Pressure Pain Thresholds in Patients With Craniomandibular Disorders Before and After Treatment With Acupuncture and Occlusal Splint Therapy: A Controlled Clinical Study

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Fifty-five patients (46 women and 9 men) with craniomandibular disorders and a history of pain of at least 6 months' duration participated in this trial. The patients were randomly assigned to three groups: one group to receive acupuncture; one group to receive occlusal splint therapy; and one group to act as controls. Pressure pain threshold, clinical dysfunction score, and visual analog scale measures were used to evaluate patients before, immediately after, and 6 months after treatment. A moderate, but statistically significant, correlation was found between pressure pain threshold and the number of tender spots in the masticatory muscles ($\tau = -.43$; $P < .001$), degree of tenderness in the masticatory muscles ($\tau = -.43$; $P < .001$), clinical dysfunction score ($\tau = .32$; $P < .001$), and the visual analog scale ($\tau = -.25$; $P < .01$). The short-term results showed a statistically significant improvement in all evaluations for both treatment groups. No significant differences were found in the control group. The improvements resulted in significant differences between the control and each treatment group immediately after treatment. At the 6-month follow-up, no significant differences in pressure pain threshold or clinical dysfunction score were found in the two treatment groups compared with the short-term results.
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Clinical studies of patients with craniomandibular disorders (CMD) show that the most commonly recorded clinical signs are pain and tenderness upon palpation in the masticatory muscles.[1–5] Finger palpation has been the most widespread method used to measure the tenderness in the masticatory muscles.[6–8] Studies of interexaminer and intra-examiner variations in the results of palpation of the masticatory muscles and temporomandibular joints (TMJs) have been presented.[9–12] One of the disadvantages with this method is the difficulty in controlling a constant and reproducible pressure on the area being palpated.

Algometers (mechanical pressure devices) have recently been tested and used in an attempt to standardize the palpation procedure.[13,14] Good reliability[14–21] and validity[15,18,20,22] of algometer measurements in the masticatory muscles have been reported. A higher interexaminer reliability was found for the algometer than for manual palpation in determining tenderness at extraoral sites.[20,21] Different trials have been performed to demonstrate the validity of

the algometer. A significant difference in pressure pain threshold (PPT) has been found between patients and healthy volunteers[15,20,22] and between patients and matched controls.[18] A good correlation between finger palpation and PPT has also been shown.[15,22,23] In clinical studies, the algometer has been used to assess pretreatment and posttreatment changes in PPT and in various treatments, such as intramuscular injections,[14,24] physiotherapy,[24-27] and biofeedback.[23]

Previous studies have shown that acupuncture and occlusal splint therapy can reduce chronic pain and symptoms of clinical dysfunction in patients with CMD.[28-31] The variable that was found to improve most significantly clinically was tenderness upon palpation of the masticatory muscles.[30,31] All of these results are based on manual finger palpation. Evaluation of treatment effects by systematic recording of PPT with the aid of an algometer has, to the authors' knowledge, not been carried out before on patients with CMD.

The objectives of the study were to: (1) compare the pretreatment and posttreatment PPTs in patients treated with acupuncture and occlusal splints with a control group receiving no treatment; (2) analyze whether there is a correlation between the PPT and clinical and subjective variables; and (3) determine the PPT in a 6-month follow-up examination for the two treatment groups.

Materials and Methods

Subjects

Fifty-five consecutive patients, 46 women (median age 43 years) and 9 men (median age 37), whose ages ranged between 22 and 69 years, participated in the study. All patients had been referred to the Department of Stomatognathic Physiology at the Institute for Postgraduate Dental Education in Jönköping, Sweden, for treatment of CMD. All patients were examined clinically regarding pain and dysfunction symptoms of the masticatory system, and a comprehensive history was taken before being accepted for the study to obtain a homogenous group. This group of 55 patients was part of a larger group of 110 patients taking part in an extensive study of treatment effects of acupuncture and occlusal splint therapy on CMD symptoms. The main group of 110 patients has been described in detail previously[31] as to sex and age distribution, pain duration, parafunctional habits, etc. All patients participating in the study gave their informed consent and were informed about the project. The ethical principles in the Declaration of Helsinki were followed in the study.

Apparatus

The modified pressure threshold meter (PTM) consists of a rubber tip (Ø = 1 cm^2) attached to a plunger, which is connected to a pressure gauge. The instrument measures the pressure being applied to a certain area of 0 to 11 ± 0.1 kg/cm^2. A stopwatch is connected to the PTM to measure the application rate in hundredths of a second (Fig 1).[32] The timer is started as soon as pressure is applied to the instrument and stops when application of pressure ceases. An estimate of the overall pressure rate can then be determined.

Procedure

The investigation was carried out by two operators: one (MH) performed the screening and the evaluation at the pretreatment and posttreatment occasions; the other (TL) performed the patient treatment. The patients were subsequently randomly assigned to one of three groups: group A (acupuncture, n = 20); group B (occlusal splint therapy, n = 20); or group C (control, with no active treatment, n = 15). The treatment period lasted between 6 and 8 weeks for groups A and B. In a few cases, where there were discrepancies between the clinical readings and the patients' experience of the symptoms, the treatment period was extended 1 to 2 weeks before a decision about whether to change the treatment method was made. In group A, all the patients received six acupuncture treatments, and in six patients up to eight were given. The treatments lasted for approximately 30 minutes each and were given at 1-week intervals. Regionally, as well as nonregionally, localized acupuncture points were stimulated. The regional acupuncture points that were stimulated manually (Ex 2, St 7, St 6, Gb 20) were standardized as much as possible, even though they differed slightly from individual to individual according to where the pain was localized and which points were tender upon palpation. Two nonregional points, one in the hand (Li 4) and the other in the leg (St 36), were stimulated with a low-frequency (2 Hz) current. The patients in group B received occlusal splints constructed to fit in the maxillary arch. Only in one patient, with molar loss in the mandible, was the splint applied to that jaw. The splints were used at night until the

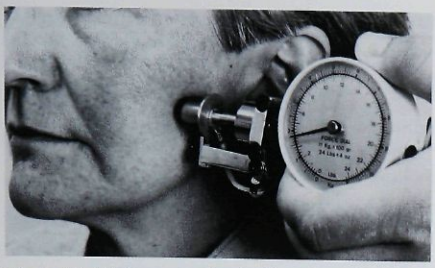

Fig 1 Modified pressure threshold meter applied to the skin at the belly of the masseter muscle.

posttreatment evaluation, approximately 7 to 8 weeks later. At the same time, the patients in group C were on a waiting list for 3 months, during which they registered their pain in pain diaries. At the last treatment session, the patients were evaluated clinically and answered a standardized questionnaire. The patients who responded favorably to occlusal splint therapy were advised to use their splints according to personal need until the 6-month follow-up. The participants from each treatment group who were not satisfied with the treatment outcome were offered additional treatment and transferred to other types of stomatognathic therapies. The remaining patients (n = 23) were followed up 6 months later. For further details concerning the patients and procedures, reference is made to a previous presentation.[31]

Assessment Variables

At the evaluation, several measures were used, including self-administered questionnaires, pain diaries, and clinical examination. For this study, only some of the variables that were considered of special interest in the analysis of the pressure pain threshold were included. All variables have been described earlier in detail.[31]

Pressure Pain Threshold (PPT)

The instrument was applied perpendicularly to the skin, at the belly of the right and left masseter muscles (Fig 1). The examiner strived to apply a gradual increase of pressure of 1 kg/cm²/s. During the palpation, the scale was turned away to avoid bias. The pressure was immediately stopped when the patient reported "tenderness" (a just noticeable amount of pain), ie, the PPT. The pressure rate was controlled so that it would be within the limits for "acceptable reproducibility" (ie, 0.5 kg/cm²/s) established in a previous study.[32]

Clinical Dysfunction Score (CDS)

The patients were clinically examined in a standardized manner[33] that included measurements of the range of movement of the mandible, the function of the TMJ, palpation of the TMJ and the masticatory muscles, and registration of pain on movement of the mandible. From these registrations, the CDS, ranging from 0 to 25 points, was determined.[6]

Tenderness in the Masticatory Muscles

Nine different bilateral sites in the masticatory muscles were evaluated with manual palpation: the anterior and posterior origins of the temporal muscle; the insertion of the temporal muscle; the origin, belly, and insertion of the superficial masseter muscle; the deep portion of the masseter muscle; and the lateral and medial pterygoid muscles. The degree of tenderness was estimated according to a 4-point scale: 0 = no pain; 1 = report of tenderness, but no visible reaction (palpebral reflex); 2 = report of tenderness and a visible reaction (palpebral reflex); and 3 = report of severe pain and a marked visible reaction (palpebral reflex) or "jump sign."

Intensity of Pain (VAS_{index})

Patients were asked to record their pain intensity on a visual analog scale (VAS) consisting of a 100-mm line with end definitions of "no pain" and "worst pain imaginable."[34] Preprinted diaries containing the VAS were given to the patients at the pretreatment examination, with the instructions that registrations of pain were to be made three times daily. The average intensity of pain was then calculated on a weekly basis. Pain diaries in which more than 70% of the required weekly registrations had been completed were taken into account; eight diaries were discarded (two in group B and six in group C).

Statistical Methods

Analysis of variance was used to test the significance of differences among groups when the variable was measured on a ratio scale. If the analysis of variance rejected the multisample hypothesis of equal means, multiple comparison testing using the Neuman-Keuls test was performed.

Table 1 Mean Values and SD for Pain Pressure Threshold

	Acupuncture Group A (n = 20)		Occlusal splint Group B (n = 20)		Control Group C (n = 15)		
	Right Side	Left Side	Right Side	Left Side	Right Side	Left Side	*P*
Before treatment	1.9 ± 0.5	1.8 ± 0.5	1.9 ± 0.6	2.0 ± 0.5	1.8 ± 0.4	1.9 ± 0.6	NS
After treatment	2.2 ± 0.4	2.2 ± 0.6	2.2 ± 0.6	2.1 ± 0.4	1.7 ± 0.5	1.8 ± 0.5	<.05*
P	<.01	<.001	<.01	<.05	NS	NS	

*Groups A and B differ from C for the right and left sides, respectively.
NS = Nonsignificant.

Table 2 Mean Values and SD for Clinical Dysfunction Score

	Acupuncture Group A (n = 20)	Occlusal splint Group B (n = 20)	Control Group C (n = 15)	*P*
Before treatment	9.8 ± 3.6	9.0 ± 2.8	9.5 ± 2.9	NS
After treatment	6.3 ± 3.7	7.0 ± 3.9	8.7 ± 3.5	<.01*
P	<.001	<.01	NS	

*Groups A and B differ from C.
NS = Nonsignificant.

Table 3 Mean Values and SD for Pain Intensity (VAS_{index})

	Acupuncture Group A (n = 20)	Occlusal splint Group B (n = 18)	Control Group C (n = 9)	*P*
Before treatment	1.8 ± 1.1	2.1 ± 1.4	3.0 ± 1.7	NS
After treatment	1.2 ± 0.7	1.5 ± 1.4	2.9 ± 1.9	<.01*
P	<.01	<.05	NS	

*Groups A and B differ from C.
NS = Nonsignificant.

Corresponding methods for variables measured on an ordinal scale were Kruskal-Wallis one-way analysis of variance followed by nonparametric multiple comparison testing. Two related samples have been analyzed using a paired *t* test for variables measured on a ratio scale and the Wilcoxon matched-pairs signed ranks test for ordinal data. Kendall rank correlation (τ) was calculated as a measure of association between two variables. Statistical tests were performed two-tailed and at the 5% significance level.

Results

Effect of Treatments

The effect of the treatments was assessed using PPT, CDS, and VAS. The results were very consistent, irrespective of variable, as shown in Tables 1 through 3. At the baseline examination, there were no significant differences between the three experimental groups.

The treatments resulted in a significant reduction of pain as compared to the control group, which did not change from the baseline during the experimental period. In consequence, the control group differed significantly from the two treatment groups immediately after treatment.

Correlation Analysis

Based on the results obtained immediately after treatment, correlation analyses between the PPT and clinical and subjective variables were performed (Table 4). A significant correlation was found between the PPT and the number of tender spots in the masticatory muscles ($P < .001$), the degree of tenderness upon finger palpation in the masticatory muscles ($P < .001$), the CDS ($P < .001$), and the VAS_{index} ($P < .01$).

Table 4 Correlation Between PPT and Clinical and Subjective Variables

Variable	τ	*P*
No. of tender spots in the masticatory muscles	−0.43	<.001
Degree of tender spots in the masticatory muscles	−0.45	<.001
Clinical dysfunction index (CDS)	−0.32	<.001
Pain intensity (VAS_{index})	−0.25	<.01

Six-Month Follow-Up

Only those patients who received just one form of treatment in groups A and B were evaluated at the 6-month follow-up (n = 28). From group A, six patients were transferred to additional treatment groups immediately after the posttreatment evaluation and the remaining 14 were followed up 6 months posttreatment. From group B, four patients were transferred to additional treatment groups immediately after the posttreatment evaluation; one patient dropped out, since she was not interested in being transferred; and one patient was not able to be examined, since he was working abroad.

Table 5 shows the results of the PPT values. Before treatment, no significant difference was found between the groups, but immediately after treatment, a significant reduction was found in both treatment groups. This obtained reduction did not significantly differ from the results found at the 6-month follow-up.

The results of the CDS are shown in Table 6. A significant reduction was found in both treatment groups immediately after treatment. A further nonsignificant reduction was noted at the 6-month follow-up in both groups.

Discussion

The results of this study showed that the PPT in the belly of the masseter muscle was significantly reduced immediately after treatment in both treatment groups when compared with the control group. Previous studies have shown the algometer to have good reliability[14–21] and validity.[15,18,20,22] The results of this study show that the method is sensitive enough to detect pretreatment and posttreatment changes in the PPT following acupuncture and occlusal splint therapy.

Table 5 Mean Values and SD for PPT of Patients Remaining at the 6-Month Follow-Up

	Acupuncture group (n = 14)			Occlusal splint group (n = 14)		
	Right Side	Left Side	*P*	Right Side	Left Side	*P*
Mean before treatment	1.8 ± 0.5	1.8 ± 0.4	<.05	1.8 ± 0.6	1.8 ± 0.4	<.05
Mean after treatment	2.2 ± 0.5	2.1 ± 0.5	NS	2.1 ± 0.6	2.1 ± 0.4	NS
Mean at follow-up	2.3 ± 0.5	2.3 ± 0.5		2.2 ± 0.6	2.2 ± 0.5	

NS = Nonsignificant.

Table 6 Mean Values and SD for CDS of Patients Remaining at the 6-Month Follow-Up

	Acupuncture group (n = 14)	*P*	Occlusal splint group (n = 14)	*P*
Mean before treatment	10.2 ± 3.9	<.01	8.6 ± 3.0	<.01
Mean after treatment	6.4 ± 4.3	NS*	6.4 ± 3.6	NS*
Mean at follow-up	5.9 ± 4.4		4.6 ± 2.8	

The reason for only registering the belly of the superficial masseter muscle was based on the results of a previous study,[15] which indicated that this part of the muscle seems to be the most sensitive predictor of tenderness of all muscles recorded. Similar results were found in another study, where the superficial masseter muscle was found to be the one best expressing the probability of TMJ disorders as a function of the PPT.[21] Furthermore, a good correlation has been found between finger palpation and PPT in the belly of the masseter muscle.[15]

The results of the PPT measurements were in agreement with the results of the pain intensity recordings (VAS_{index}) and the CDS, in which a significant reduction was also found in both treatment groups but not in the control group. This agrees with the results of another study comparing the effect of acupuncture and occlusal splint therapy after 3 months.[30] In a study of patients with tension headache, the intensity of pain was reduced significantly in the physiotherapy group according to both verbal pain rating scale and VAS. In the

acupuncture group, the intensity of pain was reduced according to the verbal rating scale but, surprisingly, not according to the VAS.[35] The difference between that study and the present one is most probably due to one or more differences in the composition of the material, methods used, signs and severity of symptoms of the patients, treatment procedures, and assessment variables.

The skewed gender distribution of the control group as compared with the experimental group has been discussed in detail in a previous study.[31] A few studies have found a significantly higher PPT in men than in women.[13,18,20,36] In the present study, higher PPT values were found in men than in women at the baseline examination (right/left side: 2.1/2.2 and 1.8/1.8, respectively). However, the differences are not statistically significant because of insufficient power in the statistical analysis, as only nine men participated in the study. Regarding the pretreatment and posttreatment changes in the PPT, there were no significant differences, or even tendencies, found between sexes. The between-session reliability, measured over several weeks, has been found to be lower for patients[14,18] than for comparable nonpatients.[17,36] This fact might reflect the natural fluctuation in symptoms among patients.[8] In the present study, this individual instability did not influence the mean PPT value in the control group, where an insignificant change was found between two measurements 3 months apart.

A reduced tenderness in the masticatory muscles has been reported following stomatognathic treatments[3,5] and acupuncture.[30,31] In a study of patients with tension headache, a significant reduction of muscle tenderness was reported after physiotherapy and acupuncture.[35] In another study, it was found that the largest analgesic effect of acupuncture was found in the segments where the needle stimulation was carried out.[37] The analgesic action is probably both at the entry region in the central nervous system[38] and at the supraspinal level, where it includes the release of endogenous opioids and other neuromodulatory substances.[39,40] Furthermore, some authors have pointed out that relief of ischemic pain may be due to inhibition of sympathetic vasoconstrictor activity.[41–43] In the region of acupuncture, increased circulation could be induced also by antidromic stimulation of thin afferent fibers containing substance P (SP) and calcitonin gene-related peptide.[44,45]

A significant correlation between severity of symptoms and tenderness in the masticatory muscles has been reported among CMD patients.[5] An inverse correlation has been found between manual palpation of pericranial tenderness and PPT.[22] This coincides with the results of our study, where a moderate, though statistically significant, correlation was found between PPT and both the total number of tender spots and the degree of tenderness in the masticatory muscles. Earlier studies have found a high correlation between muscle tenderness and the clinical dysfunction index.[2,3,5] This agrees with our results, where a significant correlation was found between CDS and the PPT value.

In a study of patients with tension headache, a significant correlation of the average tenderness of palpated muscles and pain intensity was found.[35] Similar results were also found in another study with tension-type headache patients, in which a correlation was shown between the PPT and the headache severity.[22] In the same study, it was found that the PPT in the temporal region correlated better to the subjective severity of the headache than did the PPT from occipital tender points, indicating that the relationship between headache and tenderness is not simple.[22] Also in our study, a weak but statistically significant correlation was found between the PPT and the pain intensity, indicating that the PPT measurement seems to reflect the subjective experience of pain fairly well. There are, however, some reports where no correlation has been found between these parameters.[23,25] The pain intensity is a sensory and emotional experience that can vary subjectively a great deal. This might be the reason why this variable showed the lowest correlation value among those recorded.

Twenty-eight of the patients were followed up at 6 months. The mean value of the PPT was found to be slightly increased for both groups, which also was reflected in the CDS. Although not reaching a statistically significant level, the CDS decreased more in the occlusal splint group than in the acupuncture group. This indicates that occlusal splint therapy needs more time than acupuncture to give measurable clinical effects. Both groups seemed to have responded similarly well to the treatment at the 6-month follow-up.

This study shows that measuring PPT with the aid of an algometer is a valuable complement to traditional clinical methods of recording tenderness in the masticatory muscles. It is, however, important to point out disadvantages as well as advantages with the method. Major benefits with the instrument are that it is possible to measure the applied pressure more precisely and determine the tenderness on a ratio scale, which has several statistical advantages. The method is more objective, since it eliminates some of the bias related to finger

palpation. Although it is important how the pressure is applied to the muscle, the handling of the instrument is fairly simple to learn when compared to the long clinical experience needed to master manual finger palpation. One disadvantage with the present technique is that it is only possible to measure extraoral sites quantitatively. Qualitative variables such as volume and consistency of the muscles are not possible to determine. The measurement of the PPT is primarily dependent on the patient's subjective experience and verbal response during examination. To receive reliable data, it seems to be important to carefully instruct the patient about the procedure before the actual measurement. If this is done, the instrument can be recommended for evaluation of the PPT in clinical studies.

Conclusion

Acupuncture and occlusal splint therapy have a significant effect in increasing the pressure pain threshold, and reducing the clinical dysfunction score and pain intensity in patients with CMD. A moderate but statistically significant correlation was found between the PPT and clinical and subjective variables.

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Resumen

Umbrales de Dolor en Pacientes con Desórdenes Craneomandibulares Antes y Después del Tratamiento con Acupuntura y Terapia con Férulas Oclusales

En este estudio participaron 55 pacientes (46 mujeres y 9 hombres) que sufrían de desórdenes craneomandibulares y que habían tenido dolor por 6 meses. Los pacientes fueron asignados al azar, a uno de los siguientes tres grupos de tratamiento: 20 (acupuntura), 20 (férulas oclusales) y 15 (controles). Se determinó el umbral del dolor a la presión, el puntaje asignado a la disfunción clínica, y las medidas de la escala análoga visual; para evaluar a los pacientes antes, inmediatamente después y 6 meses después de tratamiento. Se encontró una correlación moderada, pero estadísticamente significativa, entre las medidas del umbral del dolor a la presión y el número de sitios dolorosos en los músculos masticatorios, el grado de sensibilidad de los músculos masticatorios, el puntaje asignado a la disfunción clínica y la escala análoga visual. Los resultados a corto plazo demostraron que existía una mejoría estadísticamente significativa en todas las evaluaciones de ambos grupos de tratamiento. No se encontraron diferencias significativas en el grupo de control. Las mejorías dieron lugar a diferencias significativas entre el grupo de control y cada uno de los grupos de tratamiento inmediatamente después del tratamiento. En la visita de control realizada a los 6 meses, no se encontraron diferencias significativas en el umbral del dolor a la presión o en los puntajes de disfunción clínica, en el caso de los dos grupos de tratamiento; en comparación a los resultados a corto plazo.

Zusammenfassung

Druckschmerz-Schwellenwerte bei Patienten mit Myoarthropathien des Kausystems vor und nach Akupunktur und Schienenbehandlung

Fünfundfünfzig Patienten (46 Frauen und 9 Männer) mit Myoarthropathien des Kausystems und mit Beschwerden seit mindestens sechs Monaten wurden in die Untersuchung einbezogen. Die Patienten wurden zufällig einer von 3 Gruppen zugeordnet: 20 erhielten Akupunktur, 20 eine okklusale Schienenbehandlung und 15 figurierten in der Kontrollgruppe. Die Untersuchungen wurden vor Beginn der Behandlung, unmittelbar und sechs Monate danach durchgeführt und umfassten die folgenden Parameter: Druckschmerz-Schwellenwert (PPT), klinischer Dysfunktionsindex (CDS) und Ermitteln der Schmerzintensität durch Visual Analogue Scale (VAS). Eine schwache, aber statistisch signifikante Korrelation konnte zwischen PPT und der Anzahl druckempfindlicher Stellen im Muskel ($\tau = -0.43$; $P < .001$), dem Grad der Druckschmerzhaftigkeit der Kaumuskulatur ($\tau = -0.43$; $P < .001$), den CDS-Werten ($\tau = -0.32$; $P < .001$) und VAS-Werten ($\tau = -0.25$; $P < .01$). Die Kurzzeitresultate zeigten eine statistisch signifikante Verbesserung der PPT-, CDS- und VAS-Werte innerhalb beider behandelten Gruppen, nicht jedoch innerhalb der Kontrollgruppe. Die Verbesserungen führten zu signifikanten Unterschieden in den gemessenen Werten zwischen der Kontrollgruppe und den behandelten Gruppen unmittelbar nach Abschluss der Behandlung. Sechs Monate danach wurden innerhalb der behandelten Gruppen keine signifikanten Unterschiede in PPT-resp. CDS-Werten gefunden verglichen mit den Resultaten unmittelbar nach Behandlungsabschluss.