Comparison of Sonography and MRI for Diagnosing Epicondylitis

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ABSTRACT: *Purpose.* The aim of this prospective study was to compare the sensitivity and specificity of sonography with those of MRI in evaluating epicondylitis.

Methods. The affected elbows of 11 patients with suspected epicondylitis were examined sonographically, and the contralateral (normal) elbow was also examined for comparison. In 10 of these patients, the affected elbow was also examined with MRI. In addition, both elbows of 6 volunteers without epicondylitis were examined sonographically; 1 elbow of each volunteer was designated as the ''test'' elbow and was examined with MRI. The sonograms of the patients' affected elbows and the volunteers' test elbows were paired with the sonograms of the contralateral elbows for comparison and were randomly shown twice to 2 readers. These readers, working independently and without knowledge of the findings of MRI, were instructed to state whether each elbow was normal or affected by epicondylitis. The MRI scans were then shown to the readers for similar review.

Results. Sonographic features of epicondylitis included outward bowing of the common tendon, presence of hypoechoic fluid subadjacent to the common tendon, thickening, decreased echogenicity, and ill-defined margins of the common tendon. Sensitivity for detecting epicondylitis ranged from 64% to 82% for sonography and from 90% to 100% for MRI. Specificity ranged from 67% to 100% for sonography and from 83% to 100% for MRI.

Conclusions. Sonography is as specific but not as sensitive as MRI for evaluating epicondylitis. Used as an initial imaging tool, sonography might be adequate for diagnosing this condition in many patients, thus allowing MRI to be reserved for patients with symptoms whose sonographic findings are normal. © 2002 Wiley Periodicals, Inc. *J Clin Ultrasound* **30**:193–202, 2002; Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/jcu.10063

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Lateral epicondylitis, or "tennis elbow," is caused by overuse of the common extensor tendon and primarily affects the extensor carpi radialis brevis component. This condition occurs more often than medial epicondylitis, or "golfer's elbow," which primarily affects the tendons of the flexor carpi radialis, pronator teres, and palmaris longus.[1,2] The term "epicondylitis" is actually a misnomer, because the condition does not feature an inflammatory component; instead, pathologic findings range from mucinous degeneration and neovascular proliferation within the tendon to partial and complete tearing.[2–4]

Investigators have studied the relationships among the findings of MRI, surgery, and histopathologic examination in patients with epicondylitis[3,5] and have described the various characteristics of this condition on both MRI scans[5,6] and sonograms[7,8] but have not compared the accuracy of the 2 modalities. We sought to determine whether sonography is a reasonable alternative to MRI for the diagnosis of epicondylitis by comparing the sensitivity and specificity of both modalities.

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PATIENTS AND METHODS

Patients

Patients with pain in the medial or lateral aspect of the elbow who were referred to our office for evaluation with MRI and who agreed to undergo sonography only for the purpose of this prospective study were enrolled. All patients had a clinical diagnosis of epicondylitis. The patients' symptoms consisted of pain in the epicondylar region that was elicited by palpation, making a tight fist, or forced dorsiflexion of the wrist. All patients had been referred by an orthopedic surgeon for confirmation of the clinical diagnosis and for preoperative assessment.

Healthy volunteers who had neither a history of elbow injury nor current elbow pain were also included in the study and underwent sonography of both elbows and MRI of 1 elbow.

MRI Examinations

MRI was performed using a 1.5-T unit (Horizon; GE Medical Systems, Milwaukee, WI). During MRI, 6 patients were imaged in a prone position with the arm extended above the head in an attempt to position the joint at the center of the magnet. Coils were selected on the basis of each patient's body habitus and ability to tolerate positioning. We used an extremity coil in 2 cases, a small, flexible wraparound coil in 2 cases, a phased-array shoulder coil in 1 case, and dual 3-inch coils placed anteriorly and posteriorly on the elbow joint in 1 case. Four patients could not tolerate the prone position and were imaged in a supine position with the arm at their side; the small, flexible wraparound coil was used for 3 of these patients, and the dual 3-inch coils were used for the other patient. All volunteers were imaged in a prone position using an extremity coil.

Scanning was performed in planes coronal and axial to the elbow joint and consisted of T1-weighted spin-echo sequences (400–600/11–20 [repetition time (TR)/echo time (TE), in milliseconds], 256 × 192 matrix, 12–14-cm field of view, 3-mm slice thickness [with no interslice gaps], and 1–1.5 signals averaged) and frequency-selective fat-suppressed fast spin-echo sequences (3,000–5,500/35–57 [TR/effective TE, in milliseconds], 8 echo train, 256 × 192 matrix, 12–14-cm field of view, 3-mm slice thickness [with no interslice gaps], and 2 signals averaged). For the volunteers, only the frequency-selective fat-suppressed fast spin-echo sequence in the coronal plane was performed.

Sonographic Examinations

Sonography was performed using an HDI 3000 ultrasound scanner (Advanced Technology Laboratories, Bothell, WA) equipped with a 5–10-MHz linear-array or compact transducer that adjusts automatically depending on the focal zone and tissue depth. All patients were seated facing the operator. The affected arm of the subject was extended forward, with the elbow slightly flexed and either with the hand supinated and resting on the knee or with the forearm supported by the operator. The transducer was slightly oblique to the long axis of the upper extremity so that the longitudinal course of the common flexor or extensor tendons could be imaged. Sonography of the contralateral (asymptomatic) elbow was performed for comparison in all but 1 patient, in whom it was erroneously omitted.

All sonography was performed by 1 investigator (T. T. M.), who knew the identity of each subject, the clinical diagnosis, and the findings of MRI but who was not a reader. Because coordinating the presence of the readers for sonography posed difficulty and because video recording was not available, the readers interpreted static sonograms. Each sonogram used for interpretation was selected by the investigator who performed the sonography as being the most representative image.

Image Analysis

Sonograms of the patients' affected elbows and the normal volunteers' arbitrarily designated "test" elbows were paired with the sonograms of the contralateral elbows. The sonogram pairs were combined in random order into an image set by 1 investigator (T. T. M.). This image set was reviewed by the 2 readers: a musculoskeletal radiologist (E. S.) and a body imager (M. A. S.). Both readers have experience in musculoskeletal sonography and MRI and had undergone preliminary practice sessions in which they reviewed sonograms from past cases used for instructional purposes. The readers independently reviewed the pairs of sonograms and designated each pair as showing either normal elbow or epicondylitis. After 1 week, the images were reshuffled to avoid eliciting a memory response by the readers, who then reviewed the images again. The readers were unaware of the MRI findings, the results of the clinical examination, the numbers of patients and volunteers included in the study, and the identity of each subject. The readers were told which elbow was the study elbow and which was the control, however, because this information is known in a clinical setting.

Sonographic criteria for the diagnosis of epicondylitis included thickening or thinning of the tendon, altered echogenicity as compared with the contralateral elbow, outward bowing of the tendon, poor definition of the tendon, and presence of hypoechoic fluid between the tendon and the epicondyle.[8] Microcalcifications, which may be present in cases of chronic tendinosis, were not visualized in any of the cases, but our study did not include low-kilovoltage radiography to determine whether microcalcifications were present.

Two weeks after the second reading of the sonograms, the coronal fat-suppressed fast spin-echo T2-weighted MRI scans of the patients' affected elbows and the volunteers' designated test elbows were randomized into an image set and reviewed by the readers, who designated each scan as showing either normal elbow or epicondylitis. Only this single coronal sequence, and not the entire magnetic resonance examination, was reviewed. Each reader reviewed the images twice, working independently and in a blinded fashion, in 2 sessions 5 days apart. After the first session, the images were reshuffled.

MRI criteria for the diagnosis of epicondylitis, included thickening or thinning of the tendon, high signal intensity within or around the tendon, and a discrete collection of fluid between the tendon and the radial collateral ligament.[3,6]

Sensitivity and specificity scores were determined for each reader and each reading session for both sonography and MRI. The percentage of images of affected elbows of patients identified by a reader as showing epicondylitis constituted the sensitivity score. The percentage of test elbows of volunteers identified by a reader as showing normal elbow constituted the specificity score. The kappa statistic was used to determine the consistency of each reader between the 2 sessions for both sonography and MRI.

RESULTS

In total, 11 patients (7 men and 4 women) and 6 healthy volunteers (3 men and 3 women) were evaluated. The mean age of the patients was 46 years (range, 13–63 years), and their mean duration of symptoms was 7.6 months (range, 3 weeks to 2 years). The mean age of the healthy volunteers was 29 years (range, 25–30 years). Eight patients had lateral joint pain and 3 had medial joint pain. Ten patients underwent MRI; the other had been referred for MRI evaluation of rotator cuff injury and thus underwent imaging of the shoulder rather than the elbow but was included in our study group for sonography because he had a clinical diagnosis of lateral epicondylitis.

Clinical diagnosis served as the gold standard, with surgical confirmation in 5 cases and histopathologic confirmation in 4 of those 5. Both the sonographic and MRI examinations of all 11 patients revealed abnormalities that corresponded to the clinical diagnosis.

The appearance of epicondylitis on both sonography and MRI is described in Tables 1 and 2. Sonographically, epicondylitis appeared as combinations of the following characteristics: thickening or thinning of the tendon, poor definition of the tendon, decreased echogenicity of the tendon compared with that in the contralateral elbow, and outward bowing of the tendon with sub-

TABLE 1
Sonographic Features of Epicondylitis in 11 Patients

Patient Age, years	Patient Sex	Site	Tendon Bowing	Hypoechoic Region Deep to Tendon	Tendon Thickening	Tendon Thinning	Poor Definition	Decreased Echogenicity*
13	Male	M	+	+	–	+	–	–
38	Male	L	+	+	–	–	–	–
41	Male	L†	+	+	+	–	–	+
43	Male	L	+	+	–	+	–	–
44	Female	L†‡	–	–	+	–	+	+
45	Female	L	+	+	+	–	–	+
48	Female	M	–	–	+	–	–	–
53	Male	M	+	+	+	–	–	+
54	Male	L†‡	+	+	+	–	–	+
59	Female	L†‡	+	+	+	–	+	+
63	Male	L†‡	+	+	–	–	–	–

Abbreviations: M, medial; L, lateral; +, present; –, absent.
*Relative to that in the contralateral elbow.
†Surgically confirmed epicondylitis.
‡Histopathologically confirmed endocondylitis.

TABLE 2
MRI Features of Epicondylitis in 10 Patients

Patient Age, years	Patient Sex	Site	Tendon Bowing	High Signal Intensity	Tendon Thickening	Tendon Thinning
13	Male	M	+	+	–	+
38	Male	L	–	+	–	–
41	Male	L*	+	+	+	–
43	Male	L	+	+	–	+
44	Female	L*†	+	+	–	+
45	Female	L	+	+	–	–
48	Female	M	–	–	+	–
53	Male	M	+	+	+	–
59	Female	L*†	+	+	+	–
63	Male	L*†	+	+	+	–

Abbreviations: M, medial; L, lateral; +, present; –, absent.
*Surgically confirmed epicondylitis.
†Histopathologically confirmed epicondylitis.

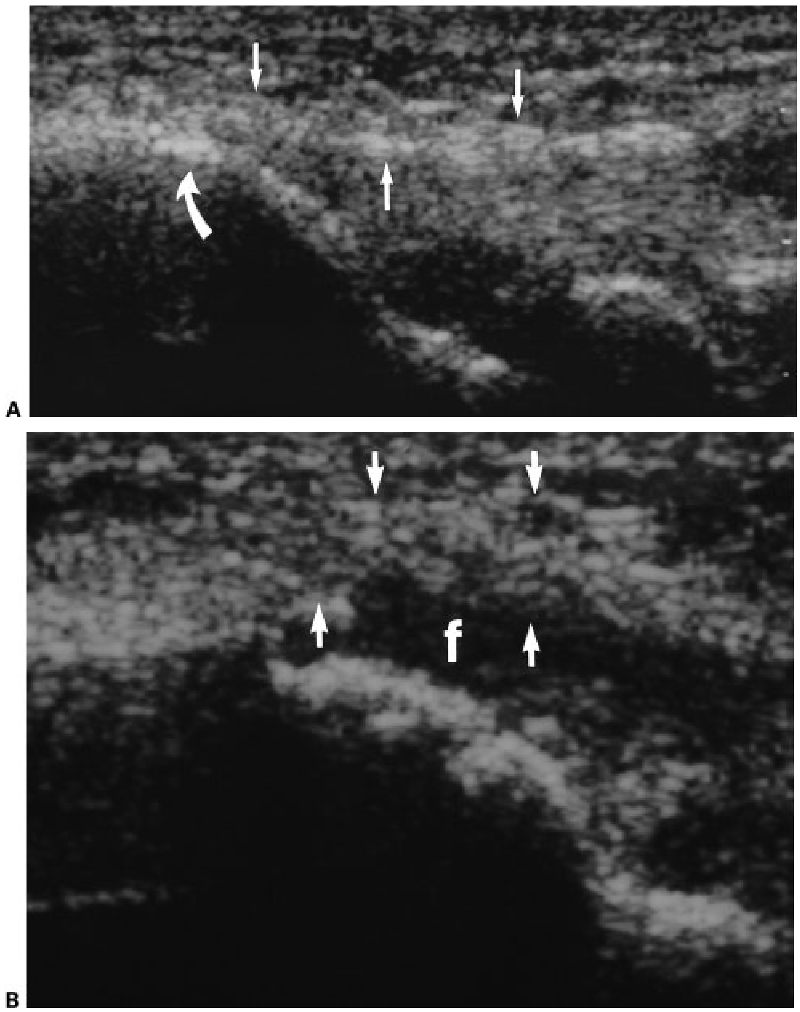


FIGURE 1. Sonographic and MRI findings for a 41-year-old man with surgically confirmed lateral epicondylitis of the right elbow. **(A)** Longitudinal sonogram of the contralateral (normal) left elbow shows the common extensor tendon (arrows) inserting on the lateral epicondyle (curved arrow). **(B)** Longitudinal sonogram of the right elbow shows thickening of the tendon and increased hypoechogenicity (arrows). The tendon is bowed outward, with hypoechoic fluid (f) between the tendon and the bony attachment. **(C)** Coronal fat-suppressed fast spin-echo T2-weighted MRI scan (repetition time/effective echo time, in milliseconds, 3,700/57; 8 echo train) of the right elbow, oriented to match the sonograms, shows thickening and outward bowing of the common extensor tendon (curved arrow) with abnormal high signal intensity at its insertion (straight arrow). Most of the extensor carpi radialis brevis tendon was intact at the time of surgery. The surgeon noted ''degenerative changes of the deeper fibers.'' Histopathologic examination was not performed.

C

FIGURE 1. *Continued.*

TABLE 3
Sensitivity and Specificity of Sonography and MRI for Distinguishing between Epicondylitis and Normal Elbow

	Sonography		MRI	
Reader	Sensitivity, %	Specificity, %	Sensitivity, %	Specificity, %
1				
First reading	82	100	100	100
Second reading	64	83	90	83
2				
First reading	73	100	90	83
Second reading	73	67	90	83

adjacent hypoechoic fluid (Figures 1 and 2). On MRI, epicondylitis appeared as areas of high signal intensity within or around the tendon on the fat-suppressed fast spin-echo sequence. The signal intensity was abnormal deep to the tendon at and near its insertion; in 2 severe cases, the signal intensity superficial to the tendon was also abnormal. Tendon morphology was also altered, consisting of tendon bowing and either thickening or thinning of the tendon (Figures 1C and 2C). Radial bursitis, defined as well-circumscribed high signal intensity, suggestive of the presence of fluid, located between the radial collateral ligament and the common extensor tendon at the level of the joint line, was not present.

The sensitivity and specificity scores of the readers are shown in Table 3. For sonography, the kappa statistic was 0.41 for reader 1 and 0.53 for reader 2, indicating only fair consistency between reading sessions for each reader.[3] For MRI, the kappa values were 0.73 for reader 1 and 1.0 for reader 2, indicating good to excellent consistency.[9]

Five patients had surgically confirmed epicondylitis with an average interval of 4 months (range, 1.5–12 months) between sonographic and MRI examinations and the surgery. The tendons were variously described in the operative reports as “necrotic,” “thickened,” “softened,” “degenerative,” and “shredded.” Surgical specimens from 4 of these patients were sent for histopathologic analysis. One specimen showed only foci of mucinous degeneration within the tendon. The other 3 specimens showed disrupted tendon fibers consistent with tear; 1 of these 3 specimens also showed reactive fibrosis and lymphocytic infiltration within the torn tendon, and the other 2 showed angiofibroblastic change and reactive fibrosis. The same 3 specimens also showed histologic changes, consisting of myxoid degeneration and fissuring, in the periosteum of the epicondyle. Review of the sonograms and MRI scans of these few cases showed that the severity, as determined by histopathologic analysis, corresponded to the appearance of the tendon on the images (Figures 2 and 3). However, despite the observed histopathologic changes in the periosteum, MRI revealed no corresponding abnormal signal intensity in the epicondyle.

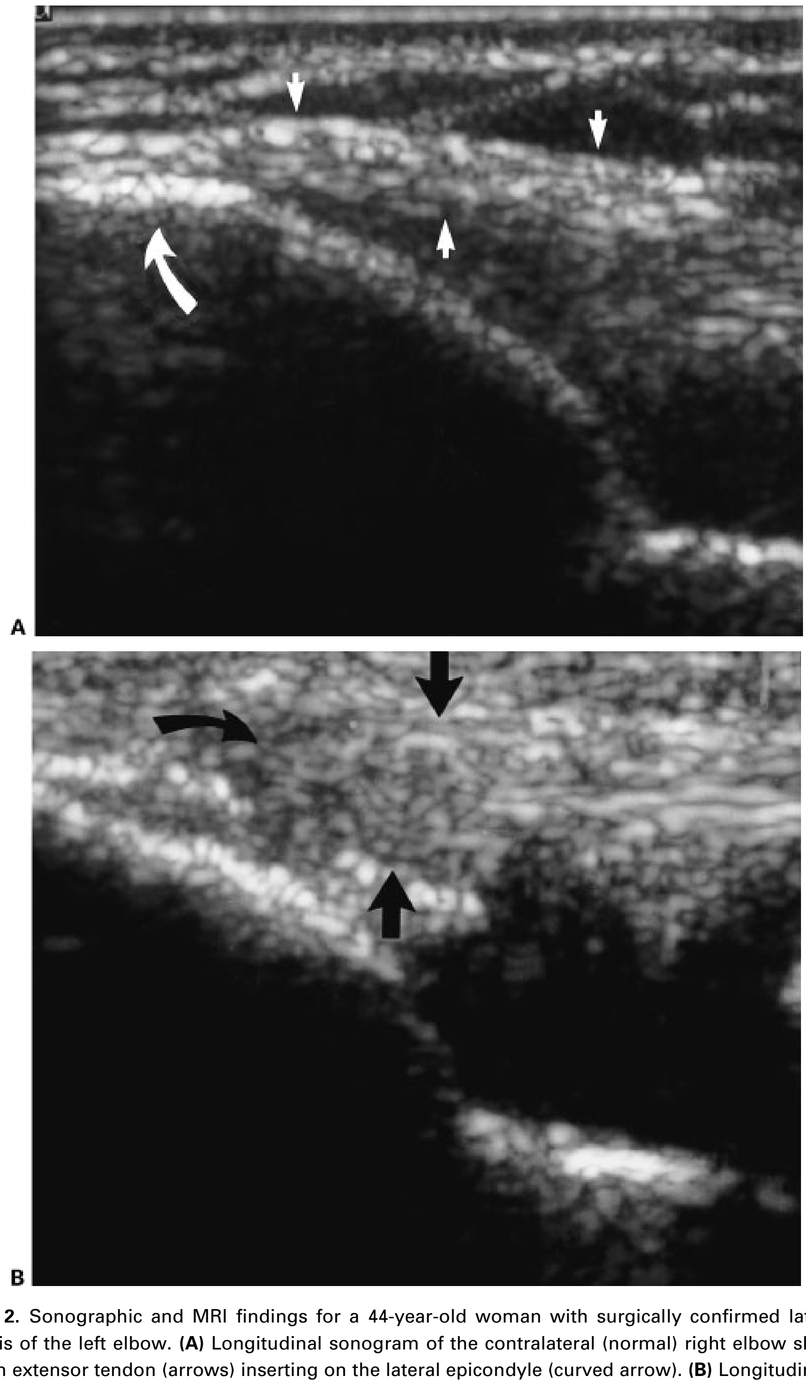


FIGURE 2. Sonographic and MRI findings for a 44-year-old woman with surgically confirmed lateral epicondylitis of the left elbow. **(A)** Longitudinal sonogram of the contralateral (normal) right elbow shows the common extensor tendon (arrows) inserting on the lateral epicondyle (curved arrow). **(B)** Longitudinal sonogram of the left elbow shows a thickened and hypoechoic tendon with ill-defined surfaces (arrows) and possible focal disruption of the fibers (curved arrow). **(C)** Coronal fat-suppressed fast spin-echo T2-weighted MRI scan (repetition time/effective echo time, in milliseconds, 3,500/45; 8 echo train) of the left elbow, oriented to match the sonograms, shows extensive high signal intensity (arrow) and thinning and outward bowing of the extensor carpi radialis brevis tendon (curved arrow). The surgeon noted ''necrotic tissue [at] the origin of the extensor carpi radialis brevis'' tendon. Histopathologic examination of the tendon showed disrupted fibers with reactive fibrosis and angiofibroblastic changes.

FIGURE 2. *Continued.*

DISCUSSION

Our results show that sonography is as specific but not as sensitive as MRI in diagnosing epicondylitis. Maffulli et al[8] reported the sonographic appearance of 41 cases of lateral epicondylitis and classified the findings into 2 categories: extratendinous pathology (intramuscular hematoma and bursitis) and tendinous pathology (enthesiopathy, tendinitis, peritendinitis, and mixed lesions). However, because the study did not provide any surgical or histopathologic confirmation of the sonographic features, their categories should be considered merely descriptive and not indicative of specific pathologic characteristics. In contrast, the sonographic findings of lateral epicondylitis in the series reported by Connell et al[7] were supported by surgical findings in 21 of 72 cases and also by histopathologic findings in 8 of those 21 cases. Tendinopathy, which appears in histopathologic specimens as collagen degeneration, fiber rupture, fibrofatty change, fibroblastic proliferation, and lymphocytic infiltration, appeared sonographically as either a focal hypoechogenicity or a generalized decreased echogenicity, whereas tears in the tendon appeared as either focal anechoic regions or discrete linear cleavage planes.[7] Lymphocytic infiltration has not been a feature of previous histopathologic descriptions[2–4] but was present in 1 of our cases (similar to the findings of Connell et al[7]), suggesting that an element of chronic inflammation may be superimposed on the degenerative process.

Three of the patients in the study by Maffulli et al[8] had no sonographic abnormalities. The authors surmised that these patients might have had cases too acute or too mild for the abnormalities to be detected by the 7-MHz linear-array transducer used in their study. However, none of the patients underwent MRI, so it is unknown whether those 3 patients would have had any abnormal findings on MRI. Two patients in the study by Connell et al[7] had normal sonograms and normal MRI examinations. In our series, 1 sonogram showing epicondylitis (Figure 3B) was incorrectly interpreted as normal by both readers at both reading sessions. The corresponding MRI scan (Figure 3C) demonstrated high signal intensity at the tendinous insertion and altered tendon morphologic characteristics and was correctly interpreted. Retrospective review of the sonogram revealed subtle bowing of the tendon and a hypoechoic region deep to the tendon insertion (Figure 3). In addition, in 1 of our cases (Figure 2), the tendon appeared to be thickened on sonograms but thinned on MRI scans.

Failure of the studies of Maffulli et al[8] and Connell et al[7] to describe the MRI features that corresponded to their descriptions of sonographic features of epicondylitis adds to the confusion in terminology of the disease process. For example, the hypoechoic fluid between the tendon and bony attachment with associated outward bowing of the tendon in our series, described by Maffulli et al as radial head bursitis,[8] did not correspond to radial head bursitis on our MRI scans but corresponded instead to abnormal signal intensity at the tendinous attachment itself. Similarly, radial head bursitis was not present on MRI in any of the 24 cases reported by Martin and Schweitzer[6] or on sonography for any of the cases reported by Connell et al.[7] In the study by Potter et al,[3] 10 of the patients whose MRI showed abnormal signal intensity between the extensor carpi radialis brevis tendon and the radial collateral ligament were also found to have inflamed bursal tissue in addition to the tendinous abnormality on surgery; however, those authors believed that the primary pathology was tendinous.

The reported appearance of epicondylitis on MRI is abnormal signal intensity within the tendon and altered tendon morphologic characteristics that appear as thickening or thinning.[3,5,6] Of the 24 patients in the study of Martin and Schweitzer,[6] all had increased intratendinous signal intensity on fat-suppressed T2-weighted images, and 22 had increased signal intensity on T1-weighted images. In contrast,

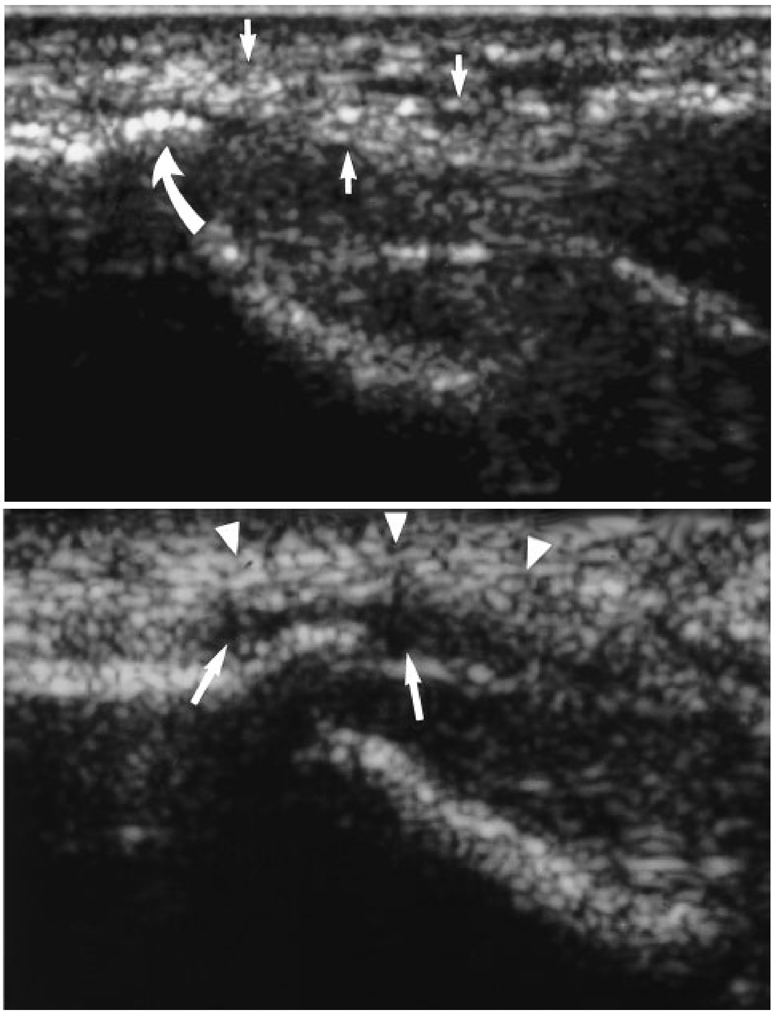
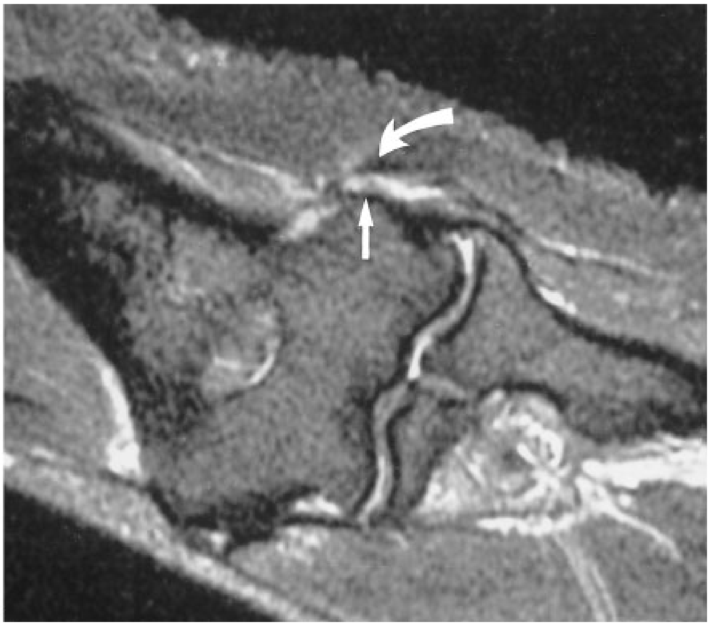

A
B

FIGURE 3. Sonographic and MRI findings for a 63-year-old man with surgically confirmed lateral epicondylitis of the left elbow. **(A)** Longitudinal sonogram of the contralateral (normal) right elbow shows the common extensor tendon (arrows) inserting on the lateral epicondyle (curved arrow). **(B)** Longitudinal sonogram of the left elbow shows outward bowing of the tendon (arrowheads) with subtly decreased echogenicity (arrows) deep to the tendon. This sonographic examination was incorrectly interpreted as normal by both readers at both sessions. **(C)** Coronal fat-suppressed fast spin-echo T2-weighted MRI scan (repetition time/effective echo time, in milliseconds, 3,700/51; 8 echo train) of the left elbow, oriented to match the sonograms, shows high signal intensity (arrow) and outward bowing of the extensor carpi radialis brevis tendon (curved arrow), but these features are not as marked as in Figure 2. The surgeon described the extensor carpi radialis brevis tendon as ''thickened, softened, [and] degenerated.'' Histopathologic examination of the tendon showed that only foci of mucinous degeneration were present.



C

FIGURE 3. *Continued.*

Pfahler et al[5] reported that signal intensity was abnormal on T1-weighted images but normal on T2-weighted images for 7 of 34 patients and that therefore the T1-weighted images were a better indicator of epicondylitis than the T2-weighted images were. The discrepancy between the 2 investigations may be related to the fact that Martin and Schweitzer used fat-suppression techniques with the T2-weighted images, whereas Pfahler et al did not. Potter et al[3] described high signal intensity within the tendon using a gradient echo sequence without a corresponding T1-weighted sequence. In our series, the fat-suppressed fast spin-echo T2-weighted images for all 10 cases imaged showed abnormal signal intensity.

The T2-weighted images of 3 patients in the study by Martin and Schweitzer[6] showed increased signal intensity in the condyle. In contrast, the 2 patients in our series who showed periosteal changes on histopathologic examination and corresponding findings on MRI (a third case lacked the MRI examination) did not show increased signal intensity in the condyle.

Although the studies by Potter et al,[3] Martin and Schweitzer,[6] and Pfahler et al[5] describe the appearance of epicondylitis on MRI scans and the studies by Maffulli et al[8] and Connell et al[7] describe the appearances of epicondylitis on sonograms, none of these studies attempted to evaluate the accuracy of these modalities. In fact, only the study by Martin and Schweitzer included asymptomatic volunteers and provided blinded review of the images. Data from the studies indicate that MRI does not provide 100% sensitivity or specificity: in the study by Pfahler et al,[5] 2 of the 34 patients showed no signal abnormality on either the T1- or the T2-weighted sequence, and in the study by Martin and Schweitzer,[6] 1 volunteer showed increased signal intensity on both sequences and 2 other volunteers showed increased signal intensity on the T1-weighted images.

In our study, the specificity of sonography was comparable to that of MRI. The poorer sensitivity of sonography compared with MRI might be partially explained by the fact that our study design precluded real-time scanning, a major advantage of sonography over MRI. The readers reviewed only static, hard-copy sonographic images of each elbow; nevertheless, the sonographer had selected the images he believed best represented each case.

Weaknesses of our study include the small number of patients and the even smaller number of patients for whom the diagnosis of epicondylitis was confirmed surgically. The sample size was small because we restricted the investigation to patients who were willing to undergo sonography as well as MRI. This approach allowed side-by-side comparison of the findings of each modality and direct comparison of the sensitivity and specificity of the 2 modalities, which the previously reported studies have lacked. The small size of our sample also reflects the fact that epicondylitis is usually diagnosed clinically; indeed, most patients with the condition do not undergo any imaging. In addition, we evaluated only those patients with a clinical diagnosis of epicondylitis rather than patients with any nonspecific elbow pain. This measure undoubtedly introduced selection bias; however, we also included volunteers in an attempt to determine the sensitivity and specificity of both modalities. We do not believe there is any difference in diagnostic capability between the lateral and medial sides.

We did not use power Doppler sonography to assess hyperemia in any of our cases and therefore do not know whether this modality would have increased the accuracy of our sonographic examinations. Connell et al[7] reported that both color and power Doppler sonography in 71 patients failed to demonstrate the neovascularity that is expected with epicondylitis and thus was not helpful in the diagnosis. Of the 5 cases in which histopathologic examination was performed in our series, only 2 cases featured angiofibroblastic proliferation. The absence of such degenerative vascularity in all the cases of epicondylitis may account for the lack of hyperemia on power Doppler examination in the study by Connell et al.[7] Future studies should investigate the usefulness of power Doppler sonography in assessing this condition.

In summary, although the small number of cases in this series precludes any statistical comparison between the diagnostic accuracy values of sonography and MRI, sonography showed comparably high specificity but poorer sensitivity than MRI in diagnosing epicondylitis. A potential role for sonography would be as an initial screening tool, reserving MRI for cases in which the sonographic findings do not correlate with the clinical diagnosis.

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