted jaw opening, during laterotrusion, and during protrusion. In addition, PPTs on the TMJs were measured. The jaw-stretch reflex responses were then assessed. A total of 1.0 mL carbocaine (10 mg/mL; Astra) was injected into the painful TMJ. The intra-articular injections were made by a lateral approach technique to infiltrate the superior cavity of the joint.[26] Immediately following the injection, the subjects reported a slight change in their occlusion on the side of the injection, which was taken as a clinical indication that the LA had indeed been placed in the upper TMJ space. Fifteen minutes after the injection, the VAS pain scores were measured again during maximal clenching and jaw movements, along with PPTs; this was followed by a new series of jaw-stretch recordings. The same protocol was followed for the healthy subjects, except for measurement of PPTs. The healthy subjects were examined about 2 to 3 months after examination of the TMJ pain patients.

In TMJ pain patients, the term *ipsilateral* was used to refer to the painful side and in healthy subjects, *ipsilateral* referred to the side that was injected with LA. The painful TMJ was located on the right side in 4 patients and on the left side in 9 patients. The visual feedback was always from the masseter muscle on the painful side. In the healthy subjects, LA was always injected into the left TMJ, and visual feedback was obtained from the left masseter muscle.

Statistics

One-way and 2-way analyses of variance (ANOVA) with repeated measures were performed and followed by pairwise multiple comparison procedures (Student-Newman-Keuls [SNK]). The

Table 1 Pain Intensity Measured on a 0–100 mm VAS Before and After Administration of Local Anesthetic to the TMJ

Exercise	Before	After	*P* value
Rest	15.8 ± 8.3	1.2 ± 0.8	.074
Clench	31.2 ± 8.4	7.7 ± 5.3	.014*
Opening	34.2 ± 7.0	5.0 ± 2.1	.001*
Protrusion	30.2 ± 8.0	8.1 ± 3.6	.013*
Left	27.7 ± 8.9	8.9 ± 5.7	.021*
Right	21.5 ± 7.5	6.1 ± 4.6	.057

*Indicates significant difference between before and after values ($P < .05$).

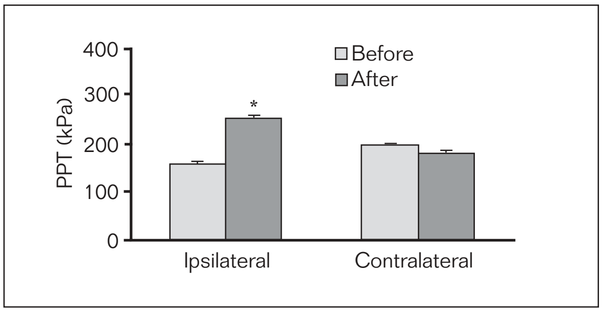


Fig 2 PPTs (mean values + SEM) measured in the ipsilateral (painful side) and contralateral TMJs before and after intra-articular injection of LA (n = 13). *Indicates significant difference between conditions (SNK: $P < .05$).

factors in the ANOVA were experimental conditions (2 levels: before and after LA injections) and muscles (4 levels). The TMJ pain patients and healthy subjects were also compared with ANOVA models and unpaired *t* tests. The level of significance was set at $P < .05$. Mean values ± SEM are presented in the text and figures.

Results

Pain Intensity and PPTs

The pain intensities rated by the TMJ pain patients during maximal clenching in the intercuspal position, maximal unassisted jaw opening, maximal protrusion, and maximal laterotrusion to the left were all significantly reduced after LA injection compared with baseline values (ANOVAs: F > 7.09, $P < .021$) (Table 1). None of the healthy subjects reported any pain during maximal clenching or during jaw movements.

The PPTs measured on the painful TMJ were significantly higher after the LA injection compared with baseline (ANOVA: F > 8.56, $P < .01$), and there were significantly lower PPTs on the painful TMJ compared with the nonpainful side at baseline ($P = .014$) (Fig 2).

Jaw-Stretch Reflexes

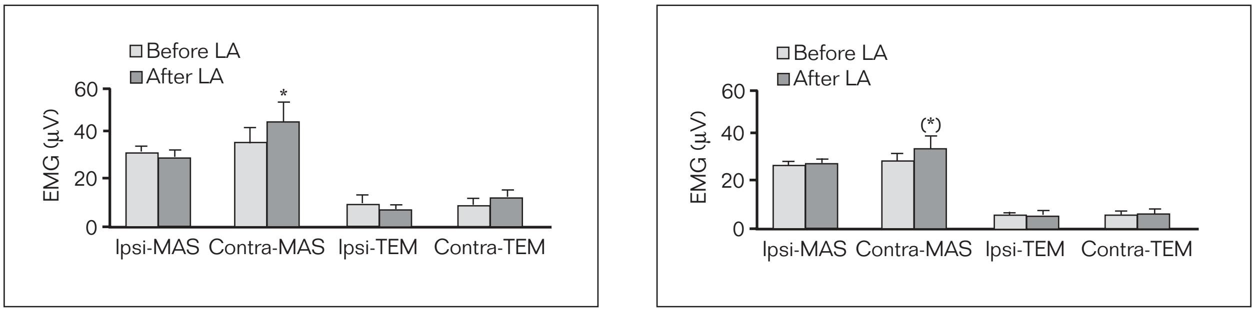
The EMG activity from the ipsilateral masseter muscle, which served as the feedback muscle during the reflex recordings, remained constant following the LA injection in both groups (ANOVA: F < 1.31, $P > .262$). However, injection of LA into the TMJ caused a significant increase in the prestimulus EMG activity from the contralateral masseter muscle in the TMJ pain patients (SNK: $P = .041$) and a tendency toward increase in the healthy subjects (SNK: $P = .091$) (Figs 3a and 3b).

The jaw stretch evoked a short-latency reflex response in all participants. The mean onset latency of the stretch reflex was 8.7 ± 0.3 ms, with a duration of 12.4 ± 0.3 ms in the TMJ pain group. There were no significant side-to-side differences ($P = .773$). The onset latency and duration of the stretch reflex in the healthy group were 8.8 ± 0.2 ms and 12.2 ± 0.4 ms, respectively, with no significant difference compared to the TMJ pain group ($P > .385$). There were no significant effects of the LA injections on the onset latency and duration in the TMJ pain patients and healthy subjects (ANOVAs: F < 0.723, $P > .495$).

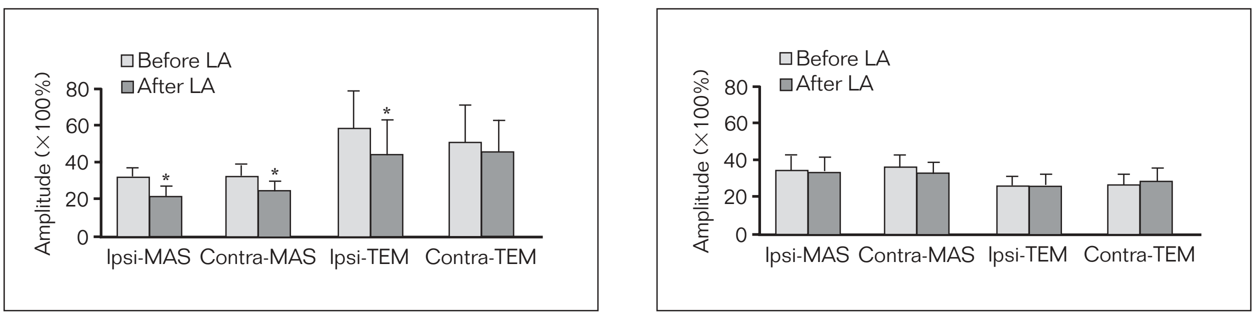
The peak-to-peak amplitude of the stretch reflex normalized to the prestimulus EMG was significantly influenced by the LA injection in the TMJ pain group (ANOVA: F = 5.52, P = .037) (Fig 3c). Thus, the normalized peak-to-peak amplitude was significantly reduced after the LA injection compared with baseline in the ipsilateral masseter (SNK: $P = .005$), contralateral masseter (SNK: $P = .021$), and ipsilateral temporalis (SNK: $P = .04$) (Fig 3c).

In the healthy subjects, the normalized peak-to-peak amplitude of the stretch reflex was not significantly influenced by injection of LA into the TMJ (ANOVA: F < 0.917, $P > .361$) (Fig 3d). There were no significant differences in the normalized peak-to-peak amplitude at baseline between the TMJ pain patients and healthy subjects (ANOVAs: F < 2.846, $P > .122$).

Figs 3a to 3d *Effects of injections of LA into the TMJ in patients with pain (n = 13) and in healthy subjects without pain (n = 11) on mean prestimulus EMG activity and normalized peak-to-peak amplitude of the short-latency reflex response recorded from the ipsilateral (painful and injection side) and contralateral masseter and temporalis muscles (Ipsi-MAS, Contra-MAS, Ipsi-TEM, Contra-TEM). Mean values + SEM shown. *Indicates significant difference between conditions (SNK: P < .05); (*)indicates* P = .019.



Figs 3a and 3b Effect of LA on mean prestimulus EMG activity *(left)* in patients with pain and *(right)* in healthy subjects.



Figs 3c and 3d Effect of LA on normalized peak-to-peak amplitude of the reflex response *(left)* in patients with pain and *(right)* in healthy subjects.

Discussion

The main finding in the present study was that injection of LA into painful TMJs reduced pain significantly and was associated with a significant reduction in the amplitude of the stretch reflex in the jaw-closing muscles. There were no such effects of LA injections on the stretch reflex in healthy subjects. Furthermore, no significant side-to-side asymmetries in measures of the jaw-stretch reflex were observed in patients with TMJ pain.

Methodologic Issues

This study involved experiments in which the jaw-stretch stimuli and prestimulus EMG activity in the masseter muscle were all carefully controlled for and standardized. Overall, the net effectiveness of the jaw-stretch stimuli was decreased by the LA injection when the level of muscle excitation was taken into account. We were very careful to ensure that a number of control procedures were incorporated into the experimental design. This included a careful selection of the TMJ pain patients, selecting only women to avoid gender differences in the jaw-stretch reflex.[21] Furthermore, the TMJ pain patients were selected according to the international criteria for disc displacement without reduction and arthralgia.[1] Although it was impossible for us to verify with MRI the exact position of the disc in all patients, the history and clinical examination of the patients strongly suggested a clinical diagnosis of disc displacement and, most important for this study, all patients complained of pain in the TMJ region either at rest or during jaw function.

We also acknowledge that this was an open study that was not controlled for placebo or volume effects. However, the exact same protocol applied to healthy subjects did not change the jaw-stretch reflex, which seems to suggest that placebo or volume effects are unlikely to explain the LA-induced reduction of stretch reflex amplitude in the TMJ pain patients. We could not replicate previous findings of a difference in the amplitude and latency between TMJ pain patients and healthy subjects,[7–9] but the lack of statistical differences could be the result of methodologic issues, eg, lack of statistical power (the low number of participants in each group) or sequence effects (because all the TMJ pain patients were studied before the healthy subjects). Future studies should employ a randomized, placebo-controlled, double-blind design. However, the level of muscle excitation on the painful side was controlled by visual feedback and computer-controlled triggering of the jaw-stretch stimulus. This is important because during isometric contractions, the amplitude of the jaw-stretch reflex is proportional to the prestimulus EMG level.[24,27–29]

In the present study, prestimulus EMG activity in the contralateral masseter (noninjection side) was significantly increased after the LA injection in the TMJ pain group, and a similar trend was observed in the healthy group (Figs 3a and 3b). This phenomenon was also observed at the contralateral masseter muscle in previous studies that used painful injection of hypertonic saline into the masseter in healthy subjects.[16,17,30] Although the mechanisms behind the reduced EMG activity in these 2 different types of pain conditions might not be the same, it can be speculated that when the sensory input is changed on one side, the subject has to adjust the excitatory descending drive, and the predominant bilateral, but not symmetric, voluntary control of the jaw-closing muscles[31,32] would then change the total output of the contralateral muscle to reach the target EMG level in the homonymous muscle. Thus, subtle bilateral differences in prestimulus EMG activity could probably explain the asymmetry in the amplitude of the jaw-stretch reflex in patients with painful TMD conditions when the prestimulus EMG level is not carefully controlled.[7,10,11] In the present study, the peak-to-peak value of the short-latency and biphasic response was considered the reflex amplitude,[11,33] and the normalization of the peak-to-peak amplitude with respect to the prestimulus EMG was performed to exclude the influence of the prestimulus EMG.

TMJ Pain

The pain intensity during maximum clenching and jaw movements, as well as PPTs in the TMJ region before and after LA injections, was recorded to document the effect of the LA (Fig 2, Table 1). Nevertheless, some limitations of this approach also need to be mentioned. We assumed that the injection of LA would have an effect on the afferent inputs from nociceptive endings in the TMJ region; however, mechanoreceptive inputs and motor nerve fibers to the posterior deep temporal nerve, masseteric nerve, or lateral pterygoid nerve might also have been influenced by the injection of LA. However, there were no changes in prestimulus EMG activity for either the ipsilateral masseter or the temporalis (injection side), which suggests that the decrease in jaw-stretch reflex amplitude cannot be explained by a decrease in EMG activity in muscles supplied by the masseteric and deep temporal nerves. Furthermore, we applied the stretch stimulus to the jaw but carried out no experiments to try to resolve whether the reflex effects were solely the result of the activation of jaw muscle spindles or TMJ mechanoreceptors, or whether other mechanoreceptors (eg, periodontal) that might contribute to the jaw-stretch reflex were involved.[34–36] One study reported, for example, that the jaw-stretch reflex amplitude can be influenced by injections of LA into healthy TMJs,[37] although we were unable to replicate this finding in a double-blinded placebo-controlled study with our experimental setup.[26] The lack of LA effect in the healthy group could have been the result of anesthetic failure, but a complete effusion of the LA from the TMJ to the surrounding structures or systematic misplacement of the injection needle in the healthy subjects seems unlikely, since at least part of the intra-articular LA would have remained in the region and we used the same standard injection techniques for TMJs in both groups. Thus, we believe that the present study provides preliminary evidence that the jaw-stretch reflex responses are influenced to a significant extent by nociceptive activity but not by mechanoreceptive inputs from the TMJ region.

The relationship between nociceptive activity and stretch reflex responses is still controversial. A series of animal studies demonstrated that various algogenic substances including hypertonic saline can induce significant changes in muscle spindle afferent activity.[38–40] Thus, the changes in muscle spindle afferent activity could be mediated via fusimotor reflexes. It has also been suggested that hypertonic saline–induced changes in the proprioceptive properties of brain stem neurons are in accordance with the notion that muscle nociceptors acting through interneurons alter fusimotor drive, which in turn alters muscle spindle primary and secondary endings.[41,42] In contrast, but also relevant to the present study, are the consistent facilitatory effects of nociceptive activity from the TMJ region of rats and cats on bilateral EMG activity in the masseter muscle and digastric muscle (which lacks muscle spindles).[43–49] The present finding of a bilateral reduction of the normalized amplitude of the jaw-stretch reflex following LA injection is also in accordance with our previous studies, which have indicated bilateral effects of experimental jaw-muscle pain,[16,17,19,20] although it may be difficult to make direct comparisons between the effect of a clinical TMJ pain condition and an experimental jaw muscle pain condition on the sensitivity of the jaw-stretch reflex.

The present study has shown that the amplitude of the jaw-stretch reflex is significantly reduced after injection of LA into painful TMJs. It is therefore suggested that the sensitivity of the jaw-stretch reflex is influenced by nociceptive activity from the TMJ region. Further controlled studies will be needed to test the implications of such changes in neuromuscular function in patients with painful TMD.

Acknowledgments

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