# Lateral Epicondylitis of the Elbow: US Findings[1]

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**Abbreviation:**
CI = confidence interval

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**PURPOSE:** To determine the sensitivity and specificity of ultrasonography (US) in the detection of lateral epicondylitis and identify the US findings that are most strongly associated with symptoms.

**MATERIALS AND METHODS:** Internal review board approval was obtained for retrospective review of the patient images, and the need for informed consent was waived. Internal review board approval was also obtained for scanning the 10 volunteers, all of whom gave informed consent. The study was compliant with the Health Insurance Portability and Accountability Act. US of the common extensor tendon was performed in 20 elbows in 10 asymptomatic volunteers (six men, four women; age range, 22–38 years; mean age, 29.6 years) and 37 elbows in 22 patients with symptoms of lateral epicondylitis (10 men, 12 women; age range, 30–59 years; mean age, 46 years). Fifty-seven representative images, one from each elbow, were randomly assorted and interpreted by three independent readers who rated each common extensor tendon as normal or abnormal. Abnormal images were further classified as demonstrating one or more of eight US findings. Readers interpreted each image at two separate sessions to determine intrareader variability. The authors calculated the sensitivity and specificity of US in the diagnosis of lateral epicondylitis and the odds ratio for each US finding. Odds ratios were considered statistically significant at $P < .05$ when 95% confidence intervals did not include one.

**RESULTS:** Sensitivities of US in the detection of symptomatic lateral epicondylitis ranged from 72% to 88% and specificities from 36% to 48.5%. Odds ratios for the following findings were statistically significant ($P < .05$) for both reading sessions: calcification of common extensor tendon, tendon thickening, adjacent bone irregularity, focal hypoechoic regions, and diffuse heterogeneity. Odds ratios for lateral epicondyle enthesophytes were statistically significant ($P < .05$) for the first reading session only. Odds ratios for linear intrasubstance tears and peritendinous fluid were not statistically significant.

**CONCLUSION:** US of the common extensor tendon had high sensitivity but low specificity in the detection of symptomatic lateral epicondylitis. The relationship between symptoms and intratendinous calcification, tendon thickening, adjacent bone irregularity, focal hypoechoic regions, and diffuse heterogeneity was statistically significant.



Lateral epicondylitis, also known as "tennis elbow," is an overuse syndrome of the common extensor tendon, predominantly affecting the extensor carpi radialis brevis. Lateral epicondylitis typically occurs in the 4th and 5th decades, with equal prevalence in women and men. The diagnosis of lateral epicondylitis requires history and physical examination (1–3). Patients complain of poorly defined pain located over the lateral elbow that is typically exacerbated by activities requiring wrist extension and/or wrist supination against resistance. There will often be pain in the morning as well as after any period of time that the elbow has been held in a flexed position. At physical examination, signs of lateral epicondylitis include pain at palpation over the origin of the common extensor tendon and reduced strength with resisted grip, supination, and extension of the wrist. These provocative maneuvers, along with such tests as the chair test and resisted long

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finger extension, help support the diagnosis (2). Imaging is usually reserved for cases refractory to nonsurgical treatment and for patients in whom the clinician wants to exclude other abnormalities and assess the amount of tendon damage before surgery. In general, such imaging includes radiography, computed tomography, and magnetic resonance (MR) imaging. Connell et al (4) described the ultrasonographic (US) appearance of lateral epicondylitis, and Miller et al (5) compared the sensitivity and specificity of US with that of MR imaging.

The purpose of our study was to determine the sensitivity and specificity of US in the detection of lateral epicondylitis and identify the US findings that are most strongly associated with symptoms.

## MATERIALS AND METHODS

### Subjects

Between February 2000 and December 2000, US of the common extensor tendon at the lateral epicondyle of the elbow was performed in 22 patients with symptoms of lateral epicondylitis who had been referred by the same sports medicine physician. The patient group was composed of 10 men and 12 women aged 30–59 years (mean age, 46 years). Fifteen patients underwent bilateral US examinations and seven underwent unilateral examinations. Three patients underwent a contralateral examination because of symptoms; the other 12 underwent a contralateral examination for the purpose of comparison. In addition, bilateral US was performed in 10 asymptomatic volunteers consisting of six men and four women aged 22–38 years (mean age, 29.6 years). Therefore, a total of 57 elbows (25 symptomatic and 32 asymptomatic) in 32 subjects were scanned. Internal review board approval was obtained for retrospective review of the patient images, and the need for informed consent was waived. Internal review board approval was also obtained for scanning the 10 volunteers, all of whom gave informed consent. Our study was compliant with the Health Insurance Portability and Accountability Act.

### Imaging and Interpretation

All examinations were performed by the same experienced sonographer with 5 years of musculoskeletal US experience and supervised by a musculoskeletal radiologist (L.N.N.) with 7 years of musculoskeletal US experience. Images of the common extensor tendon were obtained in the transverse and longitudinal planes from the musculotendinous junction to the insertion on the lateral epicondyle. Color, power Doppler, and harmonic scans were not obtained.

Multifrequency linear-array transducers with a peak frequency of 13 or 12 MHz were used for all cases (Siemens Elegra, Siemens Medical Systems, Issaquah, Wash; or Philips HDI 5000, Philips Medical Systems, Bothell, Wash). Fifty-seven representative hard-copy images, one from each elbow, were chosen by one of the radiologists (L.N.N.) and any identifying information was masked. The scans were randomly assorted by a radiology resident (D.L.) and interpreted by three independent radiologists. The readers were not told which elbows were symptomatic. Two of the radiologists (P.L.O., R.I.F.) were fellowship trained in US and had 3 and 12 years of postfellowship experience, respectively. The third reader (T.T.M.) was a fellowship-trained musculoskeletal radiologist with 4 years of experience in musculoskeletal US.

Each US study was classified by these radiologists as demonstrating at least one of the following findings within the common extensor tendon: linear intrasubstance tears, tendon thickening, intratendinous calcifications, adjacent bone irregularity, focal hypoechoic regions, enthesophytes at the tendon insertion site, diffuse heterogeneity of the tendon, and peritendinous fluid. A linear intrasubstance tear was defined as a linear hypoechoic focus associated with discontinuity of tendon fibers. A focal hypoechoic region was defined as being rounded and not associated with tendon disruption. Common extensor tendon thickening was subjectively evaluated. Peritendinous fluid was not specifically differentiated from intraarticular fluid. Studies were considered abnormal if at least one of the criteria were present. The same reader interpreted each image on two separate occasions at least 2 weeks apart to determine intrareader variability. The images were not randomized again for the second reading, that is, the blinded images were interpreted in the same order as for the first reading.

### Reference Standard

In our study, clinical evaluation was used as the reference standard in the diagnosis of lateral epicondylitis. Symptoms included lateral elbow and forearm pain exacerbated by activities involving resisted wrist extension. Signs at physical examination included tenderness of the lateral epicondyle at the extensor conjoined tendon origin. Although the volunteers did not undergo clinical examination, their elbows were not tender at US examination and they did not have a history of elbow problems.

### Statistical Analysis

We expected large differences in this small-scale study. This study was powerful enough to detect differences in odds ratios of at least 5.1 at 80% power with $\alpha$ of .05. Data collected from each of the three readers as well as patient symptoms were entered into a spreadsheet. The spreadsheet was converted to a data set, and all analyses were conducted by using software (SAS, version 9.0; SAS Institute, Cary, NC). The sensitivity, specificity, and accuracy in the diagnosis of lateral epicondylitis were calculated for each of the three raters for each session and for the two sessions combined, by using the PROC FREQ procedure. The positive and negative predictive valves were also calculated for each session (6). The age ranges of the patient and volunteer groups were compared with the Student *t* test.

The relationship between US findings of lateral epicondylitis and clinical symptoms was analyzed by constructing contingency tables and calculating the odds ratios and confidence intervals (CIs) (if the CI did not include one, then the relationship was considered statistically significant at the $P < .05$ level) by using the CMH option in PROC FREQ. Interreader reliability was calculated for each US finding as well as for overall impression, and intrareader reliability was also calculated for all three readers. We used the intraclass correlation–an index similar to $\kappa$, ranging from 0 to 1, which enables calculations for more than two readers (6). The intraclass correlation was calculated by using the macrocode (INTRACC) of the software.

## RESULTS

Overall, the mean sensitivity of US in the assessment of symptomatic lateral epicondylitis was 85% (61 of 75 readings) for the first session and 75% (56 of 75) for the second session. The mean specificity was 46% (44 of 96) for the first session and 42% (40 of 96) for the second session. The mean positive predictive value was 55% (64 of 116) for the first session and 50.0% (56 of 112) for the second session. The mean negative predictive

**TABLE 1**
**Sensitivity, Specificity, and Positive and Negative Predictive Values of US for the Diagnosis of Lateral Epicondylitis**

| | Sensitivity (%) | | | Specificity (%) | | | Positive Predictive Value (%) | | | Negative Predictive Value (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reader | Session 1 | Session 2 | Mean | Session 1 | Session 2 | Mean | Session 1 | Session 2 | Mean | Session 1 | Session 2 | Mean |
| A | 92 | 84 | 88 | 43.8 | 28.1 | 36.0 | 56 | 52 | 54 | 88 | 69 | 78.5 |
| B | 84 | 76 | 80 | 53.1 | 40.6 | 46.9 | 58 | 50 | 54 | 81 | 68 | 74.5 |
| C | 80 | 64 | 72 | 40.6 | 56.3 | 48.5 | 51 | 53 | 52 | 72 | 67 | 69.5 |

Note.—Results are expressed as means for readers A–C for each session individually, as well as means of the two sessions combined.

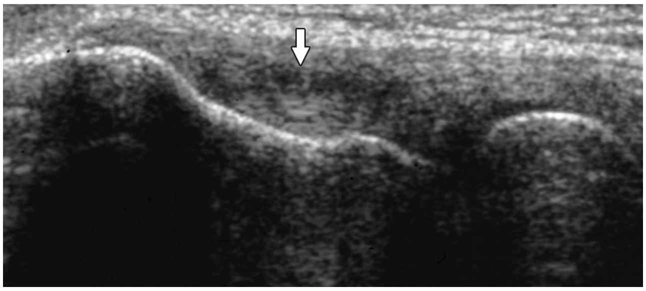

**Figure 1.** Longitudinal US scan of the common extensor tendon of the asymptomatic left elbow in a 52-year-old woman with lateral epicondylitis on the right side. A linear hypoechoic focus (arrow) is consistent with intrasubstance tear.

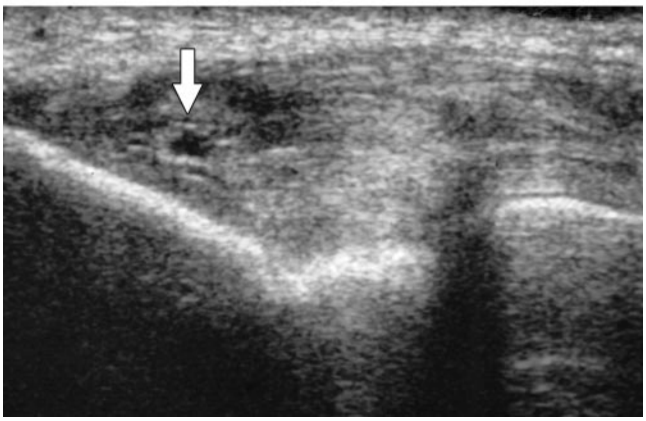

**Figure 2.** Longitudinal US scan of the common extensor tendon of the symptomatic left elbow in a 43-year-old man with lateral epicondylitis. The tendon is markedly thickened, is heterogeneous, and has hypoechoic foci consistent with intrasubstance tears (arrow).

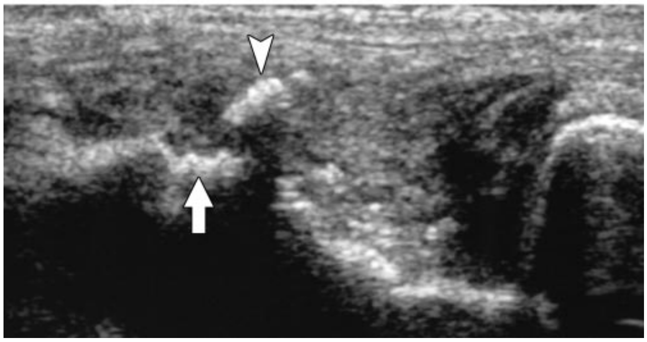

**Figure 3.** Longitudinal US scan of the common extensor tendon of the symptomatic right elbow in a 37-year-old man with lateral epicondylitis. The tendon is thickened and diffusely heterogeneous, with a calcification (arrowhead) and markedly irregular adjacent bone (arrow).

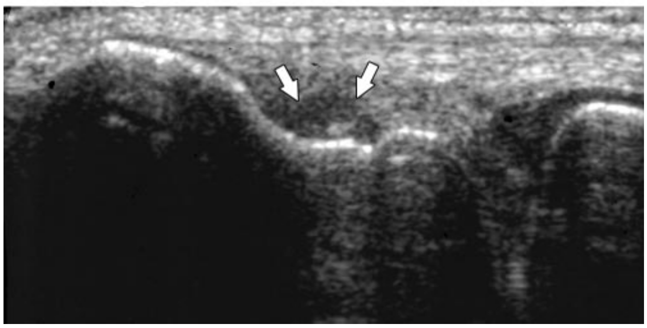

**Figure 4.** Longitudinal US scan of the common extensor tendon of the right elbow in a 30-year-old asymptomatic male volunteer. Arrows indicate a round hypoechoic area with a punctate hyperechoic focus at its deep aspect.

value was 80% (44 of 55) for the first session and 68% (40 of 59) for the second session. The mean accuracy was 63.2% (108 of 171) for the first session and 56.1% (96 of 171) for the second session. The sensitivity, specificity, and positive and negative predictive values for each reader are given in Table 1. The volunteer group was younger than the patient group ($P < .05$).

For the first session, the odds ratios relating each US finding to patient symptoms were 6.8 (95% CI: 0.8, 59.4) for linear intrasubstance tears (Figs 1, 2), 6.7 (95% CI: 3.3, 13.6) for thickening of the common extensor tendon (Fig 2), 6.2 (95% CI: 2.2, 17.5) for intratendinous calcification (Fig 3), 4.8 (95% CI: 1.5, 15.5) for adjacent bone irregularity (Fig 3), 4.0 (95% CI: 1.6, 10.2) for focal hypoechoic regions (Fig 4), 2.7 (95% CI: 1.2, 6.3) for enthesophytes at the common extensor tendon insertion site (Fig 5), 3.0 (95% CI: 1.6, 5.5) for diffuse heterogeneity (Fig 2), and 1.8 (95% CI: 0.7, 5.0) for peritendinous fluid (Fig 6).

The corresponding odds ratios for the second session were as follows: 8.3 (95% CI: 1.0, 70.2) for linear intrasubstance tears, 2.9 (95% CI: 1.5, 5.5) for thickening of the common extensor tendon, 7.8 (95% CI: 2.2, 27.9) for intratendinous calcification, 7.8 (95% CI: 2.2, 27.9) for intratendinous calcification, 4.0 (95% CI: 1.2, 13.0) for adjacent bone irregularity, 4.0 (95% CI: 1.2, 13.0) for focal hypoechoic regions, 2.3 (95% CI: 0.9, 5.9) for enthesophytes at the common extensor tendon insertion site, 2.4 (95% CI: 1.3, 4.4) for diffuse heterogeneity, and 0.8

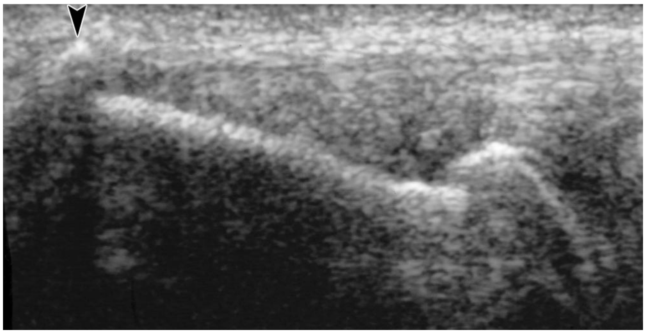

**Figure 5.** Longitudinal US scan of the common extensor tendon of the asymptomatic left elbow in a 47-year-old man with lateral epicondylitis on the right side. The tendon is mildly thickened with an enthesophyte (arrowhead) at insertion site.

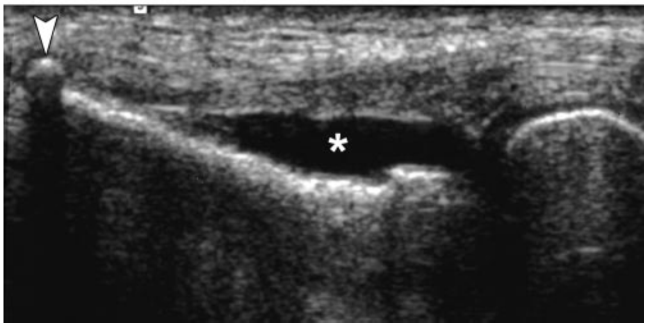

**Figure 6.** Longitudinal US scan of the common extensor tendon of the symptomatic right elbow in a 52-year-old man with lateral epicondylitis. The common extensor tendon has detached from the underlying bone, with peritendinous fluid in its place (*). Arrowhead indicates enthesophyte.

(95% CI: 0.4, 1.9) for peritendinous fluid (Table 2).

Therefore, for both reading sessions, intratendinous calcification, tendon thickening, adjacent bone irregularity, focal hypoechoic regions, and diffuse heterogeneity were all positively and significantly associated with symptoms ($P < .05$). Enthesophytes were significantly associated with symptoms for the first session but not the second session. For both sessions, linear intrasubstance tears had the highest mean odds ratio, but the relationship was not statistically significant ($P > .05$) because of high variability. Peritendinous fluid was not associated with symptoms for either reading session.

Interreader reliability among all readers for overall impression was poor, 0.22 for the first session and 0.29 for the second session. Interreader reliability among all readers for individual US findings ranged from 0.06 for peritendinous fluid to 0.49 for tendon thickening.

The mean intrareader reliability for overall impression was 0.61. Intrareader reliability for individual findings varied widely, and the weakest correlation, 0.31, was for hypoechoic regions within the tendon and the strongest correlation, 0.85, was for intratendinous calcifications.

**TABLE 2**
**Odds Ratios for US Findings of Lateral Epicondylitis**

| US Finding | Odds Ratio | |
|---|---|---|
| | Session 1 | Session 2 |
| Linear intrasubstance tears | 6.8 (0.8, 59.4)* | 8.3 (1, 70.2)* |
| Thickening of common extensor tendon | 6.7 (3.3, 13.6) | 2.9 (1.5, 5.5) |
| Intratendinous calcification | 6.2 (2.2, 17.5) | 7.8 (2.2, 27.9) |
| Adjacent bone irregularity | 4.8 (1.5, 15.5) | 4.0 (1.2, 13.0) |
| Focal hypoechoic regions | 4.0 (1.6, 10.2) | 4.0 (1.2, 13.0) |
| Enthesophytes at common extensor tendon insertion site | 2.7 (1.2, 6.3) | 2.3 (0.9, 5.9)* |
| Diffuse heterogeneity | 3.0 (1.6, 5.5) | 2.4 (1.3, 4.4) |
| Peritendinous fluid | 1.8 (0.7, 5.0)* | 0.8 (0.4, 1.9)* |

Note.—Numbers in parentheses are 95% CIs.
* Odds ratio is not statistically significant ($P > .05$).

## DISCUSSION

The term "lateral epicondylitis" is a misnomer because, pathologically, this condition consists of mucoid degeneration with a paucity of acute or chronic inflammatory cells. The condition is, therefore, more appropriately referred to as "tendinosis." It is believed that tendinosis is the result of repetitive trauma causing microtearing of the tendon. Scar tissue forms during the healing process, which is then subjected to further tearing with repeat trauma (1,3,7). Eventually, as the cycle of injury and repair continues, the patient will become symptomatic.

We found that US for symptomatic lateral epicondylitis has mean sensitivities in the 72%–88% range, which is similar to those previously reported (5). The US findings we used were adapted from two previous investigations (4,5). Most US findings—namely calcification within the common extensor tendon, tendon thickening, adjacent bone irregularity, focal hypoechoic regions in the tendon, and diffuse tendon heterogeneity—showed statistically significant correlation ($P < .05$) with symptoms in both reading sessions.

We believe that sensitivities in our study would likely have been higher if the three readers had been present during the examinations because the operator dependence of musculoskeletal US makes it difficult to review static, hard-copy images. In addition, real-time imaging enables direct correlation to tenderness and is a major advantage of US compared with other imaging modalities. Because we blinded the readers as to which elbows were symptomatic, our study design probably sacrificed accuracy in its attempt to reduce bias.

Specificities of US were quite low across all readers, ranging from 36% to 62.5%. These are lower than those from a recent study by Miller et al (5), who reported specificities in the 67%–100% range. Again, real-time imaging may have resulted in better specificities: If the readers had known which elbow was symptomatic, they may have tended to dismiss US findings in asymptomatic elbows.

Another potential reason for low specificity is that a spectrum of pathologic and US findings may be present before the onset of symptoms, thus giving a false-positive result. Martin and Schweitzer (8) have described abnormal T1-weighted signal intensity on MR images of common extensor tendons of the elbow in asymptomatic patients. Asymptomatic US findings have also been demonstrated in other musculoskeletal structures such as the ulnar collateral ligament in major league baseball pitchers (9). In addition, it has been reported that only 39% of heel enthesophytes are symptomatic (10). We therefore hypothesize that US changes can sometimes precede clinical symptoms of lateral epicondylitis just as, conversely, symptoms can sometimes precede US changes. Because the negative predictive value in our study was higher than the positive predictive value, it was more likely for an abnormal elbow at US to be asymptomatic than a normal elbow at US to be symptomatic.

Although intrareader reliability was good, interreader reliability was poor. Improved reliability statistics might have also been obtained if images had been interpreted in real time. A formal training session may have helped improve interreader reliability. Other limitations of this study include a relatively small series of patients. In addition, the sonographer may have served as a potential source of bias because he was not blinded to symptoms and may have been more likely to record abnormal images in symptomatic elbows. Also, clinical symptoms are not an optimal standard of reference, and none of these patients went on to surgery. Finally, the control group was younger than the patient group; however, the retrospective design made it difficult to match the ages of the two groups.

In conclusion, we found US to have a relatively high sensitivity but low specificity in the detection of symptomatic lateral epicondylitis. Calcification within the common extensor tendon, tendon thickening, adjacent bone irregularity, focal hypoechoic regions in the tendon, and diffuse tendon heterogeneity were all significantly associated with symptoms. Because of the high false-positive rate, US examination for lateral epicondylitis will probably be most useful for evaluating the extent of disease in patients with typical clinical presentations.

### References


1. Nirschl RP. Elbow tendinosis/tennis elbow. Clin Sports Med 1992;11:851–871.
2. Plancher KD, Halbrecht J, Lourie GM. Medial and lateral epicondylitis in the athlete. Clin Sports Med 1996;15:283–305.
3. Potter HG, Hannafin JA, Morwessel RM, Dicarlo EF, O'Brien SJ, Altchek DW. Lateral epicondylitis: correlation of MR imaging, surgical and histopathological findings. Radiology 1995;196:43–46.
4. Connell D, Burke F, Coombes P, et al. Sonographic examination of lateral epicondylitis. AJR Am J Roentgenol 2001;176: 777–782.
5. Miller TT, Shapiro MA, Schultz W, Kalish PE. Comparison of sonography and MRI for diagnosing epicondylitis. J Clin Ultrasound 2002;30:193–202.
6. Fleiss JL. Statistical methods for rates and proportions. 2nd ed. New York, NY: Wiley, 1981; 218.
7. Regan W, Wold LE, Coonrad R, Morrey BF. Microscopic histopathology of chronic refractory lateral epicondylitis. Am J Sports Med 1992;20:746–749.
8. Martin CE, Schweitzer ME. MR imaging of epicondylitis. Skeletal Radiol 1998;27:133–138.
9. Nazarian LN, McShane JM, Ciccotti MG, O'Kane PL, Harwood MI. Dynamic US of the anterior band of the ulnar collateral ligament of the elbow in asymptomatic major league baseball pitchers. Radiology 2003; 227(1):149–154.
10. Cornwall MW, McPoil TG. Plantar fasciitis: etiology and treatment. J Orthop Sports Phys Ther 1999;29:756–760.