Pain-Pressure Threshold in Painful Jaw Muscles Following Trigger Point Injection

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Pain and tenderness at trigger points and referral sites may be modified in subjects with myofascial pain in the head and neck region by injecting local anesthetic into active trigger points, but the effect of injection on jaw muscle pain-pressure thresholds has not been measured. The mechanism by which trigger-point injection affects muscle tenderness is also unclear and may be related to the "hyperstimulation analgesia" induced by stimulation of an acupuncture point. A pressure algometer was used before and after an active trigger point injection in the masseter to measure the pain-pressure threshold in the masseter and temporal muscles of 10 subjects with jaw muscle pain of myogenous origin. The pain-pressure threshold in the masseter and temporal muscles was also measured in a matched control group before and after an acupuncture-point injection in the masseter. The pain-pressure threshold was significantly lower in myofascial pain subjects than in control subjects at all recording sites. Pain-pressure thresholds increased minimally in the masseter after trigger-point injection, whereas the temporal region was relatively unaffected. In the control group, the pain-pressure threshold increased significantly at all recording sites in the masseter after acupuncture-point injection. Although local anesthetic injection acts peripherally at the painful site and centrally where pain is sustained, pain-pressure thresholds were not dramatically increased in myofascial pain subjects, in contrast to controls. This suggests that in subjects with myofascial pain, there was continued excitability in peripheral tissues and/or central neural areas which may have contributed to the persistence of jaw muscle tenderness.
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Jaw muscle tenderness is a common clinical finding in patients with craniomandibular dysfunction.[1,2] In cases of myofascial pain, focal areas of muscle tenderness, coined "trigger points" (TPs), have been observed clinically in the masseter and temporal muscles; referred pain associated with active TPs has been mapped to more distant anatomic sites in the craniofacial region.[3,4] Although TPs are palpable as hyperalgesic spots within the muscle, no specific histopathologic, biochemical, or electrophysiologic phenomena have been attributed to them. However, trauma to deep craniofacial tissues appears to be the most likely cause.[5,6]

Diminished pain and tenderness at TPs and referral sites have resulted from injection of local anesthetic (LA) into active TPs, although the reduction in tenderness has not been quantified.[7] The mechanism by which LA injection reduces symptoms at referral sites is also unclear. When LA is injected diagnostically, the blocking effect is presumed to occur at the injection site; however, LA injected peripherally may reach the central nervous system (CNS),

particularly when no vasoconstrictor is used.[8,9] For example, Rowbotham and Fields[10] have described pain relief following intramuscular injections in body regions not anatomically associated with the painful area.

The distribution of TPs correlates spatially with acupuncture points in the limbs and jaws.[11] Stimulation of these sites produces gradients of analgesia.[11,12] Thus it seems possible that LA injection of an acupuncture point in a normal jaw muscle may also generally affect somatosensory thresholds in the jaw muscles because of the LA effect on the CNS or the counterirritation effect of the needle itself.[8,13]

Measurement of the pain-pressure threshold (PPT) with a pressure algometer is commonly used to quantify TP sensitivity in the jaw muscles.[14,15] When variables such as the rate of applied pressure, the size of the algometer recording tip, and the degree of muscle contraction are controlled, the recording technique is sensitive and reliable.[3,15,16,17]

The LA injection of TPs in painful jaw muscles appears to affect the PPT locally and at more distant sites in the jaws.[7] Therefore, for this study, PPTs were measured in different regions of the masseter and temporal muscles before and after the injection of TPs in painful muscles and acupuncture points in normal muscles. The authors postulated that thresholds would increase in painful and normal muscles as a consequence of LA injection and that a similar mechanism may be involved.

Materials and Methods

Twenty female subjects aged 21 to 54 years participated in the study. Subjects were matched for gender and age because PPTs in craniofacial muscles are affected by these variables.[18] Ten subjects were recruited from patients referred to the TMJ/facial pain clinic at the University Hospital, Vancouver, BC, for the diagnosis and management of temporomandibular disorders and craniofacial pain. The subjects were classified as having craniofacial pain of myogenous origin. Diagnostic criteria for subject selection was based on the International Headache Society's Classification of myofascial pain,[19] namely continuous, dull pain in one or more jaw muscles, localized tenderness in firm bands of muscle, and palpation of specific tender areas ("active" TPs) that lead to changes in patterns of pain referral. There was no radiographic evidence of TMJ pathosis in the subjects with muscle pain.

The other 10 "control" subjects were dental hygiene students who had complete natural dentitions and reported no history of jaw dysfunction.

PPT Recording

Each subject was seated in an upright position in a dental chair. The masseter muscle was palpated to determine the anterior and posterior limits of its superficial part. The central point of site M1 was located 10 mm posterior to the anterior border of the muscle and 10 mm superior to the inferior border of the mandible. Site M3 was located 10 mm posterior to the anterior border of the muscle and 10 mm inferior to the lowest point on the zygomatic buttress. Site M2 was located 10 mm posterior to the anterior border of the muscle, equidistant from sites M1 and M3. Site M4 was located 10 mm anterior to the posterior border of the muscle, equidistant from sites M2 and M3. Site M5 was located 10 mm anterior to the posterior border of the muscle, equidistant from sites M1 and M2 (Fig 1).

The anterior temporal muscle was palpated to determine its anterior border. Site T1 was located 10 mm posterior to the anterior border of the muscle and 10 mm superior to the highest point on the zygomatic buttress. Site T2 was located 10 mm posterior to the anterior border of the muscle and 15 mm superior to the central point of site T1. Site T3 was 15 mm superior to site T2. Site T4 was located 10 mm superior to the highest point on the zygomatic buttress and 15 mm posterior to T1. Site T5 was located 15 mm posterior to site T4 (Fig 1).

A pressure algometer with a recording tip 10 mm in diameter (Model PTH-AF2, Pain Diagnostics and Thermography Corp, Great Neck, NY) was used to measure PPTs. The instrument has been described by Reeves et al.[14] Before data were collected, the operator was calibrated using a stopwatch to ensure that a controlled rate of pressure (0.5 kg/cm2/s) was applied perpendicular to the skin overlying the recording sites.[20]

The PPT was determined as the point at which the pressure stimulus applied to the skin changed from a sensation of pressure to pain.[15] Each subject was asked to raise her right hand when the pressure applied to the recording site changed from a sensation of pressure to pain. Then the algometer was removed from the recording site.

The experiment took place in a dental office with only the operator and subject present to minimize distraction from extraneous sources. The subject sat upright in a dental chair with her

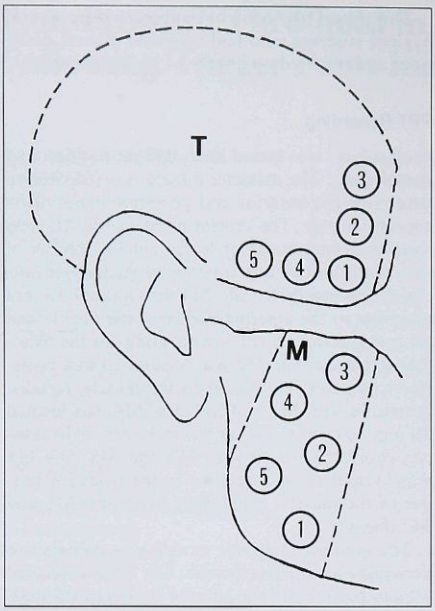

Fig 1 The location of PPT measurement sites in the right masseter (M1 to M5) and temporal (T1 to T5) muscles.

arms resting on her lap. The subject fixed her attention on the test stimulus (algometer), because a change in attention has been shown to modulate cutaneous sensitivity.[21] Pain-pressure thresholds were measured in the right masseter and temporal muscles of control subjects. In myofascial pain subjects, PPTs were measured in the masseter and temporal muscles on the side associated with an active TP. Two PPT measurements were made at each recording site. During PPT measurement, the operator used his or her hand to exert counterpressure on the contralateral side of the subject's head.

The order of measurement of PPT recording sites was randomized.[15] During a rest period of at least 30 seconds between each measurement, the subject relaxed her jaw. All sites were measured with the subject clenching lightly in the intercuspal position (approximately 10% maximum voluntary contraction) because variations in motor activity can affect sensory thresholds.[17,22]

Local Anesthesia

In normal subjects, the acupuncture point "S6" (Jiache) was located in the right masseter.[23] Using anatomic landmarks, the surface marking of the point was located on the skin, 15 mm anterior and superior to the angle of the mandible. The location of the point was then confirmed using an acupuncture point locator (Model 4, Joanco Medical Electronics, North Vancouver, BC).

In subjects with myofascial pain, the masseter muscles were palpated to locate an active TP. The spot was determined on the basis of local and referred symptoms intensifying on firm palpation.[4] Its location was marked on the skin overlying the muscle.

After baseline PPT measurements of both control and pain subjects, 0.5 mL of procaine (1%) LA without vasoconstrictor was injected percutaneously into the designated acupuncture point of control subjects by means of a 25-gauge hypodermic needle and disposable syringe. In the myofascial pain subjects, the active TP was injected using the same protocol. In both groups, the PPT measurement procedure was repeated after 4 minutes.

Data Analysis

Mean PPTs obtained from the two stimulus trials at each recording site, before and after injection, were used for data analysis. A four-factor analysis of variance (ANOVA) was used to compare PPTs from both masseter and temporal muscles before and after injection of LA in an acupuncture or active trigger point. A two-factor ANOVA was then used to compare PPTs by region in each muscle before and after injection of LA in an acupuncture point or active TP. An independent two-sample t test was used to compare PPTs in control and myofascial pain subjects prior to injections. A 5% level of significance was used for all tests. Using confidence intervals, PPT data from control subjects (before injection) were calculated to permit pairwise regional comparisons of PPTs (confidence limits, 95%).

Results

In control subjects, there were regional differences in PPTs in both muscles ($P < .0001$). Before injection, pairwise regional comparisons revealed that thresholds at recording areas M1, M2, and M3; M4 and M5; and T2, T4, and T5 were similar. The magnitude of the PPT measured at each recording site increased after injection of LA in the

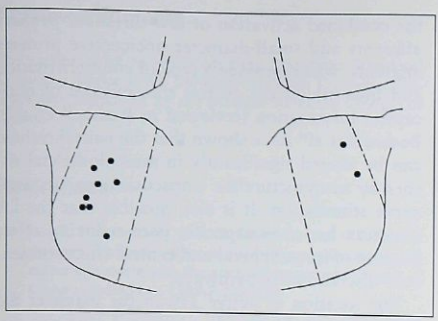

Fig 2 Location of TP injection sites (n = 10) in the masseter muscles of myofascial pain subjects.

acupuncture point, and there were statistically significant differences at all recording sites in the masseter ($P < .001$). Thresholds in the temporal region were consistently higher than in the masseter muscle before and after injection ($P < .0001$). Mean PPT values (kg) measured at recording sites in the right masseter and temporal muscles of control subjects, before and after injection of LA in acupuncture point S6, are shown in Table 1.

PPTs were significantly lower in myofascial pain subjects than controls at all recording sites ($P < .0001$). The magnitude of the PPT measured at each recording site in the masseter increased slightly after LA injection in the TP. However, in the temporal region only the PPT at site T4 increased. There were statistically significant differences between PPTs before and after injection at sites M2 and M3 ($.05 > P > .01$). PPT data from right and left masseter and temporal muscles in myofascial pain subjects, before and after injection of LA in TPs, are shown in Table 2. Data from right and left sides were pooled because PPTs obtained bilaterally in the jaws have been shown to be correlated.[14] The distribution of TP injection sites in the masseter are depicted in Fig 2.

Table 1 Pain-Pressure Threshold (PPT, mean ± 1 SD) in the Right Masseter (M) and Temporal (T) Muscles of Control Subjects (n = 10) Before and After Acupuncture-Point Injection

Recording site	PPT (kg)	
	Before	After
M1	1.8 ± 0.4	2.2 ± 0.3*
M2	1.7 ± 0.4	2.1 ± 0.4*
M3	1.8 ± 0.4	2.2 ± 0.5*
M4	2.1 ± 0.5	2.5 ± 0.5*
M5	2.1 ± 0.5	2.7 ± 0.4*
T1	2.5 ± 0.5	2.6 ± 0.4
T2	2.8 ± 0.6	2.9 ± 0.5
T3	3.2 ± 0.7	3.5 ± 0.8
T4	2.7 ± 0.4	2.9 ± 0.4
T5	2.9 ± 0.5	3.1 ± 0.6

*Statistical test: ANOVA, $P < .001$.

Table 2 Pain-Pressure Threshold (PPT, mean ± 1 SD) in Masseter (M) and Temporal (T) Muscles of Myofascial Pain Subjects Before and After Trigger-Point (TP) Injection

Recording site	PPT (kg)	
	Before	After
M1	0.5 ± 0.2	0.6 ± 0.2
M2	0.4 ± 0.1	0.5 ± 0.2*
M3	0.5 ± 0.2	0.6 ± 0.3*
M4	0.5 ± 0.2	0.7 ± 0.4
M5	0.6 ± 0.2	0.7 ± 0.3
T1	0.7 ± 0.2	0.7 ± 0.3
T2	0.8 ± 0.4	0.8 ± 0.3
T3	0.8 ± 0.2	0.7 ± 0.3
T4	0.7 ± 0.3	0.8 ± 0.3
T5	0.8 ± 0.3	0.8 ± 0.4

*Statistical test: ANOVA, $.05 > P > .01$.

Discussion

PPTs in Painful Muscles

Measurement of the PPT is used as an adjunct in the diagnosis of myogenic pain and to assess the effectiveness of clinical treatments such as passive muscle stretch and intramuscular injections.[1,2] In the present study, the PPTs in subjects with muscle pain were markedly lower than those in normal jaw muscles. Ohrbach and Gale[15] and Reeves et al[14] have described similar findings in subjects with myofascial pain affecting the jaws. The reason for the decrease in pain threshold is still unclear, but when muscles suffer mechanical or chemical trauma, pressure stimuli of innocuous intensity applied over the affected site result in muscle pain.[6,24] The hyperalgesia is thought to be a consequence of sensitization of muscle nociceptors and other low-threshold mechanoreceptive endings so that weak stimuli elicit pain. The sensitization is most likely due to the release of endogenous substances, such as prostaglandin E2 and bradykinin, from damaged tissue. This release lowers the mechanical threshold of nociceptive endings into the innocu-

ous range.[25] Any increase in input from peripheral tissues such as muscles appears to increase the excitability of trigeminal and spinal nociceptive neurons.[6,24] These neurons respond to both deep and cutaneous afferent input. Hu et al[6] have observed that stimulation of rat muscle afferents by the small-fiber irritant mustard oil appears to facilitate cutaneous afferent input to nociceptive brain stem neurons. It also causes an expansion of cutaneous mechanoreceptive fields with the potential effect that a stimulus applied to a hyperalgesic area is likely to result in greater afferent input to the brain stem than a comparable stimulus applied to a normal area. This mechanism may account, at least in part, for the tenderness and pain referral patterns that were associated with the myofascial pain subject group in the present study.

Effect of LA on PPTs

The LA injection of TPs has been cited as a means of reducing muscle tenderness locally and at referral sites.[4,14] A minor increase in the PPT throughout the masseter muscles of myofascial pain subjects after injection was found in the present study, but the PPT was relatively unaffected in the temporal region. There are a number of reasons why there was only a minimal change in the PPT at more distant anatomical sites. Travell and Simons[4] have described how referred pain may, in some instances, become more intense when the TP is penetrated by a needle; during the injection itself, the increase in pain may activate "latent" TPs, resulting in a decrease in the PPT at referral sites. It is also possible, although unlikely, that the TP was missed during injection, leading to a diminished LA effect.[4] Local anesthetic is used to treat muscle pain because of its peripheral action at the painful site and because it can act centrally where the pain is thought to be sustained.[24,26] However, it has been shown in the limbs that LA administered at the injury site does not necessarily decrease the excitability of the spinal cord to preinjury levels.[27] Thus it is possible that in the subjects of the present study, although the local site was blocked, there may have been continued excitability in trigeminal neurons in the brain stem, which led to persistence of the pain.

There was a generalized increase in the PPT after the LA injection of an acupuncture point in the masseter muscles of normal subjects. This was not unexpected because stimulation of acupuncture points by needling can produce sustained changes in pain thresholds.[11] Such "hyperstimulation analgesia" is thought to be a consequence of the combined activation of low-threshold primary afferents and small-diameter nociceptive primary afferents, which provide a type of counterirritation and thus inhibit the central transmission of nociceptive information (reviewed in Bushnell et al[28]). Bushnell et al[28] have shown that the pain threshold can be altered significantly in musculoskeletal tissues by acupuncturelike transcutaneous electrical nerve stimulation. It is also possible that the LA injection had a nonspecific pain-reducing effect because of its peripheral and central effects on sensory-discriminative pathways.[8,25,29]

The location of active TPs in the masseter did not appear to be closely correlated with the disposition of known acupuncture points; however, the sample size was small compared with previous studies.[11,12]

General Observations on PPTs

During isometric exercises such as clenching of the teeth, somatosensory thresholds may be altered if pain is associated with the motor task.[13,28] However, in the current study, control subjects reported no discernible discomfort during light clenching, and myofascial pain subjects reported no additional discomfort as a consequence of the task. Such innocuous conditioning stimuli do not appear to inhibit pain in humans.[13]

Pain-pressure thresholds in the temporal region were higher than in the masseter muscles of normal and painful muscles, irrespective of the anatomic location of the recording site. These findings concur with previous observations in the jaws[15,17] and may be due in part to the different density of connective tissue tendon in the anterior temporal muscle compared with the masseter.[30] In control subjects, there were regional differences in thresholds in both muscles, which has been shown previously by Ohrbach and Gale[15] and McMillan and Lawson,[17] although there was some variation in the distribution of anatomic regions with similar thresholds. In the current study, values for PPTs in the temporal region were similar to those measured by McMillan and Lawson; however, PPTs in the masseter were lower than those measured by McMillan and Lawson.[17] These results may have been due to gender differences in craniofacial muscle PPTs.[3] The PPTs found in the current study were consistently lower than those described by Ohrbach and Gale[15]; although they measured PPTs in both males and females, and it is uncertain whether they controlled the level of muscle contraction during recordings. Both of these variables could account for the differences in PPTs.

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Resumen

El umbral de presión-dolor en los músculos mandibulares dolorosos luego de una inyección en puntos de estimulación

El dolor y la sensibilidad en los puntos de estimulación y en los sitios de referencia pueden ser modificados en las personas con dolor miofacial en la cabeza y la región cervical por medio de la inyección de anestésico local en puntos de estimulación activos, pero no se ha determinado el efecto de tal inyección sobre los umbrales de presión-dolor de los músculos mandibulares. El mecanismo por el cual la inyección en los puntos de estimulación afecta la sensibilidad muscular no está claro y puede ser relacionado a la "analgesia por hiperestimulación," inducida por la estimulación de un punto de acupuntura. Se utilizó un algómetro de presión antes y después de realizar una inyección en un punto de estimulación activo en el masetero para medir el umbral de presión-dolor de tal músculo y de los temporales, en 10 sujetos afectados por dolor muscular mandibular de origen miógeno. El umbral de presión-dolor en el músculo masetero y en los temporales también fue medido en un grupo de control correspondiente, antes y después de la inyección en un punto de acupuntura del masetero. El umbral de presión-dolor fue significativamente menor en el grupo que padecía dolor miofacial que en el grupo de control. En todos los sitios de registro, los umbrales de dolor aumentaron como mínimo en el masetero luego de la inyección en los puntos de estimulación, mientras que la región del temporal no fue afectada relativamente. En el grupo de control, el umbral de presión-dolor aumentó significativamente en todos los sitios de registro después de la inyección en un punto de acupuntura. Aunque la inyección con anestésico local actúa periféricamente en el sitio doloroso y centralmente donde el dolor es alimentado, los umbrales de presión-dolor no fueron aumentados dramáticamente en el grupo experimental en comparación con el grupo de control. Esto indica que en los sujetos con dolor miofacial, existía una excitabilidad continua en los tejidos periféricos y/o en las áreas nerviosas centrales las cuales pueden haber contribuido a la persistencia de la sensibilidad de los músculos mandibulares.

Zusammenfassung

Druckschmerzschwelle schmerzhafter Kiefermuskeln nach Injektion im Triggerpunkt

Schmerz und Empfindlichkeit in Triggerpunkten und Arealen mit übertragenem Schmerz können wohl bei Personen mit myofaszialem Schmerz im Kopf und in der Nackenregion durch Injektion von Lokalanästhetikum in aktive Triggerpunkte gelindert werden, aber die Auswirkung einer Injektion auf die Druckschmerzschwelle der Kaumuskeln ist nicht untersucht worden. Der Mechanismus, durch den eine Triggerpunktinjektion die Empfindlichkeit der Muskulatur beeinflusst, ist unklar und könnte verwandt sein mit der "Hyperstimulations-Analgesie," welche bei Stimulation eines Akupunkturpunkts induziert wird. Die Druckschmerzschwelle der Mm. Masseteren und Temporales von 10 Patienten mit myofaszialen Kaumuskelschmerzen wurde mit einem Druckdolorimeter vor und nach Injektion in einem aktiven Triggerpunkt im M. Masseter gemessen. Die Druckschmerzschwelle in den Mm. Masseteren und Temporales wurde auch in einer parallelisierten Kontrollgruppe vor und nach einer Injektion in einen Akupunkturpunkt im M. Masseter gemessen. Die Druckschmerzschwelle war bei den Patienten mit muskulären Schmerzen signifikant tiefer als bei den Kontrollpersonen. Bei allen Messstellen stiegen die Druckschmerzschwellen im M. Masseter nach Triggerpunktinjektion leicht an, währenddem sich in der Temporalregion kaum eine Auswirkung zeigte. In der Kontrollgruppe stieg die Druckschmerzschwelle signifikant bei allen Messstellen nach einer Akupunkturpunktinjektion. Obwohl eine Injektion von Lokalanästhetikum peripher bei der schmerzhaften Stelle wirkt und zentral, wo der Schmerz erhalten bleibt, wurde bei den Patienten mit myofaszialen Schmerzen im Gegensatz zur Kontrollgruppe keine dramatische Erhöhung der Druckschmerzschwelle erzielt. Dies legt nahe, dass bei Personen mit myofaszialen Schmerzen eine bleibende Erregbarkeit der peripheren Gewebe und/oder der zentralen neuralen Regionen bestenhen bleibt, welche zur bleibenden Empfindlichkeit der Kiefermuskeln beigetragen haben könnte.