Referred pain from trapezius muscle trigger points shares similar characteristics with chronic tension type headache

César Fernández-de-las-Peñas a,*, Hong-You Ge b, Lars Arendt-Nielsen b, Maria Luz Cuadrado c, Juan A. Pareja c

a Department of Physical Therapy, Occupational Therapy, Physical Medicine and Rehabilitation of Universidad Rey Juan Carlos, Alcorcón, Madrid, Spain
b Centre for Sensory-Motor Interaction (SMI), Department of Health Science and Technology, Aalborg University, Aalborg, Denmark
c Departments of Neurology of Fundación Hospital Alcorcón and Universidad Rey Juan Carlos, Alcorcón, Madrid, Spain

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Abstract

Referred pain and pain characteristics evoked from the upper trapezius muscle was investigated in 20 patients with chronic tension-type headache (CTTH) and 20 age- and gender-matched controls. A headache diary was kept for 4 weeks in order to confirm the diagnosis and record the pain history. Both upper trapezius muscles were examined for the presence of myofascial trigger points (TrPs) in a blinded fashion. The local and referred pain intensities, referred pain pattern, and pressure pain threshold (PPT) were recorded. The results show that referred pain was evoked in 85% and 50% on the dominant and non-dominant sides in CTTH patients, much higher than 55% and 25% in controls (P < 0.01). Referred pain spread to the posterior-lateral aspect of the neck ipsilateral to the stimulated muscle in both patients and controls, with additional referral to the temple in most patients, but none in controls. Nearly half of the CTTH patients (45%) recognized the referred pain as their usual headache sensation, i.e. active TrPs. CTTH patients with active TrPs in the right upper trapezius muscle showed greater headache intensity and frequency, and longer headache duration than those with latent TrPs. CTTH patients with bilateral TrPs reported significantly decreased PPT than those with unilateral TrP (P < 0.01). Our results showed that manual exploration of TrPs in the upper trapezius muscle elicited referred pain patterns in both CTTH patients and healthy subjects. In CTTH patients, the evoked referred pain and its sensory characteristics shared similar patterns as their habitual headache pain, consistent with active TrPs. Our results suggest that spatial summation of perceived pain and mechanical pain sensitivity exists in CTTH patients.

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Keywords: Referred pain; Muscle pain; Myofascial trigger point; Pressure pain threshold; Tension type headache

1. Introduction

Tension-type headache (TTH) is the most common type of headache with one-year prevalence rates of 38.3% for the episodic form, and 2.2% for the chronic form (CTTH) (Schwartz et al., 1998). Despite some advances, the pathogenesis of this primary headache is not clearly understood. TTH is a prototypical headache in which peripheral, i.e. muscular, factors may play an important etiologic role (Jensen et al., 1998). Although the most prominent clinical finding in TTH subjects is an increased tenderness to palpation of pericranial tissues (Langemark and Olesen, 1987; Jensen and Olesen,
increased tenderness is the cause or the consequence of headache.

In their comprehensive text, Simons et al. (1999) described the referred pain patterns from different myo-fascial trigger points (TrPs) in head and neck muscles, which produced pain features that are usually found in patients suffering from TTH. They define a TrP as a hyperirritable spot associated with a taut band of a skeletal muscle, that is painful on compression and on stretch, and that gives rise to a referred pain pattern. Active TrPs are cause of clinical symptoms and their elicited referred pain is responsible for patients’ complaints. Latent TrPs may not be an immediate source of pain, but they can elicit referred pain with mechanical stimulation or muscle contraction. Some characteristics of head pain in TTH, such as pressure or band-like tightness (IHS, 2004) and increased local pain on palpation of several muscles (Langemark and Olesen, 1987; Jensen and Olesen, 1996; Lipchik et al., 1997) resemble the descriptions of referred pain originating in TrPs (Simons et al., 1999). Fernández-de-las-Peñas et al. (2006) have recently demonstrated that CTTH patients with suboccipital active TrPs had greater headache intensity and higher frequency than those with latent TrPs. This proposes the possibility that TrPs in the neck and shoulder region could be one source contributing to headache, as suggested recently by Gerwin (2005).

According to Simons et al. (1999), referred pain evoked by TrPs in the upper trapezius muscle spreads ipsilaterally from the posterior-lateral region of the neck, behind the ear, and to the temporal region (Fig. 1a). TrPs in the upper trapezius muscle have been found in patients with TTH (McNulty et al., 1994) and headache pain has been induced from the upper trapezius muscle in experimental pain models (Mørk et al., 2003; Christensen et al., 2005; Ge et al., 2005). However, the relationship between TrP pain characteristics in the trapezius muscle and the headache has not been established in patients with CTTH.

The aims of the present study were: (1) to describe differences in localization, intensity and quality of referred pain evoked by manual stimulation of TrPs in the upper trapezius muscles between CTTH patients and healthy subjects; (2) to describe whether the localization, intensity and quality of referred pain evoked by TrPs in the upper trapezius muscles mimic the pain pattern experienced by CTTH patients during headache attacks; (3) to assess the relationship between active or latent TrPs and several clinical variables concerning the intensity and the temporal profile of headache in CTTH patients; and, (4) to analyse if the decrease in pressure pain threshold in the upper trapezius muscle was related to the presence of TrPs in the upper trapezius muscle in both CTTH and healthy subjects.

2. Materials and methods

2.1. Subjects

A total of 20 CTTH subjects, 11 men and 9 women, aged 18–56 years old (mean: 36 ± 11 years) and 20 healthy age- and sex-matched subjects, 13 men and 7 women, aged 20–56 (mean: 35 ± 9 years) without headache history participated in this study from July to November 2005. Patients were recruited from the Neurology Department of the Fundación Hospital Alcorcón, a local hospital centre. The patients recruited were outpatients who visited neurologist actively for consultation and management. They had previously received the prophylactic, i.e. tricyclic antidepressants, or non-specific anti-inflammatory drugs, but none of the patients received physical therapy or antidepressants by the time the study was completed. The period from which patients were free from prophylactic drugs ranged from 2 to 6 months prior to the study. The patients were referred to participate into the study by an experienced neurologist. The controls were recruited from the staff personal of the Hospital. No significant differences were found for gender or age between both study groups. All subjects were right-handed. Subjects with CTTH were diagnosed according to the criteria of the International Headache Society (2004) by an experienced neurologist. CTTH subjects had to have headache for at least 15 days per month. A headache diary was kept for 4 weeks in order to confirm the diagnosis (Russell et al., 1992). Medication-overuse headache as defined by the International Headache Society (2004) was ruled out. Patients were not allowed to take analgesics or muscle relaxants 24 h prior to the examination. All patients had taken several prophylactic drugs and were not allowed to maintain the prophylactic therapy at the time of the
study. All patients were examined on the days when headache intensity was less than 4 points on a 10-cm horizontal visual analogue scale. The health status of all participants was clinically stable, without current symptoms of any other concomitant illness.

This study was supervised by the Departments of Physical Therapy and Neurology of Rey Juan Carlos University and Fundación Hospital Alcorcón, and it was also approved by the local human research Committee. All subjects signed an informed consent prior to their inclusion.

2.2. Myofascial trigger point examination

Both upper trapezius muscles were examined for the presence of myofascial TrPs by an assessor who had more than four years’ experience in TrPs diagnosis. TrP diagnosis was performed following the criteria described by Simons et al. (1999) and by Gerwin et al. (1997): (1) presence of a palpable taut band in a skeletal muscle; (2) presence of a hypersensitive tender spot within the taut band; (3) local twitch response elicited by the snapping palpation of the taut band; and (4) reproduction of referred pain in response to TrP compression. A TrP was considered active if the referred pain evoked by its compression reproduced the same subject’s head pain; whereas a TrP was considered latent if the evoked referred pain did not reproduce a usual or familiar pain (Gerwin et al., 1997; Simons et al., 1999).

The TrP examination was performed in a blinded fashion. After TrP assessment, the patient or subject was asked if the evoked referred pain reproduced a usual or familiar pain, e.g. the same pain than during headache attacks in CTTH patients. Since control subjects could have had some head pain without being current headache-sufferers, the assessor remained blinded through the end of the TrP examination.

2.3. Assessment of pain intensity, quality, and referred pain pattern

The intensity of both local pain, defined as pain located around the compression site, and referred pain, defined as pain located outside the local pain area evoked by TrP compression, was scored on a 10-cm horizontal visual analogue scale (Jensen et al., 1986) (VAS; range: 0 = no pain, to 10 = maximum pain). The quality of referred pain was assessed by the Spanish version of the McGill Pain Questionnaire (MPQ) (Lazarro et al., 1994, 2001). Words from the MPQ chosen by at least 40% of subjects were used to describe the referred pain quality. The subject was asked to draw the distribution of referred pain on an anatomical map after TrP palpation. The referred pain area was calculated with a digitizer (ACECAD D9000, Taiwan).

2.4. Pressure pain threshold assessment

Pressure pain threshold (PPT) is defined as the minimal amount of pressure where a sense of pressure first changes to pain in a certain point (Fischer, 1990). A mechanical pressure algometer (Pain Diagnosis and Treatment Inc., Great Neck, NY) was used in this study. This device consists of a round rubber disk (area 1 cm²) attached to a pressure (force) gauge. The gauge displays values in kilograms. Since the surface of the rubber tip is 1 cm², the readings are expressed in kg/cm². The range of the algometer is 0–10 kg with 0.1 kg divisions. Previous papers have reported an intra-examiner reliability of this procedure ranging from 0.6 to 0.97, while the inter-examiner reliability ranges from 0.4 to 0.98 (Takala, 1990; Levoska, 1993).

A standardized protocol was applied in order to calculate the PPT in the upper trapezius muscle (extra-cranial PPT) at a point 2 cm lateral to the halfway point between the spinous process of the seventh cervical vertebra (C7) and the lateral edge of the acromion. The PPT levels in the right or left sides were measured in a balanced order across subjects and randomized by numerical opaque envelopes. Three consecutive measurements at intervals of 30 s were obtained by the same assessor and the mean was considered in further analysis.

2.5. Patient or control assessment

All subjects, controls and patients, had two appointments within a four-week period. At the first visit, assessor 1 gave a headache diary to CTTH patients. Each patient registered on this diary the daily headache intensity, on a 10-cm visual analogue scale (VAS: range: 0 = no pain, to 10 = maximum pain), the headache duration (in hours per day), and the days with headache. This headache diary was kept for 4 weeks. Assessor 1 also informed control subjects about physical therapy and headache, but did not give them a headache diary. Assessor 2, blinded to the subjects’ condition, took the extra-cranial PPT measurement as described above in both patients and controls.

At the second visit four weeks later, assessor 2 examined, in a randomized order, both upper trapezius muscles for the presence of TrPs. After TrP examination, patients and controls reported their pain, i.e. intensity, quality and referred pain location, measures. Finally, all CTTH patients returned the headache diary to the first assessor who calculated the following variables: (1) headache intensity, which was calculated from the mean of the VAS of the days with headache; (2) headache frequency (days per week); and (3) headache duration (hours per day).
### 2.6. Statistical analysis

Data were analysed with the SPSS statistical package (13.0 Version). A normal distribution of quantitative data was assessed by means of the Kolmogorov–Smirnov test. Quantitative data without a normal distribution (i.e. intensity of referred pain in either left or right sides, number of either latent or active TrPs) were analysed with non-parametric tests, whereas those data with a normal distribution (i.e. headache intensity, frequency or duration, pressure pain threshold, intensity of local pain in both sides) were analysed with parametric tests. Differences in the number of either latent or active TrPs between both study groups were assessed with the U-Mann–Whitney test. The chi square ($\chi^2$) test was used to assess the differences in occurrence of referred pain and the distribution of either latent or active TrPs within each side between both study groups. Referred pain areas were analysed with two-way (patient and controls, dominant and non-dominant sides) analysis of variance (ANOVA). The unpaired Student’s $t$-test was used to analyse the differences in both the clinical variables relating to headache (headache intensity, frequency and/or duration) and PPT data in CTTH subjects with either latent or active TrPs in either left or right sides. Within each study group, differences in PPT between right and left sides were assessed with the paired Student’s $t$-test. Since no differences were found between right and left sides in both groups, data for comparison between groups were derived from the average of right and left values for each variable. Differences in PPT between both study groups were assessed with the unpaired Student’s $t$-test. Finally, differences in local pain intensity between both sides were assessed with the paired Student’s $t$-test, whereas differences in referred pain intensity were assessed with the Wilcoxon signed rank test. The statistical analysis was conducted at a 95% confidence level. A $P$ value less than 0.05 was considered statistically significant. Data were presented as mean ± SD in text and tables.

### 3. Results

#### 3.1. Headache diary

Headache history ranged from 4 to 30 years (mean duration: 9 ± 11 years). The mean headache period per day was 8 h (minimum 3, maximum 10 h), and the mean intensity (VAS) per episode was 5.1 (minimum 3, maximum 8). CTTH subjects were examined on the days when headache intensity was less than 4 on the VAS (mean: 2.9 ± 0.4). No correlation was found between headache history and the other headache clinical parameters.

#### 3.2. Referred pain pattern in CTTH patients

Within the CTTH group, referred pain was obtained in 17 out of 20 (85%) right upper trapezius muscles, and 11 out of 20 (55%) left upper trapezius muscles. Since all patients were right-handed, the occurrence of referred pain was higher in the dominant than the non-dominant upper trapezius muscle ($P = 0.017$). The reported referred pain (Fig. 1b) was spread to the posterior-lateral aspect of the neck ipsi-lateral to the stimulated muscle (17/17 on the right side; 11/11 on the left), and to the temple (14/17 on the right, 9/11 on the left). Unilateral stimulation of the trapezius muscle evoked unilateral referred pain, while bilateral stimulation of both muscles evoked symmetrically referred pain patterns. The qualitative words mostly chosen were pressing (15/17 right side, 10/11 left side), tightening (12/17, 8/11, respectively), sore (8/17, 6/11, respectively), hot (6/17, 5/11, respectively) and drilling (5/17, 4/11, respectively).

#### 3.3. Referred pain pattern in healthy control subjects

Within the control group, referred pain was obtained in 11 out of 20 (55%) in the right trapezius, and 5 out of 20 (25%) in the left trapezius. Again, the occurrence of referred pain was higher in the dominant than the non-dominant upper trapezius muscle ($P = 0.03$). Referred pain area was confined only to the posterior-lateral aspect of the neck. The qualitative words mostly chosen were tightening (10/11 right side, 5/5 left side), pressure (7/11, 3/5, respectively) and hot (5/11, 3/5, respectively).

#### 3.4. Comparison of the referred area between patients and controls

Two-way ANOVA revealed a significant difference in referred pain areas between patient and control groups ($F(1,76) = 70.01, P < 0.001$), and between dominant and non-dominant sides ($F(1,76) = 11.46, P = 0.001$) with a significant interaction between these two factors ($F(1,76) = 6.59, P = 0.012$). Referred pain area (cm$^2$) was larger in the dominant side (4.95 ± 0.41) than the non-dominant side (2.54 ± 0.21) in patients, and no significant differences between dominant side (0.52 ± 0.45) and non-dominant side (0.18 ± 0.25) were found in controls. Referred pain areas in both dominant and non-dominant sides in patients were larger than those in the controls, respectively (both, $P < 0.05$).

#### 3.5. Myofascial trigger point description in both groups

Eight out of 20 CTTH subjects (40%) reported referred pain upon compression of the right upper trapezius muscle as their usual headache sensation, consistent with active TrPs. Four out of 20 CTTH patients (20%)
reported referred pain evoked by compression of the left upper trapezius muscle as their usual head pain, i.e. active TrPs. Only 3 out of 20 patients (15%) had bilateral active trigger points associated with headache. Therefore, 9 out of 20 patients (45%) had active TrPs leading to their usual headache. On the other hand, no control subjects recognized the evoked referred pain as a familiar pain. The mean number of TrPs for each CTTH patient was 1.4 (SD: 0.5), of which 0.6 (SD: 0.7) were active, and 0.8 (SD: 0.5) were latent. Control subjects only had latent TrPs (mean: 0.8; SD: 0.6). TrP occurrence between the two groups was significantly different for active TrPs (\( P = 0.006 \)), but not for latent TrPs (\( P > 0.05 \)).

Eight CTTH subjects (40%) showed bilateral muscle TrPs, whereas the remaining 12 patients (60%) showed unilateral muscle TrP. On the other hand, 2 healthy subjects (10%) showed bilateral latent TrPs, another 12 (60%) showed unilateral latent TrPs, and the remaining 6 (30%) controls showed no muscle TrP. Therefore, bilateral TrPs in the upper trapezius muscle were more conspicuous in CTTH subjects than in controls (\( P = 0.008 \)).

### 3.6. Myofascial trigger points and headache pain characteristics in CTTH patients

CTTH subjects with active TrPs in the right upper trapezius muscle showed greater headache intensity and frequency, and longer headache duration than those with latent TrPs. In the same way, active TrPs in the left upper trapezius muscle were related to a greater headache intensity and longer headache duration, but not headache frequency, than latent TrPs. Finally, those CTTH subjects (\( n = 8 \)) with bilateral muscle TrPs reported a greater headache intensity and longer headache duration, but no headache frequency, than those patients (\( n = 12 \)) with unilateral TrPs. Table 1 summarizes headache intensity, frequency and duration data depending on TrP activity.

### 3.7. Local and referred pain intensity in both groups

All CTTH subjects (\( n = 20 \)) reported local pain intensity (VAS, 0–10 cm) during muscle palpation (5.3 ± 1.4 cm for the right side, 4.8 ± 1.5 cm for the left side). On the other hand, local pain was evoked in 16 controls (80%) in both right (1.5 ± 0.9 cm) and left (1.6 ± 1.0 cm) sides. Therefore, CTTH patients reported greater local pain intensity than healthy controls in both upper trapezius muscles (\( P < 0.001 \)).

Within the CTTH group, referred pain intensity during muscle palpation was 3.7 ± 1.9 cm for the right upper trapezius muscle and 2.4 ± 2.3 cm for the left upper trapezius muscle. Within the control group, referred pain intensity was 1.3 ± 1.2 cm for the right upper trapezius muscle, and 0.7 ± 1.2 cm for left upper trapezius muscle. Again, referred pain intensity was greater in patients than in controls (\( P < 0.001 \)).

Finally, both local and referred pain intensities were greater in either left or right sides in CTTH subjects presenting with bilateral TrPs than those patients with unilateral TrP (\( P < 0.01 \)). Table 2 details both local and referred pain intensities of both CTTH and control groups.

### 3.8. Extra-cranial pressure pain thresholds data in both groups

The intra-examiner repeatability of PPT readings ranged from 0.93 to 0.97, suggesting high repeatability of the PPT data. No significant differences were found in PPT between right and left sides within both groups. CTTH subjects showed decreased PPT (1.5 ± 0.4 kg/cm\(^2\) for the left side, 1.4 ± 0.4 kg/cm\(^2\) for the right side) than controls (2.5 ± 0.4 kg/cm\(^2\) for the left side, 2.6 ± 0.5 kg/cm\(^2\) for the right side), with a \( P \) value of 0.001.

In both groups, PPT was not related to TrP activity, i.e. latent or active TrP, in either right or left upper

### Table 1

Headache intensity, frequency and duration depending on myofascial trigger point activity within the chronic tension-type headache group

<table>
<thead>
<tr>
<th></th>
<th>Headache intensity (VAS)</th>
<th>Headache frequency (days/week)</th>
<th>Headache duration (h/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Right upper trapezius</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active TrPs (( n = 8 ))</td>
<td>5.8 (1.8)(^a)</td>
<td>5.4 (1.2)(^a)</td>
<td>9.3 (4.4)(^a)</td>
</tr>
<tr>
<td>Latent TrPs (( n = 9 ))</td>
<td>4.5 (1.7)</td>
<td>4.5 (0.6)</td>
<td>6.9 (5.7)</td>
</tr>
<tr>
<td><strong>Left upper trapezius</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active TrPs (( n = 4 ))</td>
<td>5.5 (1.3)(^a)</td>
<td>5 (0.9)</td>
<td>9.8 (2.5)(^a)</td>
</tr>
<tr>
<td>Latent TrPs (( n = 7 ))</td>
<td>4.7 (0.5)</td>
<td>5 (0.8)</td>
<td>8.3 (2.7)</td>
</tr>
<tr>
<td><strong>Unilateral-bilateral TrPs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilateral TrPs (( n = 8 ))</td>
<td>5.5 (1.9)(^b)</td>
<td>5.3 (1)</td>
<td>9.9 (2.7)(^b)</td>
</tr>
<tr>
<td>Unilateral TrPs (( n = 12 ))</td>
<td>4.6 (1.7)</td>
<td>4.7 (1)</td>
<td>7.4 (4.3)</td>
</tr>
</tbody>
</table>

Values are expressed as means (standard deviations).

VAS = Visual Analogue Scale (0–10 cm).

TrPs = Myofascial Trigger Points.

\(^a\) Significant in comparison with the latent TrPs subgroup (unpaired Students’ \( t \)-test, \( P < 0.05 \)).

\(^b\) Significant differences between bilateral and unilateral TrPs (unpaired Students’ \( t \)-test, \( P < 0.05 \)).
trapezius muscles ($P > 0.2$). CTTH patients with bilateral TrPs reported significant decreased PPT than those patients diagnosed with unilateral muscle TrP ($P < 0.01$). On the contrary, PPT did not differ among control subjects with bilateral, unilateral or no TrPs. Table 3 shows pressure pain threshold data depending on either active or latent TrPs in both study groups.

### Table 2
Local and referred pain intensities in both chronic tension type headache and control groups

<table>
<thead>
<tr>
<th></th>
<th>CTTH</th>
<th>Controls</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS local right</td>
<td>5.3 (1.4)</td>
<td>1.5 (0.9)</td>
<td>$&lt;0.001^*$</td>
</tr>
<tr>
<td>VAS local left</td>
<td>4.8 (1.5)</td>
<td>1.6 (1)</td>
<td>$&lt;0.001^*$</td>
</tr>
<tr>
<td>VAS referred right</td>
<td>3.7 (1.9)</td>
<td>1.3 (1.2)</td>
<td>$&lt;0.001^*$</td>
</tr>
<tr>
<td>VAS referred left</td>
<td>2.4 (2.3)</td>
<td>0.7 (1.2)</td>
<td>$&lt;0.001^*$</td>
</tr>
<tr>
<td>Unilateral TrP ($n = 12$)</td>
<td>4.1 (1.2)</td>
<td>5.9 (1.4)</td>
<td>0.007 $^b$</td>
</tr>
<tr>
<td>Bilateral TrP ($n = 8$)</td>
<td>2.5 (1)</td>
<td>4.8 (1)</td>
<td>0.03 $^b$</td>
</tr>
</tbody>
</table>

Values are expressed as means (±standard deviations).

TrPs = Myofascial Trigger Points.

VAS = Visual Analogue Scale (0–10 cm).

$^a$ Significant differences between CTTH and controls.

$^b$ Significant differences between unilateral and bilateral TrPs.

### Table 3
Pressure pain thresholds of the upper trapezius muscle depending on myofascial trigger point activity

<table>
<thead>
<tr>
<th>Trigger point</th>
<th>PPT right upper trapezius muscle</th>
<th>PPT left upper trapezius muscle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CTTH patients</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right upper trapezius</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active TrPs ($n = 8$)</td>
<td>1.3 (0.3)</td>
<td>1.4 (0.3)</td>
</tr>
<tr>
<td>Latent TrPs ($n = 9$)</td>
<td>1.5 (0.4)</td>
<td>1.4 (0.4)</td>
</tr>
<tr>
<td>Left upper trapezius</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active TrPs ($n = 4$)</td>
<td>1.4 (0.5)</td>
<td>1.5 (0.5)</td>
</tr>
<tr>
<td>Latent TrPs ($n = 7$)</td>
<td>1.2 (0.2)</td>
<td>1.3 (0.3)</td>
</tr>
<tr>
<td>Unilateral–bilateral TrPs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilateral TrPs ($n = 8$)</td>
<td>1.1 (0.2)$^a$</td>
<td>1.2 (0.2)$^a$</td>
</tr>
<tr>
<td>Unilateral TrPs ($n = 12$)</td>
<td>1.7 (0.4)</td>
<td>1.7 (0.4)</td>
</tr>
<tr>
<td><strong>Control subjects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right upper trapezius</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-TrP ($n = 9$)</td>
<td>2.5 (0.4)</td>
<td>2.5 (0.4)</td>
</tr>
<tr>
<td>Latent TrPs ($n = 11$)</td>
<td>2.6 (0.5)</td>
<td>2.4 (0.5)</td>
</tr>
<tr>
<td>Left upper trapezius</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-TrP ($n = 15$)</td>
<td>2.6 (0.4)</td>
<td>2.5 (0.4)</td>
</tr>
<tr>
<td>Latent TrPs ($n = 5$)</td>
<td>2.6 (0.5)</td>
<td>2.5 (0.5)</td>
</tr>
<tr>
<td>Unilateral–bilateral–no TrPs (ANOVA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilateral TrPs ($n = 2$)</td>
<td>2.6 (0.7)</td>
<td>2.5 (0.6)</td>
</tr>
<tr>
<td>Unilateral TrPs ($n = 12$)</td>
<td>2.6 (0.5)</td>
<td>2.5 (0.5)</td>
</tr>
<tr>
<td>No TrP ($n = 6$)</td>
<td>2.5 (0.4)</td>
<td>2.5 (0.4)</td>
</tr>
</tbody>
</table>

Values are expressed as means (standard deviations).

PPT = Pressure pain threshold (cm/kg$^2$) of the upper trapezius muscle (extra-cranial point).

TrPs = Myofascial Trigger Points.

$^a$ Statistically significant differences in PPT between bilateral and unilateral TrPs in CTTH (unpaired Students’ $t$-test, $P < 0.01$).

### 4. Discussion

This study provides for the first time the evidence that referred pain and pain characteristics elicited by manual examination of TrPs in the upper trapezius muscle share similar patterns as habitual headache pain in patients with CTTH. Moreover, the referred pain areas were larger in patients than in controls. On the other hand, the elicited referred pain by the upper trapezius muscle did not reproduce any usual or familiar pain in control healthy subjects. Moreover, headache intensity, frequency, and duration were greater in CTTH patients who had active TrPs compared to those with latent TrPs in the upper trapezius muscle. Bilateral TrPs were also related to a greater headache intensity and longer headache duration than unilateral TrPs in patients. Finally, within the CTTH group, but not in the control group, we found a decreased PPT in those patients who showed bilateral TrPs, but not in those with unilateral TrPs.

### 4.1. Referred pain from active TrPs in the upper trapezius muscle shares similar pain patterns with CTTH

Stimulation of active TrPs in the upper trapezius muscle reproduced usual headache pain in 40% and 20% in the right and left upper trapezius muscles, respectively, in the patients group. Further, stimulation of active TrPs bilaterally in the trapezius muscle reproduced headache pain in 15% of the patients. Although healthy subjects also perceived referred pain during muscle exploration, this referred pain was not familiar to controls. Further, both local and referred pain intensities were higher in CTTH patients than in healthy subjects. The referred pain area was larger in patients than in controls, with
pain referral to temporal and, sometimes, frontal regions in patients, and confined to the posterior-lateral neck in controls. Active TrPs activity was significantly related to higher headache intensity and longer headache duration than those with latent TrPs in CTTH patients. Pain quality of the referred pain elicited by manual examination of TrPs in the upper trapezius muscle was perceived as pressing, tightening or soreness in both patients and controls. These pain characteristics are similar to those reported CTTH patients in previous studies (Rasmussen et al., 1991, 1992). These results argue for the view that active TrPs in the upper trapezius muscle is contributing to CTTH and referred pain from TrPs may contribute directly to TTH perception. The headache pain of the other 40% patients may have other sources, such as TrPs from suboccipital muscles (Fernández-de-las-Peñas et al., 2006), sternocleidomastoid muscles (Simons et al., 1999) or from mal-alignment of upper cervical vertebrae (Bogduk, 2001).

In our previous study, we found that referred pain elicited by suboccipital muscle TrPs also reproduced the usual headache pain in 65% of our 20 CTTH patients (Fernández-de-las-Peñas et al., 2006). It seems that TrPs from several head and shoulder muscles are contributing at the same time to headache pain perception in TTH.

Animal (Kerr and Olafson, 1961; Bartsch and Goadsby, 2002) and human (Piovesan et al., 2003; Ge et al., 2004) studies clearly show the convergence of cervical and trigeminal afferents, constituting the anatomical basis for the referred headache pains from the TrPs in the trapezius muscle. In addition, peripheral and central sensitization and decreased descending inhibition induced by long-term nociceptive stimuli from trigger point may also involve in referred pain to trigeminal region from active TrPs in the upper trapezius muscle (Arendt-Nielsen et al., 2000). Olesen (1991) proposed that headache is due to an excess of nociceptive inputs from peripheral structures. Higher levels of concentration of protons, bradykinin, calcitonin gene-related peptide, substance P, tumor necrosis factor-α, interleukin-1β, serotonin and norepinephrine have been found in the TrP (Shah et al., 2005), but not in the tender point (Ashina et al., 2003). Based on previous and current findings we would hypothesize that referred pain elicited from TrPs in the upper trapezius muscle, as well as in other muscles, may play an important role in the pathogenesis of TTH.

4.2. Spatial and temporal summation of perceived pain and mechanical pain sensitivity in CTTH

Unilateral stimulation of the trapezius muscle evoke unilateral referred pain, bilateral stimulation of both muscles evoke symmetrically referred pain patterns, and local and referred pain intensities were greater in CTTH patients with bilateral TrPs than those with unilateral TrPs. Furthermore, bilateral TrPs in the upper trapezius muscle were more conspicuous in patients than in controls. CTTH subjects with bilateral active TrPs reported higher levels of headache and longer headache duration than those patients with unilateral active TrPs. This result conforms to our previous experimental study showing increased pain intensity and referred pain area by bilateral hypertonic saline injection than unilateral injection into the upper trapezius (Ge et al., 2003). It is also interesting to note the similarities between the referred pain pattern from trapezius muscle in this patient group (Fig. 1b) and in the classical trigger point pattern depicted by Simons et al. (1999) (Fig. 1a) and the experimentally induced in healthy subjects (Ge et al., 2003). These findings suggest that the higher levels of headache pain may also come from spatial summation of TrP related pain, especially in the trapezius muscle. In addition, CTTH subjects with bilateral TrPs showed a significant lower extra-cranial PPT values than those patients with unilateral muscle TrP. This may indicate multiple TrPs spatially increase the mechanical pain sensitivity peripherally and centrally, since the PPT is not measured directly on the TrPs, but on the fixed point. Continuous nociceptive afferent inputs from extracranial tissues, as seen in pericranial tissues, may result in spatial summation (Ge et al., 2003), increasing pain perception, mechanical pain sensitivity and the intensity of headache.

Our results underline the importance of inspection and inactivation of trigger points bilaterally in the trapezius muscle in patients with CTTH.

4.3. Higher trigger point activity in the dominant than non-dominant trapezius

In either the CTTH group or the control group, the occurrence of referred pain was higher in the dominant than the non-dominant upper trapezius muscles. The active TrPs in the dominant upper trapezius muscle correlated significantly with greater headache intensity, frequency, and longer headache duration. Referred pain area was larger in the dominant than non-dominant sides in patients but not in controls, probably provoked by a ground effect or smaller referred pain areas in controls. Epidemiological studies suggest that highly repetitive work and forceful arm or hand movements cause neck and shoulder pain (Bernard, 1997). Repetitive use of the muscle in the dominant side may be a factor to the development of TrPs (Simons, 2004). The release of different metabolic products and algogenic substances (Rosendal et al., 2004), especially in the TrPs (Shah et al., 2005) stimulate nociceptors and may induce spontaneous muscle pain and related referred pain. However, the fundamental understanding of TrP anatomy and physiology is not known.

In conclusion, manual exploration of TrPs in the upper trapezius muscle elicited referred pain patterns in both CTTH patients and healthy subjects. In CTTH patients,
the evoked referred pain and its sensory characteristics shared similar patterns as their habitual headache pain, consistent with active TrPs. Our results suggest that spatial summation of perceived pain and mechanical pain sensitivity exists in CTTH. This study was limited by its small sample size in subgroups. Further research with a larger sample size is needed to define the pathogenic role of referred pain from muscle TrPs of head and neck muscles in the pathogenesis and/or maintenance of TTH.

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References