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**ORIGINAL ARTICLE** / ÖZGÜN ARAŞTIRMA

# Ultrasonographic assessment of the shoulder in patients with carpal tunnel syndrome

## Karpal tünel sendromlu hastaların omuzlarının ultrasonografik olarak değerlendirilmesi

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**ABSTRACT**

**Objectives:** To detect the causes of shoulder pain with shoulder ultrasonography in patients with carpal tunnel syndrome (CTS) and compare the findings of the patients with CTS to healthy controls.

**Patients and Methods:** Patients with CTS and healthy controls were evaluated clinically, electrophysiologically. and ultrasonographically by three masked researchers. Electrophysiological assessment consisted median and ulnar nerve conduction studies (NCS). In ultrasonographic assessment, cross-sectional areas of the median nerve were measured at hamatum hook, psiform bone, radio-ulnar joint levels. Shoulder joint, axial and longitudinal biceps tendon, subscapularis tendon, supraspinatus tendon, infraspinatus tendon, rotator cuff, acromioclavicular joint were evaluated by a standardized protocol.

**Results:** The study was completed with 30 patients with CTS and 30 healthy subjects. The presence of shoulder pain in the last week was 53.3% in the CTS group and 30% in the control group but there was no statistically significant difference between the groups (p=0.16; p>0.05). Subdeltoid bursitis was significantly more common in CTS group when compared to the control group (p=0.03) in ultrasonographic assessment, and there was no significant difference between the two groups for other parameters.

**Conclusion:** Shoulder pain and subdeltoid bursitis were common in patients with CTS however, shoulder pain was not directly related to shoulder problems alone. Central sensitization may play a role for shoulder pain rather than shoulder problems.

**Keywords:** Ultrasonography, Carpal tunnel syndrome, Shoulder pain, Central sensitization

**ÖZ**

**Amaç:** Karpal tünel sendromlu (KTS) hastalarda omuz ağrısı nedenlerini omuz ultrasonografisi ile saptamak ve KTS'li hastaların değerlerini kontrol grubu değerleri ile karşılaştırmak.

**Hastalar ve Yöntem:** KTS'li hastalar ve control grubu klinik, elektrofizyolojik ve ultrasonografik olarak üç kör araştırmacı tarafından değerlendirildi. Elektrofizyolojik olarak median ve ulnar sinir iletim çalışmaları yapıldı. Ultrasonografik değerlendirmede median sinir kesitsel alan ölçümleri hamatum çengeli, psiform kemik ve radioulnar eklem mesafesinden ölçüldü. Omuz eklemi, biseps, subskapularis, supraspinatus, infraspinatus tendonları, rotator manşon ve akromyoklavikular eklem standart bir yaklaşımla değerlendirildi.

**Bulgular:** Çalışma 30 KTS ve 30 kontrol grubu hastasıyla tamamlandı. KTS'li hastalarda omuz ağrısı sıklığı %53.3 iken kontrol grubunda %30 bulundu, istatistiksel fark saptanmadı (p=0.16; p>0.05). KTS'li hastalarda ultrasonografik olarak subdeltoid bursit anlamlı olarak fazla iken (p=0.03) diğer parametreler için her iki grup arasında fark saptanmadı.

**Sonuç:** KTS'li hastalarda omuz ağrısı ve subdeltoid bursit sık görülmesine rağmen omuz ağrısı tek başına bu bulguya dayanmamaktadır. Omuz ağrısının santral sensitizasyon mekanizmaları ile gelişmesi muhtemeldir.

**Anahtar kelimeler:** Karpal tünel sendromu, Ultrasonografi, Omuz ağrısı, Santral sensitizasyon,

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## Introduction

Carpal tunnel syndrome (CTS) is the most frequent peripheral neuropathy. It occurs by the entrapment of the median nerve at the wrist. The prevalence in the population has been reported as 3.8% [1]. The clinical presentation of CTS is pain, numbness, burning, tingling in the distal distribution of median nerve. These symptoms tend to be worse at night and increase with median nerve compression tests (eg: Tinel and Phalen tests). Weakness of the thenar muscles can also be observed in severe cases [2].

In CTSsensory symptoms are usually determined in the median nerve innervation area in hand (thumb, index, middle finger and the radial side of the ring finger). However, the sensory symptoms can also be seen out of median nerve distribution. Pain or paraesthesia can referred commonly to wrist, forearm or arm in CTS [2,3]. Many studies have reported that the pain spread to extramedian areas and proximal part of the upper extremity. This phenomenon has contributed to central sensitization [3-6]. Additionally, patients with CTS complain shoulder pain frequently [5,6]. In a study, proximal pain was found 45% in CTS [5], in another study 21% of patients had forearm pain, 13.8% elbow pain, 7.5% arm pain, 6.3% shoulder pain and 0.6% neck pain [7]. Titchener et al., suggested that CTS and rotator cuff syndrome might be associated with each other and CTS was a risk factor for rotator cuff syndrome [8].

In recent years, diagnostic value of musculoskeletal ultrasound has been particularly increasing in compression neuropathies and shoulder disorders. We observed that there was no increased abnormality in shoulder ultrasound, despite the increased frequency of shoulder pain in patients with CTS. In this study, we aimed to detect the causes of shoulder pain with shoulder ultrasonography in patients with CTS and compare the findings of the patients with CTS to healthy volunteers**.**

## Patients and Methods

One hundred and twenty seven female patients and 36 female healthy volunteers were included in the study. Patients with CTS referred to the outpatient clinic of Marmara University Training and Research Hospital, Physical Therapy and Rehabilitation outpatient clinic between January 2014 and June 2014. The study was approved by the Ethics Committee of Marmara University, School of Medicine.

Patients who had symptoms of CTS at least 2 months and diagnosed with mild and moderate CTS according to electrodiagnostic studies were enrolled to the study as patient group. The control group consisted healthy subjects without symptoms of CTS and with normal electrodiagnostic findings. We used strong exclusion criteria for creating an homogenous study group and also elimination of systemic disorders. The exclusion criteria were; prior treatment for CTS such as steroid injection, splinting or surgery, history of upper extremity trauma, systemic diseases (diabetes mellitus, thyroid disorders, rheumatoid arthritis, gout arthritis, renal failure, neurologic diseases etc.), pregnancy, cervical pain, myofascial pain syndrome and fibromyalgia. Patients with concomitant polyneuropathy and radiculopathy diagnosed by electrophysiological studies were also excluded from the study. Patients with bifid, trifid median nerve, persistent median artery or space-occupying lesion determined by ultrasonography were also excluded for preventing measurement issues. The flowchart of the study design and the reason of exclusions are summarized in Figure 1. The clinical, electrophsiological and ultrasonographic assessments were done by three masked researchers.

## Clinical assessment

All clinical evaluation was performed by the same physician (MAL). Age, gender, occupation, marital status, height, weight, body mass index, concomitant disorders, previous surgery, alcohol consumption and smoking were assessed with a standardized patient assessment form. Neurological examination was performed with standard assessment including muscle strength, sensory testing (light touch, pinprick, position, temperature, vibration senses), knee and ankle stretch reflexes. Presence of Tinnel's sign, Phalen's test, tenar atrophy were examined. Pain in median nerve innervation area was measured with visual analogue scale (VAS). Proximal pain was defined as the presence of pain in upper extremity in any site proximal to the wrist except to the neck with hand symptoms. Presence of proximal pain was recorded in CTS patients.

Katz hand diagram was used for diagnosing clinical CTS [9]. Patients were asked to mark as accurately as possible the areas of pain, paresthesia and/or numbness. Katz hand diagram classified patients into four groups: classic pattern, probable pattern, possible pattern, unlikely pattern. The specificity and sensitivity of Katz hand diagram was found as 70% and 79% percent in Turkish population [10. The patients with classic and possible pattern were accepted to CTS group and classic, probable and possible pattern excluded from healthy group.

Boston Questionnaire was proposed for clinical standardization for CTS patients. Turkish version of the questionnaire has established validity and reliability [11]. Both groups filled out the Boston Questionnaire which is a self-administered disease specific questionnaire for the assessment of the severity of symptoms and functional status in CTS based on two scales. The symptom severity scale is comprised of 11 questions, and the functional status scale includes 8 questions. The assessment of each question was on a scale of 1 point to 5 points, in which 1 indicates no symptom, and 5 indicates severe symptoms [12].

Presence of shoulder pain in the last week has been asked to both groups and clinical examination has been performed for the shoulder. Range of motion and provocative tests (Hawkin's, Speed's, Yergeson's, Neer's) were evaluated.

Hawkin's test is positive if there is a pain with flexed shoulder and elbow to 90º and forcible internal rotation of the shoulder. The sensitivity is 83-92%, specificity is 38-56%. In Neer's test, while the patient's position is elbow extension, forearm pronation and thumbs down, patient's shoulder is carried to extension. Test is positive if there is a pain. The sensitivity is 75-88%, specificity is 31-51% according to literature. These two tests were used to assess shoulder impingement syndrome clinically. Yergeson's test is done with the elbow flexed to 90 º, with the forearm in pronation. The examiner holds the patient's wrist to resist supination and then directs active supination against his or her resistance. Pain localizes in bicipital grove. The sensitivity is 37%, specificity is 86% for detecting biceps tendinopathy. Positive Speed's test is pain in bicipital grove with resisted flexion of shoulder with extension of the elbow and forearm supination. The sensitivity and specificity of Speed's test for bicipital tendinopathy were %68-89 and %14-55 [13].

## Nerve conduction studies and median nerve ultrasonography

Nerve conduction studies (NCS) and median nerve sonography were performed by the same physician (BMK) who was blind to clinic evaluation and shoulder sonography results. NCS were done with Medtronic-Keypoint (Denmark, 2007) device and under standard room temperature of 25ºC. Hand temperature was maintained at 32ºC or greater. Median motor NCS were recorded with surface electrodes from abductor pollicis brevis muscle. The standard distance between stimulation at wrist and recording electrode was 8 cm. Median, ulnar motor nerve proximal and distal latencies, motor nerve conduction velocities, compound muscle action potential amplitudes were measured. Median sensory NCS were recorded with wire electrodes from third digit antidromically with standard distance of 14 cm. Ulnar sensory NCS were recorded from 5th digit with standard distance of 13 cm. For all sensory NCS, distal latency, sensory nerve action potential amplitude and sensory nerve conduction velocity were measured. The latencies were marked at the onset of first negative peak and the amplitudes were determined from peak to peak. Median and ulnar motor NCS were recorded with cup electrodes from 2nd lumbrical-interosseous muscle. The stimulation points were over the carpal tunnel for median nerve and Guyon canal for ulnar nerve with standard distance of 9 cm. Electrophysiological diagnosis of any neuropathy was obtained according to normative values of our laboratory. The measures greater than 3.7 ms for median motor nerve distal latency, and median sensory nerve velocity slower than 50 m/s for wrist-3rd digit segment were used for median nerve demyelination criteria. The differences more than 0.4 ms for latency difference of median nerve and ulnar nerve with 2nd lumbrical-interosseous difference was another criterion for median neuropathy. The severity of CTS was defined as mild, moderate and severe CTS electrophysiogically according to the American Association of Neuromuscular and Electrodiagnostic Medicine (AANEM) guideline. Prolonged sensory latency and/or decreased sensory nerve action potential amplitude with normal motor studies was defined as mild CTS. In addition prolonged sensory latency and delayed median motor distal latency were accepted as moderate CTS. In the presence of axon loss (absence or low amplitude of median sensory nerve action potential, absence or low amplitude of median motor nerve action potential, a needle EMG with fibrillation potentials or motor unit potential changes) were mentioned severe CTS [14].

Both the median nerve and shoulder ultrasonography examinations were performed by a 6-18 MHz linear array probe (Esaote Mylab 60, Italy). All examinations were performed with the participants in a supine position for median nerve ultrasonography. The nerves were viewed in axial plane. The transducer was kept perpendicular to median nerve. Nerve cross-sectional areas were measured at hamatum hook, psiform bone, radio-ulnar joint. The cross-sectional area was measured by tracing the nerve just inside its hyperechoic rim. Three different measurements were obtained and the average measure was used for each level. If there was bifid or trifid median nerve, persistent median artery or space-occupying lesion, the patient or healthy subject was excluded from the study.

## Shoulder ultrasonography

Bilateral ultrasonography examination of shoulders, for each patient and control subject, was performed by physician with 5 years of experience in musculoskeletal ultrasonography. The radiologist was blind to clinic evaluation, electrophysiological and median nerve ultrasonography results. Shoulder joint, axial and longitudinal biceps tendon, subscapularis tendon, supraspinatus tendon, infraspinatus tendon, rotator cuff, acromioclavicular joint were evaluated with a standardized scanning protocol [15-18]. The biceps tendon groove was evaluated in short and long axis while the patient seated with the arm held in neutral position, the elbow flexed to 90˚ and the forearm in a supinated position on the thigh. Subscapularis tendon was examined while the patient externally rotated the shoulder with the elbow flexed at 90˚. For supraspinatus tendon imaging the transducer was placed to scan supraspinatus tendon while the patient was asked to put their hand on back. Subacramial- subdeltoid bursa was also examined in this position. Infraspinatus tendon was examined from behind the shoulder with the arm in neutral position. The shoulder joint was also assessed in this position. Acromioclavicular joint was examined in coronal plane with the arm in neutral position. The rotator cuff was viewed in transverse plane while the patient was asked to put their hand on back.

The ultrasound findings were investigated by a dichotomous evaluation according to following criteria.

Biceps tendinitis: Thickness of hypoechoic halo of fluid surrounding to biceps tendon greater than 2 millimeters.

Subacramial- subdeltoid bursitis: Fluid with bursa greater than 2 millimeters in thickness.

Shoulder joint synovitis: Distance from posterior labrum to posterior infraspinatus tendon greater than 2 millimeters.

Subscapularis, supraspinatus, infrasupinatus tendinitis: Absents of tendon homogeneity and presence of at least partial thickness tear.

Rotator cuff tear: At least abnormal non homogenous echogenicity. Diffuse cuff hypoechogenicity with cuff thickening and subacromial bursitis, presence of cuff discontinuity, local loss of anterior arc, segmental loss of convex cuff contour, non-visualization of the rotator cuff tendons were also accepted as rotator cuff abnormality.

Acromioclavicular hypertrophy: Bone erosion, fluid and hypertrophic changes in acromioclavicular joint.

## Statistical Analyses

The statistical analyses were performed with Statistical Package for the Social Science Program (SPSS Version 10.0). The main characteristics of patients were evaluated with descriptive studies. Comparison of the mean values of NCS parameters was performed with Mann Whitney U test and categorical values were analyzed with chi-square tests. *P* values lower than 0.05 were accepted as statistically significant.

## Results

One hundred twenty seven patients with clinically diagnosed CTS and 36 healthy subjects were evaluated at baseline. The study was completed with 57 hands of 30 patients with CTS and 60 hands of 30 healthy subjects.

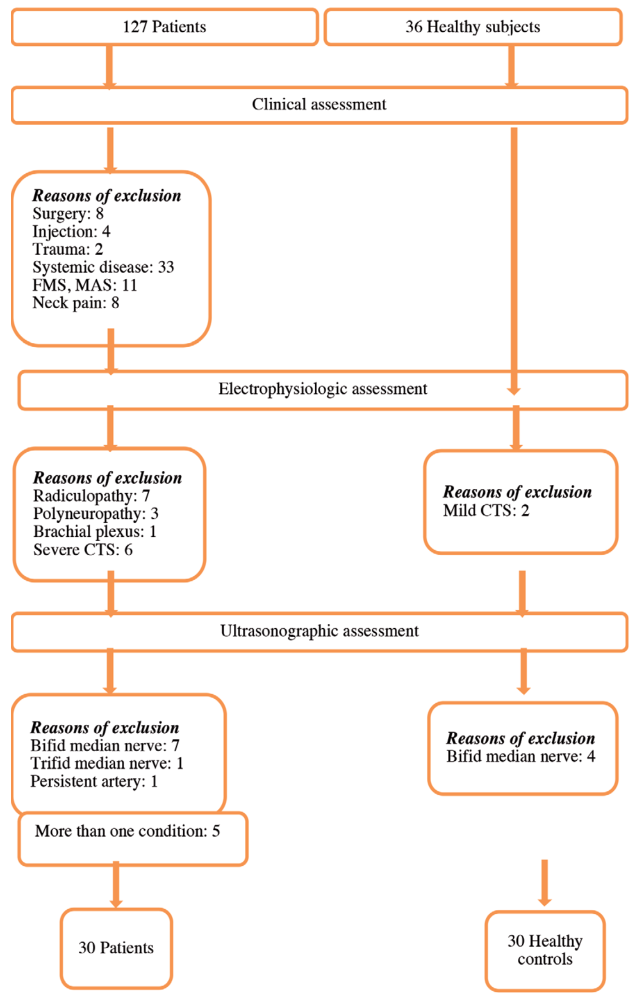


**Fig. 1.** Flowchart of the study design. *FMS: Fibromyalgia syndrome, MAS: myofascial pain syndrome*

Patient and control groups were similar according to age and body mass index (Table I). All of the patients and subjects of the control group were female and had right hand dexterity.

**Table I.** Demographic characteristics of the groups

| | CTS group | Control group | Statistical analysis |
|---|---|---|---|
| Age | 42.53±8.30 | 39.30±9.60 | F:0.29 p=0.168 |
| Body mass index | 30.75±6.42 | 29.33±5.52 | F:0.94 p=0.362 |

There were statistically significant difference in wrist pain, symptom severity score and functional capacity scores (p=0.001, p=0.001, p=0.003) between groups. In CTS group, Tinel and Phalen tests were significantly positive (p=0.001 for all) and ultrasonographic measurements of the median nerve cross-sectional area were increased significantly at three levels (p=0.001 for all) (Table II).

**Table II.** Clinical features and median nerve cross-sectional area measurements

| | CTS group | Control group | Statistical analysis |
|---|---|---|---|
| Wrist pain | 6.21±2.42 | 0 | F:128.62 p=0.001 |
| Symptom severity score | 2.74±0.66 | 1.90±1.04 | F:16.3 p=0.001 |
| Functional capacity scores | 2.89±1.28 | 1.93±1.10 | F:0.38 p=0.003 |
| Median nerve CSA radio-ulnar joint | 9.75±1.39 | 7.86±1.06 | F:4.64 p=0.001 |
| Median nerve CSA pisiform bone | 11.63±2.40 | 8.28±0.95 | F:40.41 p=0.001 |
| Median nerve CSA hamatum hook | 13.03±2.27 | 8.50±1.41 | F:18.86 p=0.001 |

*CSA*: *Cross-sectional area*

The presence of shoulder pain in the last week was 53.3% in the CTS group, 30% in the control group but there was no statistically significant difference between the groups (p=0.16; p>0.05). Proximal pain was found 56.7% in patient group. There was no difference in range of motion measurements, in Hawkin's and Neer's tests. There was statistically significant difference in Speed's and Yergeson's tests (p=0.03) n both groups. Clinical evaluation of the shoulders was summarized in Table III.

**Table III.** Clinical findings of the groups

| | CTS group | Control group | Statistical analysis |
|---|---|---|---|
| Clinical features | Positive/total (%) | Positive/ total (%) | |
| Shoulder Pain | 16/30 (%53,3) | 9/30 (%30) | P=0.16 |
| Hawkin's | 8/57 (%14) | 10 /60 (%16,7) | P=0.69 |
| Neer's | 7/57 (%12,3) | 8/60 (%13,3) | P=0.86 |
| Speed's | 8/57 (%14) | 0/60 (%0) | P=0.03 |
| Yergeson's | 8/57 (%14) | 0/60 (%0) | P=0.03 |

In ultrasonographic evaluation of the shoulder, subdeltoid bursitis was significantly more common in CTS group (P=0.03). There were no significant difference in shoulder joint, axial and longitudinal biceps tendon, subscapularis tendon, supraspinatus tendon, infraspinatus tendon, rotator cuff, acromioclavicular joint parameters between the two groups (Table IV). At least one abnormality was seen 33.3% in CTS group and 20%, in healthy group. There was no statistically significant difference in overall abnormal shoulder ultrasonography findings between the two groups(p=0.16).

**Table IV.** Pathological shoulder ultrasonographic findings of the groups

| | CTS group | Control group | Statistical analysis |
|---|---|---|---|
| Ultrasonography | abnormal / total (%) | abnormal / total (%) | |
| Subdeltoid bursitis | 8/57 (%14) | 2/60 (%3.3) | P=0.03 |
| Shoulder joint | 1/57 (%1.8) | 1/60 (%1.7) | P=0.97 |
| Axial biceps tendon | 4/57 (%7) | 3/60 (%5) | P=0.64 |
| Longitudinal biceps tendon | 4/57 (%7) | 3/60 (%5) | P=0.64 |
| Subscapularis tendon | 3/57 (%5.3) | 3/60 (%5) | P=0.94 |
| Supraspinatus tendon | 2/57 (%3.5) | 7/60 (%11.7) | P=0.98 |
| Rotator cuff | 5/57 (%8.8) | 8/60 (%13.3) | P=0.43 |
| Acromioclavicular joint | 7/57 (%12.3) | 5/60 (%8.3) | P=0.48 |
| Infraspinatus tendon | 0/57 (%0) | 2/60 (%3.3) | P=0.16 |

In CTS group, there were 30 hands with mild CTS, 27 hands with moderate CTS. In hands with moderate CTS, significantly increased median nerve cross-sectional area at hamatum hook level was found (p=0.01). There was no difference in other levels. There were no differences regarding shoulder pain, proximal spread, shoulder examination and shoulder ultrasound findings between mild and moderate CTS patients (p>0.05).

Subgroup analysis was performed for patients with CTS. There were 20 painful shoulders and 11 of them had at least one ultrasonografic finding. Subdeltoid bursitis was detected in eight shoulders and seven of them also had pain. In four of these shoulders, additional ultrasonographic findings (rotator cuff pathology, biceps tendinitis, acromioclavicular joint hypertrophy vb.) were observed. Yergason's and Speed's tests are known to be associated with biceps tendinitis. These two tests were significantly common in patients with CTS, however there was no correlation with ultrasonographic bicipital tendinitis. Clinical and ultrasonographic findings of CTS patients with shoulder pain were summarized in Table V.

**Table V.** Clinical and ultrasonographic findings of CTS patients with shoulder pain

| Patient | CTS severity | Clinical tests | Shoulder ultrasonografic findings |
|---|---|---|---|
| 1 | Mild | Negative | Negative |
| 2 | Mild | Negative | Negative |
| 3 | Mild | Hawkin's, Neer's, Speed's, Yergason's | Negative |
| 4 | Moderate | Negative | Subdeltoid bursitis |
| 5 | Mild | Negative | Negative |
| 6 | Mild | Negative | Supraspinatus tendinitis |
| 7 | Moderate | Negative | Negative |
| 8 | Moderate | Negative | Negative |
| 9 | Mild | Hawkin's, Neer's, Yergason's | Rotator cuff rupture, acromioclavicular joint hypertrophy |
| 10 | Mild | Hawkin's, Speed's | Subdeltoid bursitis, Rotator cuff rupture |
| 11 | Moderate | Negative | Negative |
| 12 | Mild | Hawkin's, Neer's, Speed's, Yergason's | Biceps tendinitis |
| 13 | Moderate | Hawkin's, Speed's, Yergason's | Biceps tendinitis, Supraspinatus tendinitis, Subscapularis tendinitis |
| 14 | Moderate | Hawkin's, Neer's, Speed's, Yergason's | Biceps tendinitis, Subdeltoid bursitis |
| 15 | Moderate | Hawkin's, Neer's, Speed's, Yergason's | Subdeltoid bursitis, Subscapularis tendinitis, Acromioclavicular joint hypertrophy |
| 16 | Moderate | Negative | Subdeltoid bursitis |
| 17 | Mild | Neer's, Speed's, Yergason's | Subdeltoid bursitis |
| 18 | Moderate | Negative | Negative |
| 19 | Mild | Negative | Negative |
| 20 | Mild | Hawkin's, Neer's, Speed's, Yergason's | Subdeltoid bursitis, biceps tendinitis |

## Discussion

Because of high frequency of shoulder pain in patients with CTS, some theories have been proposed to explain this situation. For example; Nirschl suggested a ''mesenchymal syndrome''. According to this theory, if there is rotator cuff tendinosis, there is also a predisposition to tendinosis at multiple sites as lateral and medial epicondylitis, carpal tunnel syndrome, de Quervain disease, and trigger finger and these disorders can be seen concomitantly [19]. Titchener et al., found that CTS and rotator cuff syndrome accompany each other and put forward that CTS is a risk factor for rotator cuff syndrome in a retrospective study [8]. In our study, the frequency of shoulder pain was 53.3% in the CTS group. However, this high rate of shoulder pain did not provide statistically significant difference between the two groups. Because the age and gender matched control group also had a frequency of 30% in shoulder pain. In our study, we did not include all patients with CTS. We excluded the patients with severe CTS and also patients with systemic diseases like fibromyalgia and various neurological disorders. We think that because of these reasonsthe results did not reach to statistical significance.

The aim of our study was investigate peripheral causes of shoulder pain in patients with CTS. Unlike to the literature, rotator cuff problems were similar between the two groups in our study. However, subdeltoid bursitis was significantly higher in the CTS group. There may be two possible explanations to this. First, both CTS and subdeltoid bursitis had similar aetiology such as repetitive trauma. Second, ultrasonography may have low specificity for diagnosis of subdeltoid bursitis.

Apart from the rotator cuff problems, extramedian and proximal pain in CTS patients also can be associated with central sensitization and plasticity which was demonstrated by recent studies [5,6,20]. Central sensitization can be defined as an increased pain response of the central nervous system after nociceptive stimulation. In addition to central sensitization, peripheral nerve and dorsal root ganglion sensitization was hypothesized for extramedian and proximal pain in CTS [20]. In a study, widespread pressure hypersensitivity was determined in unilateral CTS. Lower pressure pain thresholds were found in bilateral radial, ulnar, and median nerves, C5-C6 facet joint and tibialis anterior muscle suggesting central sensitization [21]. Tecchio et al., have reported that patients with CTS complaining of paraesthesia in extramedian distribution exhibited an enlargement of the hand cortical sensory representation evaluated by magneto-encephalography [22]. These authors suggested that the continuous sensory bombardment from the median nerve might trigger cortical plastic changes. In another study, Zanette et al., (6) did not find association between proximal pain and central sensitization. They hypothesized that proximal pain may represent referred pain and activation of specific A delta and C-fibre populations may cause proximal spread in CTS. In our study, twenty painful shoulders were analyzed and in nine of them there was no ultrasonographic pathology. . We thought that there was a complex interaction with mechanical pathologies such as shoulder abnormality and central sensitization. The absence of abnormalities in ultrasound suggested that the high rates of shoulder pain and proximal pain can be related to central sensitization. The frequency of proximal pain was also increased (56.7% ) in patients with CTS in our study and the results were similar to the study of Zanette et al which documented 45% proximal pain [5].

In physical examination findings, Speed's and Yergason's tests were significantly more positive in the CTS group. These tests are known to be associated with biceps tendinitis but biceps tendinitis was not correlated to ultrasonography. This finding can be explained by the low sensitivity of Yergeson's and Speed's tests. These tests are provoking the pain and central sensitization might be the cause of high positivity rates in these patients. The clinical tests of shoulder should be performed carefully in patients with CTS.

The severity of CTS was found to be associated with extramedian and proximal pain. The pain was found commonly and more severe in patients with mild CTS [5,6]. In our study, the severity of CTS had no correlation with proximal spread, shoulder pain, or shoulder ultrasonographic evaluation. Our findings were in contradiction with previous studies.

In our study, clinical, electrophysiological, and ultrasonographic assessments were done by three masked physicians. A homogeneous group of patients was able to be created because of strict inclusion and exclusion criteria. All of the assessments were done in previously standardized methods. Despite the strength of the study, we had also some limitations. These are limited number of patients and subjectivity of ultrasonographic evaluation. Limited number of patients was due to strict exclusion criteria. The second problem was a general problem for all ultrasonographic trials but it was minimized by using literature based standardization and achieving the ultasonographic assessments performed by the same experienced physician.

This study demonstrated that shoulder pain was common in CTS patients regardless of the severity. Shoulder pain may be due to mechanical reasons such as shoulder abnormalities, however there were also similar amount of abnormalities in the control group. Additionally, in some patients with shoulder pain there was no abnormality in ultrasound. This finding suggested that central sensitization may also be a reason for shoulder pain. And shoulder examination tests may be misleading to demonstrate mechanical causes because of central sensitization.

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