# Pressure Pain Thresholds in the Craniofacial Region of Female Patients with Rheumatoid Arthritis

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***Aims:*** *To determine the temporomandibular joint (TMJ) pressure pain threshold (PPT) in female patients with rheumatoid arthritis (RA) and TMJ involvement in comparison with healthy females, in order to determine its clinical usefulness for local pain assessment.* ***Methods:*** *Forty-two female patients with the diagnosis of RA, 17 of them positive and 25 negative for rheumatoid factor were investigated, as well as 17 healthy females. A pressure algometer was used to assess the PPT over the TMJ and (as a reference) the center of the glabella. The mean of the second and third TMJ PPT was used in the analysis, and the ratio between the TMJ PPT and the PPT of the reference site (PPT ratio) was calculated. Temporomandibular joint resting pain and pain upon maximum voluntary mouth opening was assessed by a visual analog scale on each side.* ***Results:*** *The TMJ PPT (median/10th to 90th percentile) and PPT ratio were significantly lower in the RA patients (148/64 to 220 and 0.63/0.40 to 1.01, respectively) than in the healthy individuals (217/111 to 352 and 0.85/0.51 to 1.25), but the overlap was considerable.* ***Conclusion:*** *This study shows that the PPT of the TMJ in RA patients is lower than in healthy individuals and that it can be used for pain assessment. However, the clinical use of the TMJ PPT and PPT ratio measurements alone is limited from a diagnostic point of view.* J OROFAC PAIN 2003;17:326–332.

**Key words:** pain, pain threshold, pressure, rheumatoid arthritis, temporomandibular joint

Pressure algometry is one approach to assessing the magnitude of pressure pain sensitivity in patients with rheumatoid arthritis (RA). The pressure pain threshold (PPT) can be assessed with an electronic pressure algometer for which the reliability as well as the intra- and interoperator variability have been investigated and reported to be acceptable.[1–3] Fredriksson et al[4] introduced the use of a relative value of PPT, ie, a ratio between the absolute PPT values over the temporomandibular joint (TMJ) and that of a reference site. This ratio was tested as an alternative to the absolute PPT, with emphasis on comparison between individuals and groups of individuals as well as longitudinal changes. The previous study investigated the use of the PPT ratio in healthy individuals, but the use of PPT ratio has not been investigated in patients.

Rheumatoid arthritis is a chronic inflammatory disease that frequently affects the TMJ.[5,6] In order to assess the degree of pain and the pressure pain sensitivity over the TMJ, assessments of the pain intensity by visual analog scales (VASs), tenderness to digital palpation, and pain provocation by mandibular movement are frequently used. So far, no study regarding PPT over the TMJ or the

**Table 1** Profile of the 42 Female Patients With Seropositive or Seronegative Rheumatoid Arthritis and 17 Healthy Females Who Participated in the Study

| | Seropositive | | Seronegative | | All patients | | Healthy females | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Age (y) | 52 | 13 | 44 | 14 | 47 | 14 | 39 | 13 |
| Duration of general involvement (y) | 12 | 9 | 13 | 10 | 14 | 9 | NA | NA |
| Duration of TMJ involvement (y) | 6 | 6 | 5 | 6 | 7 | 5 | NA | NA |
| No. of involved joints | 5 | 2 | 4 | 2 | 4 | 2 | NA | NA |
| Erythrocyte sedimentation rate (mm/h) | 30 | 14 | 22 | 21 | 25 | 19 | NA | NA |
| Thrombocyte particle concentration ($\times 10^9$/mL) | 366 | 36 | 297 | 151 | 322 | 126 | NA | NA |
| | Median | IQR | Median | IQR | Median | IQR | Median | IQR |
| C-reactive protein (mg/L) | 3 | 9 | 3 | 8 | 0 | 13 | NA | NA |
| | % | | % | | % | | | |
| Erythrocyte sedimentation > 28 (normal rate ≤ 28) | 24 | | 19 | | 31 | | | |
| C-reactive protein > 10 (normal rate ≤ 10) | 43 | | 20 | | 34 | | | |
| Thrombocyte particle concentration > 400 (normal range 150–400) | 18 | | 16 | | 17 | | | |

NA = not applicable; SD = standard deviation; IQR = interquartile range (25th to 75th percentile).

relationship between PPT and other pain parameters has been performed on RA patients with TMJ involvement. The aim was therefore to determine the TMJ PPT in RA patients with TMJ involvement in comparison with healthy individuals, in order to assess its clinical usefulness for local pain assessment.

## Materials and Methods

### Patients

This study was approved by the local Ethical Committee at Huddinge Hospital, Huddinge, Sweden (364/02). Forty-two female patients with a diagnosis of RA according to the American College of Rheumatology criteria,[7] 17 of them positive and 25 negative for rheumatoid factor in the serum, participated in this study (Table 1). Further inclusion criteria were pain for more than 6 months and tenderness to digital palpation of the TMJ. The patients had not been subjected to any treatment of the TMJ within the last 3 months. All patients were referred to the Department of Clinical Oral Physiology, Institute of Odontology, Karolinska Institute in Huddinge, Sweden by rheumatologists or general medical practitioners.

### Healthy Females

Seventeen healthy females participated (Table 1). Inclusion criteria were no current or prior (within the last 6 months) general or local joint muscle symptoms and no current headache. The subjects were not age-matched to the patients, since no correlation was previously found between PPT and age.[4]

### Pressure Pain Algometric Recordings

The PPT test site of the TMJ was defined as the palpable lateral pole of the TMJ condyle with the subject's mouth closed. The reference site was defined as the center of the glabella on the frontal bone.

The absolute PPT was defined as the minimum pressure needed to evoke a painful sensation recognizable by the subjects. The relative PPT was defined as the ratio between the absolute PPT of the TMJ and the absolute PPT of the reference site. The PPT was assessed by a hand-held electronic pressure algometer (Somedic Production) consisting of a pressure transducer probe connected to a pistol-grip with a display unit. The tip of the pressure transducer has a flat, circular rubber tip with an area of 1.0 $cm^2$. Increasing pressure was applied at a constant rate (50 kPa/s) until the subject responded to the first pain sensation by pressing a button on a device connected to the probe that froze the current PPT level on the display. The PPT was measured consecutively 3 times at both sites, and the mean of the second and third measurement was used in the statistical analyses.[4,8,9] The PPT over the TMJ was measured on both sides in the patients; since there is no evidence of a significant difference in PPTs between right and left TMJs in

healthy females,[2,3] only the PPT of the right side was measured in the healthy females.

### Pain Intensity Ratings

A 100-mm VAS with endpoints denoted by "no pain" (0 mm) and "worst pain ever experienced" (100 mm) was used to assess the ongoing pain intensity in the TMJ at rest.

### Clinical Signs

The tenderness to digital palpation of the lateral and posterior aspects of the TMJ was assessed on each side. On each side and aspect, 1 unit was scored if the patient reported tenderness and 2 units if the palpation caused a pain response, ie, a blink or a defense reaction (maximum score per joint = 4).

The number of painful mandibular movements in the TMJ, including maximum mouth opening, laterotrusion to both sides, and protrusion, was counted for each side (score 0 to 4). The pain intensity in the TMJ upon maximum voluntary mouth opening was assessed with the VAS.

### More and Less Painful Side

In the patients, the more painful TMJ was determined by assessing the number of painful mandibular movements on each side. If the number of movements was equal, the pain intensity at rest (based on the VAS score) was used to separate the more painful side from the less painful side.

### Blood Sampling

Venous blood was collected and used for determination of erythrocyte sedimentation rate (mm/h), serum concentration of C-reactive protein (mg/L), and thrombocyte particle concentration ($\times 10^9$/mL) in order to estimate the disease activity.

### Statistical Analyses

The ratio between the PPT of the TMJ and the PPT of the reference site was used to account for individual differences in general nonarticular pressure pain sensitivity. The central tendency and the variation of the variables are given as the mean and standard deviation (SD) when the variables are normally distributed and as the median and interquartile range (IQR; 25th to 75th percentile) when they are not. The significance of the differences in PPT between the 3 consecutive recordings was analyzed with the Friedman repeated measures analysis of variance on ranks. A pair-wise multiple comparison procedure Dunnett test was used post hoc. The difference in PPT between the more painful side and the less painful side was analyzed with the Wilcoxon signed rank test and the difference between RA patients and healthy females was analyzed with the Mann-Whitney U test. Correlations were analyzed with the Spearman's rank correlation test. The error of measurement of the PPT was estimated as the SD of a single measurement ($s = [\sum d_i^2/2n]^{1/2}$) and the coefficient of variation in percent ($CV = [s \times 100]/mean$). A probability level below .05 was considered as significant ($P < .05$).

## Results

### Pressure Pain Threshold Over the TMJ and the Glabella Reference Site

The PPT at the glabella reference site in the RA patients differed between measurements ($P = .008$), and the first measurement was found to be significantly higher than the third ($P < .05$). The reference site PPT in the healthy females also differed between measurements ($P < .001$), and the first measurement was higher than the second and third ($P < .05$). There was no difference between measurements for the TMJ PPT in the RA patients or in the healthy females.

The PPT of the TMJ and the reference point as well as the PPT ratio are shown in Table 2. The PPT of the TMJ of the more painful side in the patients was lower than the PPT of the healthy females ($P = .006$). The 10th to 90th percentile interval of the TMJ PPT was 64 to 220 kPa on the more painful side in the patients and 111 to 352 kPa in the healthy females. The PPT on the more painful side was within the 10th to 90th percentile interval of the healthy females for 28 out of the 42 patients (67%), while 13 (31%) were below the 10th percentile, and 1 (2%) was above the 90th percentile of the healthy individuals (Fig 1).

The TMJ PPT and the PPT ratio on the more painful side were lower than those on the less painful side in the RA patients ($P < .001$ for both). The TMJ PPT on the more painful side also was lower in the RA patients than in the healthy females ($P = .006$). The reference site PPT in the RA patients did not differ from that in the healthy individuals, but the PPT ratio in the RA patients was lower than in the healthy females ($P = .011$).

The reference site PPT was positively correlated to TMJ PPT on both the more painful side ($r_s = 0.66$, $n = 42$, $P < .001$, Fig 2) and the less painful

**Table 2** Mean of the Second and Third Pressure Pain Threshold Values of the Temporomandibular Joint and Reference Site (Glabella) in kPa as Well as the Ratio Between These Variables in 42 Females with Rheumatoid Arthritis and 17 Healthy Females

| | More painful side | | | Less painful side | | | Healthy females | | |
|---|---|---|---|---|---|---|---|---|---|
| | IQR | Median | 10/90 | IQR | Median | 10/90 | IQR | Median | 10/90 |
| Temporomandibular joint | 86 | 148 | 64/220 | 109 | 159 | 98/277 | 132 | 217 | 111/352 |
| Reference site | 122 | 229 | 112/345 | | | | 191 | 278 | 135/418 |
| Ratio | 0.33 | 0.63 | 0.40/1.01 | 0.33 | 0.78 | 0.48/1.40 | 0.35 | 0.85 | 0.51/1.25 |

IQR = interquartile range (25th to 75th percentile); 10/90 = 10th to 90th percentile.

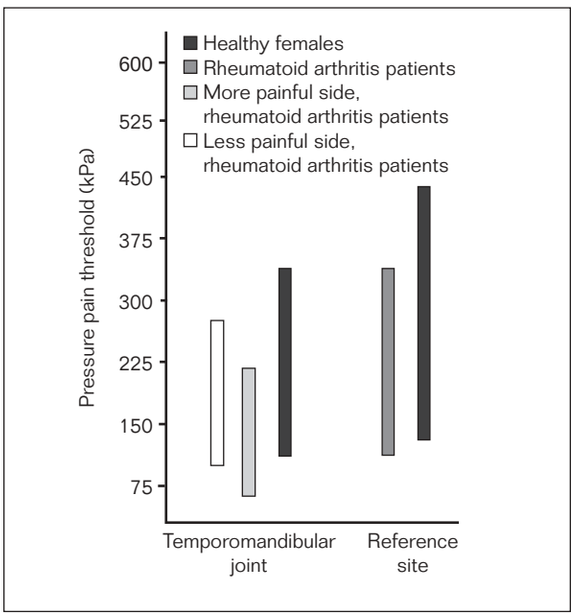


**Fig 1** The 10th to 90th percentile interval of the mean of the second and third pressure pain threshold measurement over the reference site (glabella) and the temporomandibular joint in 42 female patients with rheumatoid arthritis and in 17 healthy females.

side ($r_s$ = 0.59, n = 42, $P < .001$). It had a 10th to 90th percentile interval of 112 to 345 kPa in the patients and 135 to 418 kPa in the healthy individuals. Eight of the patients (19%) had a reference site PPT below 135 (Fig 1), ie, below the 10th percentile for the healthy females. No significant correlations were found between PPT and age in any of the groups. There were no significant differences between the seropositive and seronegative patients regarding PPT.

### Pressure Pain Threshold in Relation to Other Clinical Characteristics

The reference site PPT was negatively correlated to ongoing pain in the TMJ at rest in the RA patients ($r_s$ = –0.30, n = 42, $P$ = .049). The TMJ PPT and reference site PPT were negatively correlated to pain upon maximum mouth opening ($r_s$ = –0.34, n = 42, $P$ = .026; and $r_s$ = –0.39, n = 42, $P$ = .011, respectively) (Fig 3). No significant correlations were found between PPT and erythrocyte sedimentation rate, serum concentration of C-reactive protein, or thrombocyte particle concentration in the patients. The ongoing pain intensity in the TMJ at rest in the RA patients was higher on the more painful side (median VAS = 39) than on the less painful side (median VAS = 12; $P < .001$).

### Reproducibility of PPT Measurement

The reproducibility of the PPT measurements is shown in Tables 3a and 3b and Fig 4. Measurement of the TMJ PPT in the healthy females had the lowest coefficient of variation (11%), whereas measurement of the reference site PPT in the healthy females had the highest coefficient (23%).

## Discussion

This study has shown that the absolute and relative PPT for the TMJ in RA patients is lower than in healthy females, although there is considerable overlap of the distributions. There does not seem to be any difference between seropositive and seronegative RA for absolute or relative PPT. A low PPT was associated with a high degree of TMJ pain, which indicates validity for the PPT as an assessment of pain. The reproducibility of the absolute PPT measurements could be considered acceptable, whereas it was poor for the relative PPT. The clinical diagnostic usefulness of these variables must, however, be considered to be limited, at least when it is not used together with other clinical parameters.

The measurement of PPT with an electronic pressure algometer was introduced as an alternative to digital palpation and is assumed to be an estimate of hyperalgesia/allodynia. Although there

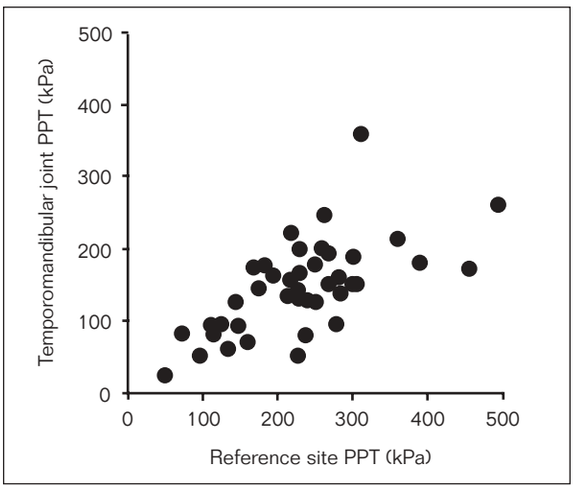


**Fig 2** Relation between pressure pain threshold over the reference site (glabella) and the temporomandibular joint on the more painful side in 42 female patients with rheumatoid arthritis ($r_s$ = 0.66, n = 42, $P < .001$).

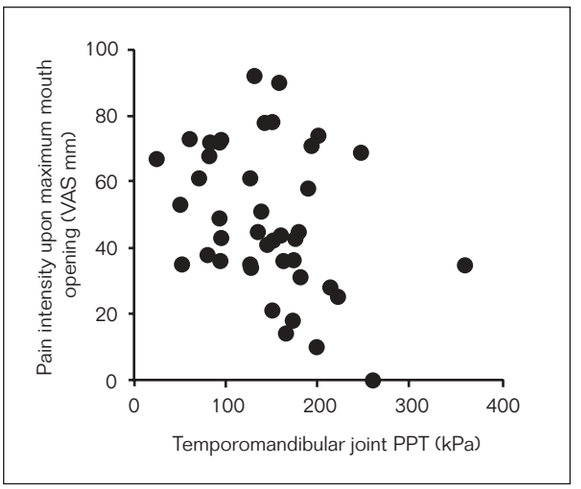


**Fig 3** Relation between pain upon maximum mouth opening (VAS score) and the pressure pain threshold over the temporomandibular joint in 42 female patients with rheumatoid arthritis ($r_s$ = –0.34, n = 42, $P$ = .026).

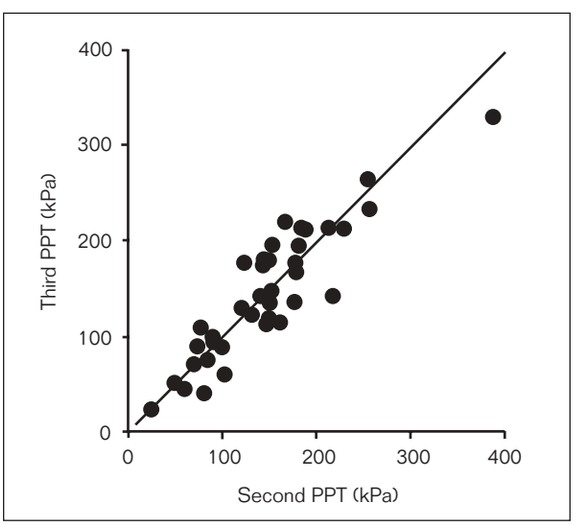


**Fig 4** Relation between the second and the third pressure pain threshold values over the temporomandibular joint on the more painful side in 42 female patients with rheumatoid arthritis ($r_s$ = 0.87, n = 42, $P < .001$). Error of measurement expressed as the standard deviation of a single measurement = 20 kPa and coefficient of variation = 14%.

**Table 3a** Reproducibility of the Mean of the Second and Third Pressure Pain Threshold Measured Over the Temporomandibular Joint and Reference Site (Glabella) in kPa as Well as the Ratio Between These Variables in 42 Females with Rheumatoid Arthritis

| | Mean | s | CV |
|---|---|---|---|
| Temporomandibular joint | | | |
| More painful side | 146 | 20 | 14 |
| Less painful side | 177 | 27 | 15 |
| Reference site | 228 | 32 | 14 |
| Ratio | | | |
| More painful side | 0.67 | 0.14 | 21 |
| Less painful side | 0.82 | 0.17 | 20 |

s = standard deviation of a single measurement; CV = coefficient of variation in percent (100 × s/mean).

**Table 3b** Reproducibility of the Mean of the Second and Third Pressure Pain Threshold Measured Over the Temporomandibular Joint and Reference Site (Glabella) in kPa as Well as the Ratio Between These Variables in 17 Healthy Females

| | Mean | s | CV |
|---|---|---|---|
| Temporomandibular joint | | | |
| Right joint | 213 | 24 | 11 |
| Reference site | 263 | 62 | 23 |
| Ratio | | | |
| Right joint | 0.86 | 0.19 | 22 |

s = standard deviation of a single measurement; CV = coefficient of variation in percent (100 × s/mean).

have been studies assessing PPT over inflamed and non-inflamed tissues in patients with RA, none to our knowledge has studied the PPT over the TMJ. Gerecz-Simon et al[10] and Dhondt et al[11] showed that RA patients compared to healthy females had a decreased PPT on the forehead, the upper and lower extremities, certain spinal processes, as well as over the ankle and knee joint. Leffler et al[12] showed that RA patients had a decreased PPT overlying painful and inflamed joints. In the present study, the TMJ PPT in the RA patients was significantly lower than in the healthy individuals, but the high degree of overlap between the patients and the healthy individuals limits the diagnostic utility of this parameter. A PPT value below approximately 111 kPa might be considered to be in the abnormal range irrespective of the kind of pathology that the pain or hyperalgesia is base upon. However, if such a threshold is to be used in a future study, the PPT value first has to be validated for each operator since this value most probably will vary considerably between operators.

Huskisson and Hart[13] found that RA patients with a lower PPT had more severe pain during a greater part of the day than patients with a higher PPT and that they required more analgesics for pain relief. This is supported by the findings in this study, where a lower TMJ PPT was associated with a higher degree of TMJ pain, which also indicates that PPT can be used as an adjunct for estimation of local pain.

There was no difference between the RA patients and the healthy females for the PPT of the glabella reference site. This finding indicates that no generalized increased pressure pain sensitivity was present in our patient sample. On the other hand, there was a significant and positive correlation between PPT of the TMJ and the reference site in the RA patients, which indicates that patients with a low TMJ PPT may have an increased pressure pain sensitivity. An explanation for the lack of difference between patients and healthy individuals could be that the average disease activity of RA in this study was low. Rheumatoid arthritis patients with a long duration of disease, as in this study, may have a central hyperexcitability beyond the primarily affected spinal cord or brainstem segments due to a long-lasting nociceptive bombardment from inflamed joints, which may cause a lowered PPT in nonarticular regions.[14–16] This may also occur within the trigeminal system on the brainstem level by involvement of the ophthalmic division of the trigeminal nerve.[16]

The first reference site PPT measurement was significantly higher than the subsequent recordings in the RA patients as well as in the healthy females. Several authors have found that healthy individuals generally present a higher PPT at the first recording than the subsequent recordings[4,8,9] and have recommended that the first recording be discarded. The mean of the second and third measurement was therefore used in this study. The reason why the first PPT recording in the healthy females was higher than the subsequent recording could be that the healthy subjects were not accustomed to the method and therefore did not recognize the PPT accurately at the first recording. Since PPT can be influenced by several factors, eg, noise or anxiety as well as the concentration and the reaction time of the subjects, the stimulus rate and the size of the contact area, it is important to explain the procedure to the subjects carefully and to perform the procedure in an appropriate environment.[10,17] These considerations were accounted for in this study. The reason why the RA patients did not present a higher PPT value over the TMJ at the first recording may be due to pain or inflammation of the joint, causing a more distinct response. The reason why the first and subsequent PPT measurements over the TMJ did not differ in the healthy individuals is probably due to the fact that the procedure was tested on the left side before the PPT assessment was made on the right side.

To test the validity of TMJ PPT as a measure of local pain in RA patients, the more and less painful sides were compared. The TMJ PPT showed lower values on the more painful side, which indicates that PPT measurement is valid for estimation of the degree of pain in TMJ involvement of RA. This is supported by our finding that the ongoing pain intensity at rest in the TMJ in the RA patients was also significantly higher on the more painful side.

There was no difference between seropositive and seronegative patients for PPT; this was not unexpected, since pain could be of the same intensity in the 2 conditions despite their having a different pathophysiology.[18]

The reproducibility of the TMJ and reference site PPT based on the coefficient of variation varied between 11% and 15%, except for the reference site in the healthy females, where it was 23%. The former values could be considered acceptable for this kind of measurement and are similar to those of other clinical parameters.[19] The error of the PPT ratio was higher (20% to 22%) and thus seems to be less reliable. The reproducibility of the PPT ratio is not only dependent on the variation of the TMJ PPT, but is also influenced by the variation of the reference site PPT. The reproducibility

of TMJ PPT was acceptable in the RA patients as well as the healthy individuals.

This study has shown that the PPT of the TMJ and the ratio between PPT of the TMJ and glabella in RA patients are lower than in healthy individuals and that the absolute PPT can be used for pain assessment. However, the clinical use of these variables alone is limited from a diagnostic point of view. Furthermore, the usefulness of PPT measurements for pain assessments in longitudinal studies and for evaluation of treatment efficacy is still an open question and should be investigated in the future.

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## References

1. List T, Helkimo M, Karlsson R. Influence of pressure rates on the reliability of a pressure threshold meter. J Craniomandib Disord 1991;5:173–178.
2. Chung SC, Um BY, Kim HS. Evaluation of pressure pain threshold in head and neck muscles by electronic algometer: Intrarater and interrater reliability. Cranio 1992;10: 28–34.
3. Chung SC, Kim JH, Kim HS. Reliability and validity of the pressure pain thresholds (PPT) in the TMJ capsules by electronic algometer. Cranio 1993;11:171–176.
4. Fredriksson L, Alstergren P, Kopp S. Absolute and relative facial pressure-pain thresholds in healthy individuals. J Orofac Pain 2000;14:98–104.
5. Tegelberg Å, Kopp S. Subjective symptoms from the stomatognathic system in individuals with rheumatoid arthritis and osteoarthrosis. Swed Dent J 1987;11:11–22.
6. Grassi W, De Angelis R, Lamanna G, Cervini C. The clinical features of rheumatoid arthritis. Eur J Radiol 1998;27 (suppl 1):S18–S24.
7. Arnett FC, Edworthy SM, Bloch DA, et al. The American Rheumatism Association 1987 revised criteria for the classification of rheumatoid arthritis. Arthritis Rheum 1988; 31:315–324.
8. Isselee H, De Laat A, Lesaffre E, Lysens R. Short-term reproducibility of pressure pain thresholds in masseter and temporalis muscles of symptom-free subjects. Eur J Oral Sci 1997;105:583–587.
9. Nussbaum EL, Downes L. Reliability of clinical pressure-pain algometric measurements obtained on consecutive days. Phys Ther 1998;78:160–169.
10. Gerecz-Simon EM, Tunks ER, Heale JA, Kean WF, Buchanan WW. Measurement of pain threshold in patients with rheumatoid arthritis, osteoarthritis, ankylosing spondylitis, and healthy controls. Clin Rheumatol 1989;8:467–474.
11. Dhondt W, Willaeys T, Verbruggen LA, Oostendorp RA, Duquet W. Pain threshold in patients with rheumatoid arthritis and effect of manual oscillations. Scand J Rheumatol 1999;28:88–93.
12. Leffler AS, Kosek E, Lerndal T, Nordmark B, Hansson P. Somatosensory perception and function of diffuse noxious inhibitory controls (DNIC) in patients suffering from rheumatoid arthritis. Eur J Pain 2002;6:161–176.
13. Huskisson EC, Hart FD. Pain threshold and arthritis. Br Med J 1972;4:193–195.
14. Schaible HG, Schmidt RF, Willis WD. Convergent inputs from articular, cutaneous and muscle receptors onto ascending tract cells in the cat spinal cord. Exp Brain Res 1987;66:479–488.
15. Yu XM, Mense S. Response properties and descending control of rat dorsal horn neurons with deep receptive fields. Neuroscience 1990;39:823–831.
16. Sessle BJ. The neural basis of temporomandibular joint and masticatory muscle pain. J Orofac Pain 1999;13: 238–245.
17. Jensen K. Quantification of tenderness by palpation and use of pressure algometers. In: Fricton JR, Awad E (eds). Advances in Pain Research and Therapy, vol 17. New York: Raven Press, 1990:165–182.
18. Kopp S, Alstergren P. Blood serotonin and joint pain in seropositive versus seronegative rheumatoid arthritis. Mediators Inflamm 2002;11:211–217.
19. Kopp S, Wenneberg B. Intra- and interobserver variability in the assessment of signs of disorder in the stomatognathic system. Swed Dent J 1983;7:239–246.