Intensity and distribution of shoulder pain in patients with different sized postero-superior rotator cuff tears

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Background: The vast majority of studies regarding rotator cuff tears (RCTs) are focused on etiopathogenesis and treatments, but information on shoulder pain characteristics needs further investigation. We analyzed the intensity and distribution of shoulder pain in patients with different sizes of RCTs.

Methods: Two hundred eighty-five consecutive patients with postero-superior RCTs were enrolled for this study. Tear size was intraoperatively classified. Before surgery, all patients completed an upper limb pain map (dermatome map made by Keegan). Shoulder pain intensity was assessed with a visual analogue scale (VAS). Data were submitted to statistical analysis.

Results: Shoulder pain intensity caused by a RCT was greater in females (P = .024); it did not vary with the side nor with age. Pain intensity was less in massive tears (P < .05) and in patients whose pain was distributed only to the shoulder (P = .035). Furthermore, patients whose pain persisted for more than 6 months maintained the same pain intensity. Pain was localized predominantly on dermatomes C5-C6, was more diffuse in massive tears (P < .05), and rarely extended beyond the elbow. In the presence of intense shoulder pain, its precise distribution was not well-delimited.

Conclusion: Shoulder pain characteristics in patients with RCTs may be influenced by gender and size of tear. Cuff tear pain distribution principally involves the antero-lateral aspect of the shoulder with extension down the lateral surface of the arm to the elbow. Information about pain intensity and distribution in patients with RCTs may contribute to a more accurate diagnosis.

Levels of evidence: Level III, Cross Sectional Study.

Keywords: Rotator cuff tear; shoulder pain; pain intensity; pain distribution

Introduction

Rotator cuff tears (RCTs) have always attracted great interest because they may be responsible for shoulder pain, loss of strength, simple or complex disabilities, partial or total inability to work, and reduced quality of life. Several
studies have been performed with the aim to understand the etiology and natural history of the lesion and how to treat it. Additionally, countless studies have been conducted about physical examination, to better understand the integrity of the cuff and if the pain originates from the shoulder or is caused by cervical spine disease. However, the shoulder literature does not accurately focus on RCT pain intensity and distribution.

Modern pain mapping was introduced in 1949 by Palmer, who provided outline diagrams of the human body and asked patients to diagram on anatomy charts the area of their pain distribution. The use of pain maps in clinical practice is now widespread. However, pain mapping for common shoulder disorders has been reported in only 1 study performed on 94 patients, with only 22 of them having a rotator cuff tear.

Therefore, the aim of our study was to investigate the intensity and distribution of shoulder pain in a sample of 285 patients with different sizes of postero-superior RCTs and to analyze differences between patients with acute or chronic symptoms, and differences in pain intensity according to age, gender or involved side.

Materials and methods

The study comprised 285 consecutive patients who underwent arthroscopic repair of a full-thickness postero-superior RCT between January 2009 and May 2011. Before surgery, all patients completed an upper limb pain map. They were given clear verbal, written, and illustrated instructions on how to complete the pain map. The patients who agreed to complete the map were included in the study. The examining clinicians were blinded to pain map results.

We used the dermatome map designed by Keegan and Garrett (Fig. 1) to obtain reliable descriptions of pain localization. This map illustrates areas of radiation (including the anterior and posterior parts of the arm, neck and shoulder). Shoulder pain intensity was assessed with a visual analogue scale (VAS). Patients rated pain intensity on a continuum from “no pain” to “maximal, worst pain imaginable” (scale from 0 to 10). The VAS score was the distance from the lowest pain level to the mark made by the patient. Patients were also separated into 2 main subgroups: those whose symptoms persisted for more or less than 6 months, with six months chosen as the threshold to distinguish acute from chronic rotator cuff tears.

Exclusion criteria were: patients with previous shoulder surgery; neck pain symptoms, subcapularis tears; other ipsilateral upper limb problems (elbow; wrist and hand pathologies, neuropathies due to intrinsic or extrinsic factors); traumatic tears; biceps and/or labral pathologies; shoulder instability; acromioclavicular arthritis; shoulder stiffness (limited passive range of motion); diabetes (because of possible diabetic neuropathy); os acromiale; degenerative arthritis of the glenohumeral joint; autoimmune or rheumatologic disease, and workers’ compensation claims. Furthermore, we excluded patients whose symptoms arose more than 12 months ago to avoid jeopardizing results due to previous medical or physical therapy. Two hundred eighty-five subjects with RCTs fulfilled all inclusion criteria. Table I shows the baseline characteristics of patients.

One hundred forty-seven patients were men (mean age: 64.3 [range, 37-82]) and 138 were women (mean age: 66.4 [range, 40-80]) \( (P = .503) \). The right shoulder was involved in 211 cases (74.0%) and the left in 74 (26.0%) \( (P < .001) \) (Table I). As we wanted to verify the correlation between pain intensity and patient’s age, we arbitrarily distinguished 3 cohorts: (1) patients younger than 55 years (41 patients); (2) patients between 56 and 64 years old (95 patients); (3) patients older than 65 years (149 patients). To verify the correlation between pain intensity and time elapsed between the onset of symptoms and clinical examination, we arbitrarily distinguished 2 groups: (1) patients with pain for less than 6 months (123 patients), and (2) patients with pain for more than 6 months (162 patients).

All operations were performed by one senior author (SG), with patients in the beach chair position under general anesthesia and interscalene block. A standard arthroscopic pump was used in all cases and standard posterior, lateral, antero-lateral, and mid-glenoid portals were used to perform a thorough diagnostic examination.

After the intra-articular evaluation, the scope was placed in the subacromial space. Subacromial bursa was removed to gain a clear view of the RCT. The Southern California Orthopedic Institute (SCOI) classification of complete RCTs was used to classify tendon tears in an operatively as:

- a small, complete tear, similar to a puncture wound (type I);
- a moderate tear (usually <2 cm) that encompassed only 1 rotator cuff tendon, with no significant retraction of the torn end (type II);
- a large, complete tear involving an entire tendon, with minimal retraction of the torn end, usually 3 to 4 cm (type III);
- a massive RCT involving 2 or more rotator cuff tendons, frequently with associated retraction and scarring of the remaining tendons ends, and often an L-shaped tear that is frequently irreparable (type IV).

| Figure 1 | Upper limb dermatomes. |
To limit the number of groups and make the sample more representative, we considered the lesions belonging to type I as small, those of type II and III as moderate-to-large and those of type IV as massive.

All patients agreed to participate in the study and signed an informed consent form in accordance with the Declaration of Helsinki. According to our country’s laws this study did not require an ethics committee approval.

**Statistical analysis**

We used parametric tests if the data were normally distributed and homogeneous, while we used nonparametric tests if these 2 conditions were not satisfied. These assumptions were assessed by Kolmogorov-Smirnov’s test and Levene’s test, respectively.

Regression analyses were used to investigate the relationship of pain to age, duration of symptoms and RCT size. Pearson correlation coefficients were interpreted as follows: 0.00-0.19 = very weak correlation; 0.20-0.39 = weak correlation; 0.40-0.69 = moderate correlation; 0.70-0.89 = strong correlation; and 0.90-1 = very strong correlation.

The chi-squared test was used to evaluate the differences in prevalence of tear size between males and females, right or left sides. Moreover, according to RCT size we used a chi-square test to analyze the relationship between the dermatomes involved. For each tear size group, we used the unpaired t-test to analyze pain level differences between males and females, right and left side and symptom history. A Mann-Whitney test was performed to analyze theVAS score differences between patients that had pain down to and past the elbow. The 1-way ANOVA test was used to analyze pain level differences between patients with pain localized onto the antero-lateral aspect of the shoulder with radiation down the lateral surface of the arm to the elbow, while only 38 described their pain as also involving the forearm. The Friedman 1-way ANOVA of VAS score demonstrated a very weak correlation. The average pain intensity was 5.5 (range, 0.7-9.3) in patients with small tears, and 4.9 (range, 0.0-10.0) in those with massive tears. Friedman 1-way ANOVA of VAS score demonstrated a significant pain association (P = .030). Post-hoc comparison (using a Bonferroni correction) showed significant differences, in terms of pain, comparing patients with massive tears to those with small pain (P = .045) and large tears (P = .018) (Table IV).

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The average pain intensity in the group whose pain arose less than 6 months ago was 5.9 (range, 0.7-10.0) and for more than 6 months ago was 5.3 (range, 0.0-9.3), respectively. We did not find significant differences between the 2 groups when they were considered independent of cuff tear size (P = .348), nor when they were further divided into subgroups according to cuff tear size (Table V). Of our 285 patients, 86% (247) described their pain as localized onto the antero-lateral aspect of the shoulder with radiation down the lateral surface of the arm to the elbow, while only 38 described their pain as also involving the forearm. The median pain intensity in the group with pain localized...
above elbow level (247 patients) was 5.3 (interquartile range, 4.0-6.7) while in the group with pain extended beyond elbow level (38 patients) it was 5.7 (interquartile range, 3.3-6.7). The difference between the 2 groups was statistically significant ($P = .035$).

Independent of RCT size, dermatomes C5 and C6 were the most involved. This result was also confirmed when data were distinguished by RCT size (Table VI and Fig. 2). Analyzing pain distribution according to RCT size, we observed that patients with massive tears had more extensive pain. In fact, the percentage of patients with massive tears who described pain in the C5, C6, C7, C8, and T1 dermatomes was higher than those patients with small or large tears (Table VI and Fig. 2). No statistical differences were found between patients with small and large tears regarding the dermatomes analyzed (from C3 to T1).

### Discussion

In an immunohistochemical and electron microscopic study, Soifer et al. observed that the subacromial tissues (subacromial bursa, rotator cuff tendons, long head biceps tendon, transverse humeral ligament) are rich in free nerve fibers. Nociceptive information relayed by these fibers may be responsible for pain associated with different subacromial disorders. Harmful stimuli, both of the mechanical and chemical type, are picked up from nociceptors. They consist of the peripheral endings (type Aδ-myelinated and unmyelinated C-type) of primary sensory neurons whose cell bodies are located in the dorsal root and in the trigeminal ganglia. Nociceptive information is transmitted from the spinal cord to the thalamus and cerebral cortex along 5 ascending pathways. Additionally, the limbic system plays an important role in determining what is defined as the “emotional component” of pain. Therefore, nociception has to be considered as a multimodal experience.

Information regarding shoulder pain is still scarce. It is known that RCTs may be painless or painful, that pain arises in patients during the night, often causing sleep disturbance, and that it may compromise shoulder function; however, pain intensity and distribution should be further elucidated. To our knowledge, only 1 study has focused attention on shoulder pain intensity and distribution in patients with shoulder disorders. Using pain mapping and asking to indicate on the map which of the different types of pain patients were feeling, Bayam et al. observed that patients with RCTs have sharp pain predominantly around the front of the shoulder and dull, aching pain affecting the rest of the arm and forearm. Unfortunately, these observations were obtained for only 22 patients whose tear size was unknown.

We assessed shoulder pain intensity using a VAS on a large group of patients with different sized RCTs. We observed that pain intensity described in females was higher than that in males. Actually, this finding has previously been described. In Kindler et al.’s series, which studied patients with shoulder pain, women experienced greater clinical pain and enhanced sensitivity to pressure pain. This difference could possibly reside in the C-fibers processing method that would lead to the development of a central sensitization greater in women than in men.

To our knowledge, there is not a hemibody condition that is more painful than the other, nor an anatomic-pathologic condition that may generate different pain intensities on symmetric organs. Our data demonstrated that

### Table III

Comparison between pain intensity and different sized RCTs, according to gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Mean VAS (range)</th>
<th>Mean difference</th>
<th>95% CI of the difference</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Small</td>
<td>43 F</td>
<td>5.8 (2.0-9.3)</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>F vs M</td>
<td>44 M</td>
<td>5.1 (0.7-8.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>51 F</td>
<td>6.1 (1.3-9.3)</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>F vs M</td>
<td>49 M</td>
<td>5.3 (2.0-9.0-9.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Massive</td>
<td>44 F</td>
<td>5.3 (0.7-10.0)</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>F vs M</td>
<td>54 M</td>
<td>4.6 (0.0-8.7)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*VAS*, visual analog scale; *CI*, confidence interval; *F*, female; *M*, male.

* Significant $P$ value.

### Table IV

Comparison between pain intensity registered in patients with different sized RCTs

<table>
<thead>
<tr>
<th>RCT sizes</th>
<th>Mean difference</th>
<th>95% CI of the difference</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Small vs large</td>
<td>$-0.20$</td>
<td>$-0.899$</td>
<td>$0.486$</td>
</tr>
<tr>
<td>Small vs massive</td>
<td>$0.56$</td>
<td>$0.128$</td>
<td>$1.264$</td>
</tr>
<tr>
<td>Large vs massive</td>
<td>$0.77$</td>
<td>$0.102$</td>
<td>$1.447$</td>
</tr>
</tbody>
</table>

*RCTs*, rotator cuff tears; *CI*, confidence interval.

* Significant $P$ value.
RCTs cause similar pain intensity between the 2 sides and that there is probably no modulation made by the two cerebral hemispheres that is potentially able to modify pain perception. We observed no differences in pain intensity based on patient age. This figure can be interpreted in 2 different ways: (1) RCT pain is independent of age; or (2) there is a different perception of pain between young and elderly patients.

Our data indicate that patients with massive RCTs had less pain than those with small or large tears. This might be due to the lower amount of bursal tissue usually present in massive tears compared to that in small and large tears. Due to the fact that the bursa has the highest concentration of free nerve fibers among the subacromial structures, this is a possible cause for why massive tears are often less painful. It is also conceivable that massive tears are older; in these cases, the nociceptors located on the edges of the lesion could have undergone “receptor adaptation”. According to this theory, if the chemical or mechanical stimuli acting on the receptor are prolonged, receptor activation decreases in patients with RCT, causing a less painful shoulder.

It is known that shoulders with RCTs may be painless or may become painless over time. Our data indicate that if pain lasts for more than 6 months, it maintains the same intensity in the following 6 months. These data do not contradict the theory of receptor adaptation, because they do not take into account all those patients who become painless over time and therefore decided not to consult a physician.

### Table V  Comparison between pain intensity and different sized RCTs according to pain history

<table>
<thead>
<tr>
<th>Pain</th>
<th>Mean VAS (range)</th>
<th>Mean difference</th>
<th>95% CI of the difference</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Small</td>
<td>≤6 mos (36)</td>
<td>5.6 (0.7-8.7) *</td>
<td>0.12</td>
<td>-0.690</td>
</tr>
<tr>
<td></td>
<td>&gt;6 mos (51)</td>
<td>5.4 (2.0-9.3) *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>≤6 mos (50)</td>
<td>5.8 (1.3-9.3) *</td>
<td>0.24</td>
<td>-0.450</td>
</tr>
<tr>
<td></td>
<td>&gt;6 mos (50)</td>
<td>5.6 (2.7-9.3) *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Massive</td>
<td>≤6 mos (37)</td>
<td>5.0 (1.3-9.3) *</td>
<td>0.12</td>
<td>-0.790</td>
</tr>
<tr>
<td></td>
<td>&gt;6 mos (61)</td>
<td>4.9 (0.0-10.0) *</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VAS, visual analog scale; CI, confidence interval.

* Number of patients.

### Table VI  Correlation between different sized RCTs according to dermatomes involved

| P values |
|----------|----------|----------|----------|----------|----------|----------|----------|
|          | C3       | C4       | C5       | C6       | C7       | C8       | T1       |
| Small vs large | .874     | .580     | .534     | .647     | .391     | .373     | .599     |
| Small vs massive | .789     | .522     | .005 *   | .075     | .021 *   | .003 *   | .002 *   |
| Large vs massive | .978     | .951     | .038 *   | .236     | .000 *   | .000 *   | .011 *   |

RCTs, rotator cuff tear sizes.

* Significant P value.

### Figure 2  Number of patients with different sized rotator cuff tears for each indicated dermatome.
We observed that when the pain radiates down the arm past the elbow it has a higher intensity than pain localized only to the shoulder. A possible explanation is that patients who have high pain intensity fail to accurately discriminate their pain boundaries. This may explain why a small percentage of patients report pain in abnormal locations (dermatomes C3 and T1). It is also possible that patients with widespread pain have greater impairment of the entire upper limb; which may contribute to symptom magnification.

The vast majority of our patients described their pain as localized to the antero-lateral shoulder and radiating down the lateral surface of the arm to the elbow. The precise location of pain does not always correlate with the site of the pathology, especially in musculoskeletal conditions. In fact, pain arising from structures deeper than the skin, such as the shoulder, is diffuse and sometimes has an unexpected distribution because of the proximal location which the shoulder has in the sclerotome and the extensive convergence of afferent signals from this area to the dorsal horn of the spinal cord.

Our data indicate that dermatomes C5 and C6 are the most involved, independent of RCT size. This result is easily understood because the suprascapular nerve (responsible for the innervation of the supraspinatus and the infraspinatus muscles) derives from the “upper trunk” consisting of the anterior branches of C5-C6 roots and a collateral of C4; and the axillary nerve (responsible for the innervation of teres minor) derives from the “posterior trunk” which consists of the posterior branches of the three main trunks (C4-5-6-7-8 and T1).

In our series, patients with massive RCTs had more extensive pain distribution. This finding may be due to the fact that massive tears involve two or more musculotendinous units which are innervated by branches which originate from different cervical levels.

We observed that the pain suffered by the patients with small or large RCTs is distributed not only to the C4-5-6 dermatomes but also to those of C7-C8-T1. This finding allows us to hypothesize that shoulder pain may not be due solely to the RCT but also to inflammation involving subacromial structures and the likely occult joint instability derived from the torn tendon.

This study has several potential limitations. First, bursitis or synovitis was not considered, even if it may affect the pain intensity. In any case, one can deduce from the relationship between cuff tear size and pain intensity (smaller size with greater pain) that bursitis, which is present mostly in smaller tears, may influence pain intensity. Second, a major drawback of this study is that we have not analyzed other shoulder pathologies; we are therefore unable to confirm that our findings are specific to rotator cuff pathology. This does not affect our main purpose which was to investigate shoulder pain intensity and distribution in patients with rotator cuff tears and to furnish pain distribution values for the diagnosis of RCT.

**Conclusion**

Shoulder pain intensity caused by RCTs is greater in females, is less in massive tears, and in patients whose pain is distributed to the shoulder only. Furthermore, if the pain persists for more than 6 months it maintains the same intensity. Pain is localized predominantly to dermatomes C5-C6, is more extensively distributed in massive tears and rarely extends beyond the elbow. When pain intensity is high, its distribution is widespread and was difficult to localize precisely. Cuff tear pain distribution principally involves the antero-lateral aspect of the shoulder with radiation down the lateral surface of the arm to the elbow.

**Disclaimer**

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