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Original Research Article

Ultrasonographic Evaluation of the Radial Nerves in Patients with Unilateral Refractory Lateral Epicondylitis

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Abstract

Objective. To evaluate the possible radial nerve entrapment of patients with unilateral refractory lateral epicondylitis (LE) by using ultrasound (US) and electroneuromyography.

Design. Cross-sectional study.

Setting. Three physical medicine and rehabilitation departments.

Subjects. Consecutive 44 patients (15 M, 29 F) with unilateral refractory LE.

Methods. All patients underwent detailed clinical, electrophysiological and ultrasonographic evaluations. Ultrasound imaging was used to evaluate thickness and presence of abnormal findings of the common extensor tendon (CET) and cross-sectional area (CSA) of the radial nerve (at spiral groove and before bifurcation) bilaterally. Unaffected sides of the patients were taken as controls.

Results. When compared with the unaffected sides, CET thickness and radial nerve CSAs (at both levels) were higher, and abnormal US findings regarding LE (47.7% vs. 6.8%) were more common on the affected sides than nonaffected sides (all $P < 0.001$). Grip strength values were lower on the affected sides ($P < 0.001$). Electrophysiological studies were all normal, and similar between the two sides (all $P > 0.05$). When subgroup analyses were performed after taking into account the hand dominance, affected and dominant sides were found to be the same in 31 and different in 13 patients. In subgroups, CETs and radial nerve CSAs at both levels were higher on the affected sides (all $P < 0.01$).

Conclusions. Radial nerves and the CETs seem to be swollen on the affected sides, independent from the hand dominance of the patients with refractory LE. These results morphologically support the previous literature that attributes some of the chronic complaints of these patients actually to radial nerve entrapment.

Key Words. Lateral Epicondylitis; Radial Nerve; Ultrasound; Electrodiagnosis; Cross-Sectional Area; Grip Strength

Introduction

Lateral epicondylitis (LE), also known as tennis elbow, refers to a painful condition at or around the lateral epicondyle of the humerus and common extensor tendon (CET) that is aggravated by dorsiflexion and/or supination of the wrist against resistance. Pain reproduced on palpation of the lateral epicondyle may also radiate along the forearm [1–3]. Tenderness, as well as weakness during gripping, may accompany the clinical picture. Although its etiology is still not well defined, several factors such as occupational or recreational activities have been proposed [4]. History and physical examination including manual provocation tests are key elements for the diagnosis [5,6]. Although diagnostic methods including magnetic resonance imaging, ultrasound (US), x-ray, and even electrophysiological evaluations are usually not required initially, they can provide additional information as regards the underlying abnormalities especially in chronic cases resistant to medical treatment [7]. Aside from the aforementioned factors, in refractory cases, radial nerve entrapment around the elbow has also been implicated [8,9].

Ultrasound imaging of the CET is an important complementary method to the clinical diagnosis of LE. It provides information about the severity of the disease with evidence of tendon thickening, focal/diffuse areas of decreased echogenicity in the tendon, epicondylar cortical irregularity or spur formation, and increased vascularity in case of local inflammation depicted by power-Doppler imaging [10,11]. Herewith, in refractory cases, US might well provide substantial imaging for other likely (accompanying) pathologies.

Since our literature review (in PubMed and Google Scholar using the key words like “radial nerve,” lateral epicondylitis,” “ultrasound,” and “electromyography”), yielded no studies on radial nerve problems in patients with clinical refractory LE using US imaging and electroneuromyography, in this study, we aimed to evaluate the relationship of radial nerve entrapment in the etiology of LE. Further, we also tried to find out whether the clinical, ultrasonographical, and electrophysiological data showed any correlation.

Methods

Participants

Between November 2014 and October 2015, subjects with pain in the lateral aspect of the elbow were recruited from three physical and rehabilitation medicine departments. They were enrolled in the study if refractory LE was diagnosed with the presence of pain in the elbow region at least for three months, flares with activity, and tenderness at or within 2 cm of the lateral humeral epicondyle on resisted extension of the wrist and/or the third finger. Participants who had constant or radicular pain, any previous surgery or acute trauma in the upper extremity, elbow deformity, bilateral symptoms, and clinical or electrophysiological findings referable to peripheral nerve (ulnar and median) disease were excluded. Following local ethics committee approval for the study, informed consent was obtained from each and every subject.

Clinical Assessment

Demographic data was obtained including age, sex, education, the use of the injured arm, symptom duration, and symptomatic and dominant sides. Severity of average pain during the day was evaluated using visual analog scale (VAS) (0, no pain; 100 mm, maximum pain). Local tenderness to pressure on the lateral epicondyle was assessed with a 0–3 point scale (absent, mild, moderate, severe) [12]. Grip strength measurements were performed at the second handle position and an average of three readings in kilograms with a Jamar dynamometer (Baseline Hydraulic Hand Dynamometer, Irvington, NY, USA) were noted [13].

Electrophysiological Evaluation

All electrodiagnostic tests were performed using Medelec Synergy equipment (Oxford, UK). Bilateral motor and sensory studies were performed for median, ulnar, and radial nerves according to Oh’s protocol [14]. In addition, needle electromyography of the extensor digitorum communis muscle was evaluated only on the affected side.

Ultrasonographic Evaluation

All ultrasonographic examinations were performed by a single physiatrist with more than three years of experience in musculoskeletal US. A 7–12-MHz linear array transducer (Logiq P5, GE, Medical Systems, USA) was used. For scanning the CET, the probe was placed on the lateral epicondyle and aligned parallel to the long axis of the extensor tendons while the elbow was kept in 90° flexion, and the forearm in mid-supination resting on a table. The morphologic characteristics of the CET (echotexture, calcification, tear) and its insertion (spur, erosion, irregularity) were initially assessed. The thickness of the CET was determined from a static image taken with a longitudinal scan selected by the physiatrist and the length of a line perpendicular to the epitendon was measured (Figure 1). Tendon echotexture was accepted to be normal if a uniform fibrillar pattern could be followed from the musculotendinous junction to the attachment to the lateral epicondyle and hypoechogenicity was described as the loss of this normal fibrillar pattern. The presence of cortical irregularity and/or spur formation (a linear superficial strong echo) at the lateral epicondyle was also assessed [15]. Power Doppler imaging was used to evaluate blood flow signals of the CET as a sign of local inflammation.

Measurements of radial nerve were taken at two different points defined by anatomic landmarks or clinically important points as follows: spiral groove and just before the bifurcation of the nerve (into the superficial and deep branches), and around the antecubital fossa in the distal humerus) [16]. A thorough axial scanning was performed. The subjects were seated while their arms were supported by an arm rest, forearms pronated and elbows moderately flexed. Cross-sectional area (CSA) of the radial nerve was measured by tracing a continuous line around the inner borders of the hyperechoic rim (Figure 2). A mean value of three consecutive measurements was recorded for each site.

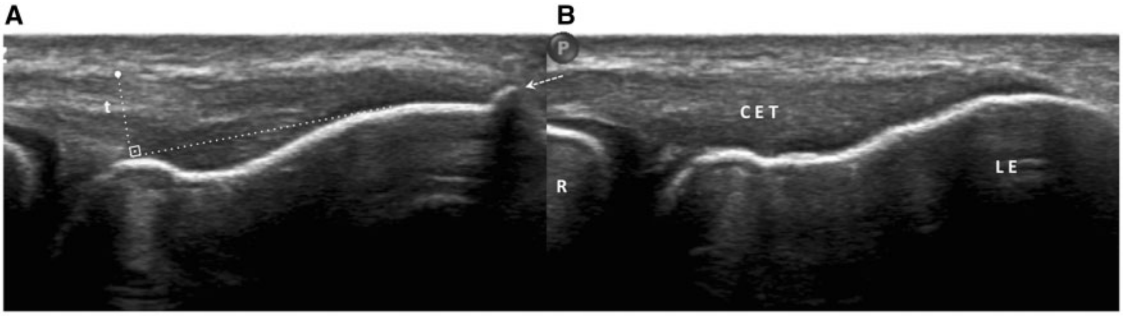

Figure 1 Longitudinal ultrasound imaging for the lateral epicondyle in a 42-year-old man with refractory lateral epicondylitis. Measurement (t) of the mildly thickened common extensor tendon (CET) is shown. Note the cortical spur (arrow) at its insertion **(A)**. Normal side **(B).** *R, radial head*.

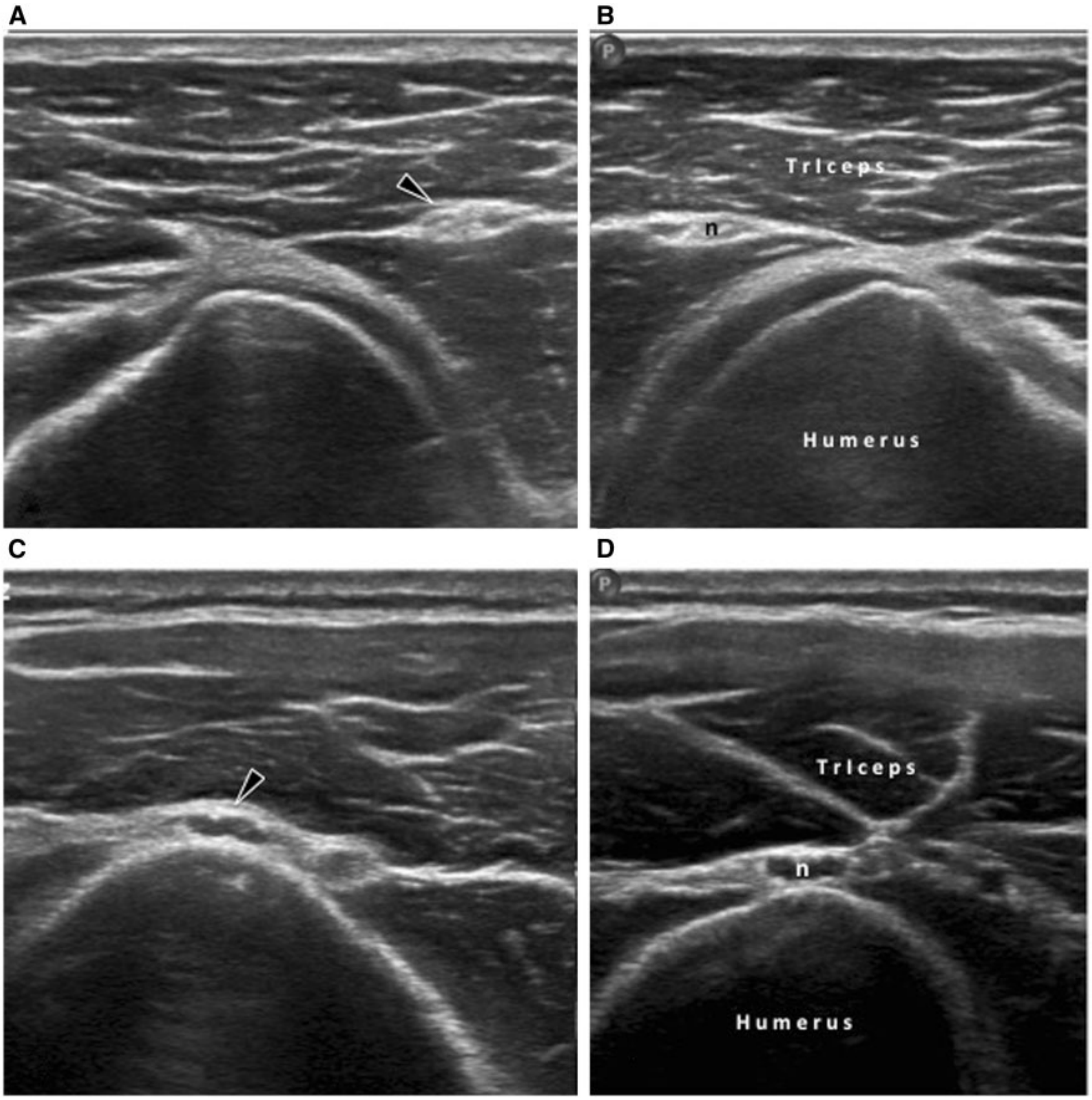

Figure 2 Transverse ultrasound imaging of the swollen (arrowheads) and normal radial nerves (n) before its bifurcation and at the spiral groove. Affected sides **(A,C).** Unaffected sides **(B,D).**

Table 1 Demographic and clinical characteristics of the patients

Characteristic	Value
Age *(years)*	47.5 ± 10.0 (26–75)
Gender *(M/F)*	15/29
Use of the affected arm	26/18
Hand dominance *(R/L)*	38/6
Duration of symptoms *(months)*	8.7 ± 6.8
Symptomatic side *(R/L)*	27/17
VAS *(0–100 mm)*	69.8 ± 14.1 (50–100)
Tenderness *(mild/moderate/ severe)*	5/24/15

Data are given as mean ± SD (min–max) or ratio.
M, male; F, female, R, right, L, left.

Table 2 Comparison of the ultrasonographic findings of the affected and unaffected sides

Variables	Affected side	Unaffected side	*P*
US findings of CET			
CET thickness (mm)	5.7 ± 0.8	5.4 ± 0.5	**<0.001**
Hypoechogenicity	10	0	**0.002**
Cortical irregularity	13	3	**0.013**
Spur formation	6	3	0.453
Power Doppler activity	4	0	0.125
US findings of radial nerve (spiral groove)			
CSA (mm^2)	6.6±2.0	5.5±1.3	**<0.001**
Hypoechogenicity	6	1	0.063
Edema	7	0	**0.016**
US findings of radial nerve (before bifurcation)			
CSA (mm^2)	8.8 ± 2.1	8.1 ± 1.6	**<0.001**
Hypoechogenicity	14	1	**<0.001**
Edema	11	1	**0.002**

CET, common extensor tendon; CSA, cross-sectional area.

Statistical Analysis

Data analysis was performed using SPSS for Windows, version 11.5 (SPSS Inc., Chicago, USA). Descriptive statistics are given as mean ± standard deviation for continuous variables, and as number (n) for categorical variables. Comparisons between the affected and unaffected sides were performed using Wilcoxon test or paired t-test (after the normality of variables was checked by the Shapiro-Wilk test) for continuous variables, and McNemar test for categorical variables. Correlations were tested using Pearson or Spearman coefficients where appropriate. Statistical significance was set at $P < 0.05$.

Results

A total of 44 patients (15 M, 29 F) with unilateral refractory LE were analyzed. Table 1 shows the demographic and clinical characteristics of the patients. Comparative US findings are given in Table 2. The CET thickness and presence of any abnormal findings regarding LE was significantly different on the affected sides of the patients (both $P < 0.001$). Affected sides showed higher CSA values of the radial nerve when compared with the unaffected sides (spiral groove, $P < 0.001$; before bifurcation, $P < 0.001$).

Electrodiagnostic studies for both upper extremities (including the radial nerves) were all normal and similar between the two sides (all $P > 0.05$). Grip strength values were lower on the affected sides (28.6 ± 10.0 kg) when compared with the unaffected sides (36.5 ± 10.2 kg) ($P < 0.001$). On the affected sides, age was positively correlated with CSA values at the spiral groove ($r = 0.313$, $P = 0.039$) and negatively correlated with the motor amplitude ($r = -0.340$, $P = 0.024$).

When subgroup analyses were performed after taking into account the hand dominance, affected and dominant sides were found to be same in 31 and different in 13 patients. In subgroups, CET and radial nerve CSA values at both levels (spiral groove and before bifurcation) were higher on the affected sides (all $P < 0.01$).

Discussion

In our study, we aimed to perform US evaluation of the radial nerves in patients with unilateral refractory LE. According to our results, radial nerves and the CETs were swollen on the affected sides, independent from hand dominance of the patients. To our best knowledge, the results of this study are unique and noteworthy.

Lateral epicondylalgia can develop due to tendinogenic, articular, vascular or neurogenic factors [8,17]. LE is a painful tendinopathy with an incidence of 1–2% [18]. It is a disease of repetitive overuse of the extensor tendons of the wrist and fingers at their origin. It is a degenerative process in which microtears develop in the musculotendinous portion of the extensor carpi radialis brevis (ECRB) and, to a lesser degree, in the CET [8]. Local inflammatory and/or vascular changes (scarring, fibrosis) may lead to compression of the radial nerve or its branches (especially the deep branch) at the radial tunnel [8,19].

At the elbow level, radial nerve lies deeply in a groove between brachialis and brachioradialis (proximally), and extensor carpi radialis (distally). It divides into the superficial and deep branches just anterior to the lateral epicondyle. There are some variations at this level; for instance, branches to extensor carpi radialis brevis (ECRB) and supinator muscles may arise from the main trunk of the radial nerve or from the proximal part of the deep branch, but almost always above the arcade of Frohse [17]. Posterior interosseous nerve (PIN) is the deep terminal branch of the radial nerve. It enters the posterior forearm by passing between the two heads of the supinator, and then it gives motor branches to all finger extensors, extensor carpi ulnaris, and abductor pollicis longus.

Radial tunnel syndrome (RTS) is a dynamic/intermittent compression neuropathy of the radial nerve near the radiohumeral joint, where different structures can potentially compress the nerve [20]. These are fibrous bands, a tendinous/fibrous arc at the superomedial margin of ECRB, radial recurrent artery, and proximal edge of the supinator muscle (arcade of Frohse) [20,21]. Some maneuvers can tighten these anatomical structures. During elbow extension, forearm pronation with wrist flexion, resisted forearm supination with wrist extension, or resisted middle finger extension may all exacerbate the symptoms [22]. RTS usually presents with pain, weakness (secondary to pain), and tenderness along the course of the radial nerve [8,23]. It often develops in the dominant arm with an insidious onset, and affects adults in the fourth to the sixth decades of life [22]. There is no sensory or motor loss. Its diagnosis is difficult/controversial due to inconclusive findings on electrophysiological tests and its close relationship with LE [22,24]. While RTS can often be the cause of refractory LE, some patients with LE actually have RTS [22]. If complete relief is achieved with a distal nerve block at the radial tunnel, the patient is likely to have pure RTS [24]. Patients with coexisting LE (18–43%) usually experience incomplete relief. Other differential diagnosis should include PIN syndrome (compression distal to the radial tunnel resulting in true motor weakness), anconeus muscle tendonitis, brachial neuritis, and De Quervain's tenosynovitis [20,25]. In our study, we believe that our patients had refractory LE concomitant with RTS. Overuse of the affected side and/or healing process of the degenerated tendon(s) might have dynamically compressed the radial nerve. Further, the swelling of the nerves more proximally (spiral groove) might be due to the likely impairment of the axoplasmic transport [26].

Electrodiagnostic studies have been used for evaluating the radial nerve involvement in RTS. Although some of those studies have found normal or insignificant changes in the affected side, others have shown increased radial nerve distal motor latency during forearm supination, or neuropathic changes on electromyography in some patients [22,24,27]. In our study, we did not find any abnormal electrophysiological findings between the affected and nonaffected sides. Ultrasound is a superior imaging modality that can be used as an adjunct to electromyography for the evaluation of peripheral nerve problems. It can be used to demonstrate swelling of the nerve proximal to the entrapment site [27–31]. In our study, two different proximal measurements revealed significant enlargement/edema of the radial nerve. This would represent useful additional imaging technique when combined with the current use of US to diagnose LE [17,32,33]. About half of our patients (21 out of 44 patients) had US-proven lesions—for example, thickening and focal hypoechoic regions in the CET, adjacent cortical irregularities, spur formation, and inflammatory activity on power Doppler imaging. Nerve echogenicity is usually assessed subjectively and based on the examiner's experience. The most commonly seen pathological changes are reduced echogenicity with loss of the fascicular echostructure [34]. Although there are studies that have evaluated the sensitivity/specificity of CSA measurements in the diagnosis of carpal/cubital tunnel syndromes, and fibular neuropathy at the fibular head [31], the pertinent literature lacks similar studies for radial nerve entrapment. Herewith, it has been reported that radial nerve CSA at the spiral groove is $3.2 \pm 1.5\,mm^2$ in healthy subjects [35].

Conclusion

Radial nerves and the CETs seem to be swollen on the affected sides of the patients with refractory LE. Our results support the previous literature that some of the chronic complaints of these patients might actually be due to radial nerve entrapment. We suggest that US may be a useful diagnostic adjunct for patients with refractory LE to diagnose radial nerve entrapment syndrome.

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