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ULTRA SONOGRAPHIC FINDINGS FOR CHRONIC LATERAL EPICONDYLITIS

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Purpose: **To assess which individual gray-scale and color Doppler US findings and their combination are strongly associated with lateral epicondylitis. Also to determine whether chronic lateral epicondylitis is possible without any positive US findings.**
Methods: **49 patients (6 bilateral) underwent gray-scale ultrasonic imaging between 2005 to 2007. All had a history of lateral epicondylitis and had concordant pain during US probe compression in the common extensor region. Mean patient age was 47 (sd 7.7) years; M/F ratio 21/28; L/R ratio 17/32. Five symptom free volunteers (all bilateral) with a mean age of 36 (sd 8.7) years; M/F = 4/6; L/R = 5/5.**
Results: **Neovascularity determined by color Doppler and four gray-scale US findings – a convex external contour, an erosive lateral epicondular cortex, internal calcifications, or a tear – have a specificity and PPV of 100% with conclusive likelihood ratios. However, only the sensitivity for neovascularity is above 50%. A combination of gray-scale and color Doppler shows a sensitivity between 92% to100%, a 90% specificity with a 98% PPV and a high likelihood ratio (9 to10).**
Conclusion: **The combination of gray-scale and color Doppler changes is diagnostically superior to identify chronic lateral epicondylitis. Signs which confirm the diagnosis are a convex boundary, an erosive cortex, internal calcifications, a tear, and neovascularity. Patients with positive clinical signs and concordant pain but no US findings require further MRI evaluation.**

Key-words: Elbow, injuries – Extremities, US.

Lateral epicondylitis or tennis elbow is characterized by pain across the lateral epicondyle of the humerus that is aggravated by resisted dorsiflexion of the wrist or wrist supination against resistance (1). It is a self-limiting condition, often seen in athletes who engage in throwing sports and in tennis players. Treatment includes the conservative methods of rest, physical therapy, anti-inflammatory drugs, steroid injections, needling with or without steroid or autologous blood injection, and in the most refractory cases, surgery.

Although the diagnosis is clinically based, ultra sonography (US) plays an important diagnostic role in chronic cases to asses the form, severity and location of the changes in epicondylitis and to exclude other possible causes of the lateral elbow pain. A US examination which includes both gray-scale and color Doppler US has been shown to have a 97% sensitivity and a 61% specificity (2), whereas for gray-scale changes alone these have been reported to be 72-88% and 36-100%, respectively; those for color Doppler alone are 95% and 88%, respectively (3, 4). Du Toit et al. recently concluded that lack of both neovascularity and gray-scale changes on US examination substantially increases the probability that the condition is not present and should prompt the clinician to consider other causes for lateral elbow pain (2). A recent study by Noh et al., also reported that the induction of tenderness with a US probe at the site of tendon pathology increases the accuracy of US examination and rules out other causes of the chronic lateral elbow pain (5). This is important because differential diagnose of lateral elbow pain is broad and includes occult fracture, osteochondritis disseccans of the capitelum, osteoarthrosis, posterolateral rotatory instability, LUCL injury, lateral synovial plica, synovitis of the radiohumeral joint, and radial tunnel syndrome (6, 7).

Purpose

To evaluate the prevalence of US findings, including neovascularity determined by color Doppler, in a large group of patients with chronic lateral epicondylitis. The presence of induced pain by compression with a US probe in the region of the lateral epicondyle common extensor tendons was used as the gold standard for lateral epicondylitis. In addition, the possibility of a patient presenting with chronic lateral epicondylitis who had no gray-scale or color Doppler findings was determined.

Material and methods

Patients

From June 2005 to March 2007 two experienced orthopedic surgeons, specialized in the upper limb, referred a total of 43 (6 bilateral) consecutive patients with chronic epicondilytis lateralis for US imaging, in total 17 left elbows and 32 right elbows. Cases were included in this historical cohort study if there had been at least a 6-month clinical history of epicondilytis lateralis with pain during a resisted dorsiflexion of the wrist or wrist supination against resistance, as well as concordant pain at the moment of imaging during compression with a US probe in the region of the lateral epicondyle/common extensor tendons. All had already received 6 months of conservative therapy consisting of rest, physical therapy, steroid injection or a brace, or a combination of these therapies. Patients who had had previous surgery related to lateral epicondylitis and patients who suffered from a systematic joint disease were excluded. In total 23 men and 20 women with a mean age of 47 (sd 7.7) years were included; for six patients both elbows were included.

In addition, bilateral US was performed in 5 asymptomatic volunteers (two men, three women) with a mean age of 36 (sd 8.7) years. These volunteers were recruited from healthy hospital employees and had no history of elbow pain, no pain during resisted dorsiflexion of the wrist or wrist supination against

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resistance and no concordant pain during compression with a US probe in the region of the lateral epicondyle/common extensor tendons.

The internal review board approved this study.

Imaging and interpretation

All patients were examined by one of two experienced radiologists, each with at least 6 years of musculoskeletal US experience. A 5-12 MHz linear-array transducer (ATL 5000, Philips, The Netherlands) was used for all cases. The patient was in a sitting position, elbow in 90° flexion, wrist pronated with the underarm resting on the examination table. A standardized imaging protocol was used to image the area of the origin of the common extensor tendon up to the level of the radius head in longitudinal and transverse planes (Fig. 1).

The patient's clinical history and the clinical evaluation by the orthopedic surgeon and lateral epicondyle concordant pain during compression with a US probe were the reference standards. The symptoms included lateral elbow and forearm pain exacerbated by activities involving resistant wrist extension for at least 6 months during which the patient received conservative therapy; the tenderness of the lateral epicondyle at the common extensor origin did not abate. As a final check before the US examination, the radiologist identified the region of the common extensor tendon and compressed it with the US probe to see whether concordant pain was induced.

Evaluation of the US images for each patient was performed retrospectively by each radiologist using a standardized scoring form; discrepancies were resolved by consensus. The following US findings were assessed: external border of the extensor tendon was defined as convex, neutral, or concave. The presence or absence of the following echological signs in either the extensor carpi radialis longus or the brevis was scored: focal hypoechoic area, tear, cortical bone irregularities, calcification which was classified as internal or external, and neovascularity.

The evaluation of the US images for the volunteers was performed real time. It was therefore, possible to perform the tilting maneuver to eliminate anisotropy in longitudinal and transversal directions, twice for each direction with reposition of the probe in two angulations with approximately 90 degrees between them (Fig. 1).

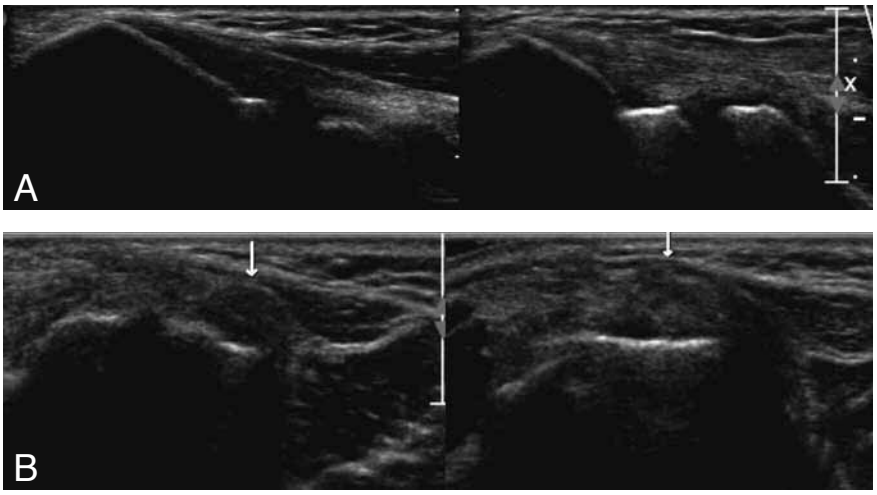

Fig. 1. — Disappearance of hypoechogenic regions in the common extension tendons following the tilt maneuver. A is the longitudinal slice; 1: tilting proximally; 2: tilting distally. B is the transverse slice. 1: tilting medially; 2: tilting laterally.

Statistical analyses

To evaluate which individual gray-scale changes are most strongly associated with the diagnosis of tennis elbow, the sensitivity, specificity, positive predictive value (PPV),and negative predictive value (NPV) were determined as well as the likelihood ratios obtained using these estimates. The same analyzes were conducted for the color Doppler finding and the combined US findings: gray scale and neovascularity. The images obtained from the ten healthy elbows were the controls.

The 95% confidence intervals were calculated using the online program: www.causascientia.org/math_stat/ProportionCI; the PPV and NPV as well as the likelihood ratios were calculated using the online program: www.medcalc3000.com/BayesianAnalysis.

Because the patient images (static, digital images) had not been assessed in real time, these could not be corrected for anisotropy. Hence it can be expected that the number of patients assessed with a hypoechoic region will include a number of false positives. Therefore, for the combined US finding *gray-scale change and neovascularity* two calculations were made: the first includes the hypoechoic region findings, the second excludes this possible gray-scale change. The first can be expected to be an estimation that is too high; the second can be expected to be the lower boundary.

Results

As shown in Table I, each gray-scale change was present in at least 7 affected elbows; the most prevalent change (hypoechoic regions) was found in 42 elbows. Only one elbow in the control group showed a positive US finding (external calcification). All 49 elbows had neovascularity and gray-scale changes when hypoechoic regions were included. However, when the hypoechoic regions were not included in the gray-scale changes because of the possibility of false positives due to anisotropy, there were 45 cases with positive combined findings. As shown in Table II, all measures show a high level of specificity. However only the combination of the gray-scale changes with a positive color Doppler result for neovascularity has a high level of sensitivity. It was possible to indicate the extent of the possible overestimation on sensitivity and negative predictive value if the findings for focal hypoechoic regions are performed without correcting for anisotropy. The sensitivity for gray-scale changes drops about 15%; the change for the negative predictive value is more extreme: more than 30%.

Discussion

This study found that the combined US findings for gray-scale changes and neovascularity determined by color Doppler in patients with a clinical diagnosis of chronic lateral epicondylitis had a sensitivity of at least 92%, a specificity of 90%,

Table I. — The US findings for the patients with chronic lateral epicondylitis (n = 49) and the controls (n = 10)

Ultra sonographic finding	Patients		Volunteers	
	Present	Absent	Present	Absent
Tear	7	42	0	10
Erosive condylar cortex	9	40	0	10
Convex external boundary	16	33	0	10
Internal calcifications	16	33	0	10
External calcifications	22	27	1	9
Calcifications	35	14	1	9
Hypoechoic regions	42	7	0	10
Gray scale changes including hypoechoic regions	48	1	1	9
Gray scale changes excluding hypoechoic regions	40	9	1	9
Neovascularity	28	21	0	10
Neovacularity and/or gray scale changes (including hypoechoic regions)	49	0	1	9
Neovacularity and/or gray scale changes (excluding hypoechoic regions)	45	4	1	9

Table II. — Diagnostic evaluation, given as percentages, of the ultrasonographic findings present during examination with and without color Doppler.

US findings	Sensitivity	Specificity	PPV	NPV	Positive LR	Negative LR
Tear	14 (8 to 27)	100 (72 to 100)	100 (63 to 100)	19 (11 to 32)	Infinity	0.86
Erosive condylar cortex	18 (10 to 11)	100 (72 to 100)	100 (69 to 100)	20 (11 to 33)	Infinity	0.82
Convex external boundary	33 (17 to 39)	100 (72 to 100)	100 (80 to 100)	23 (13 to 38)	Infinity	0.67
Internal calcifications	33 (21 to 47)	100 (72 to 100)	100 (80 to 100)	23 (13 to 34)	Infinity	0.67
External calcifications	45 (32 to 59)	90 (59 to 98)	96 (79 to 99)	25 (14 to 41)	4.49	0.61
calcifications	71 (58 to 82)	90 (59 to 98)	97 (86 to 99)	39 (22 to 59)	7.14	0. 32
Focal hypoechoic regions	86 (73 to 93)	100 (72 to 100)	100 (100 to 100)	59 (36 to 78)	Infinity	0.14
Gray scale changes including hypoechoic regions	98 (89 to 100)	90 (59 to 98)	98 (89 to 100)	43 (59 to 98)	9.80	0.02
Gray scale changes excluding hypoechoic regions	82 (69 to 90)	90 (59 to 98)	98 (87 to 99)	50 (29 to 71)	8.16	0.20
Neovascularity	57 (43 to 70)	100 (72 to 100)	100 (96 to 100)	32 (19 to 50)	infinity	0.43
Neovascularity and/or gray scale changes including hypoechoic regions	100 (93 to 100)	90 (59 to 98)	98 (90 to 100)	100 (69 to 100)	10.00	0.00
Neovascularity and/or gray scale changes excluding hypoechoic regions	92 (81 to 97)	90 (59 to 98)	98 (89 to 99)	69 (42 to 87)	9.180	0.091

The 95% confidence interval is given in parentheses.
LR, likelihood ratio; NPV, negative predictive value; PPV, positive predictive value.

a PPV of 98 % and a positive LR of at least 9 with a low negative likelihood ratio(0.09). The following individual US findings – a convex external contour, an erosive cortex of the lateral epicondyle, internal calcifications, a tear or neovascularity – had a specificity of 100%, PPV 100%, and a conclusive positive likelihood ratio. Unfortunately, the sensitivity for these four parameters is low; the respective values for the affected elbows was 33%, 18%, 33%, and 14%. Thus individually these findings are not sufficient as a stand-alone diagnostic examination. Total sensitivity and specificity for the gray scale ultrasound varies in the literature between 72-88% and 36-100% (3), respectively; in combination with power Doppler a sensitivity of 97% and specificity of 61% has been found (2). In this study we found a gray scale sensitivity of 82-98% and specificity of 90 %, PPV+ of 98-99%, with a positive LR 8-10% and in combination with color Doppler indicating a high accuracy. The lower values were calculated when hypoechoic reagions were not included in the gray-scale findings because of possible anisotropy, the higher values when they were

included. In this study, more patients were included than in the Du Toit study (2), all the patients had been referred by experienced orthopedic surgeons specialized in the upper limb, and all patients had concordant pain induced by compression.

Our study showed the absence of neovascularity in 21/49 symptomatic tendons, a proportion which is higher than in most other studies but comparable with the results found by Zanetti et al (8). Neovascularity had the highest sensitivity (57%) in the group of individual findings, with 100% specificity with a confidence interval of approximately ± 10%. Presentation with neovascularity is a relatively specific US sign for a painful tendon (8). The literature reports a color Doppler sensitivity of 81-95% with a specificity of 98-88% (3, 4) for tennis elbow while for painful patellar tendinopathy these values are 92% and 100%, respectively (2, 3, 4, 9) and for the Achilles tendon the respective values are 52% and 96% (5). Our study has a lower sensitivity and higher specificity for neovascularization than most other studies, but it is based on 49 patients while the other studies were based on fewer patients (ranging from 22-28) (3, 7, 10).

In this study, calcification also has a relatively high sensitivity (71%) but only a 90% specificity. Superficial linear calcification at the origin of the ECRL has low specificity as it was demonstrated in 1 of the 10 volunteers. Our volunteer group had a mean age of 36 years compared to the mean age of 47 in the symptomatic group. It is reasonable to expect that in an older group more asymptomatic calcification may be presented at the origin of the ECRL. Furthermore, it has been reported that only 39% of all enthesophytes are symptomatic (11).

In our study, the presence of a focal hypoechoic region had an 86% sensitivity with a 100% specificity. A sensitivity between 53% and 67% with a specificity between 81 to 89% has recently been published (3, 12). We do not think that previous treatment of the patients with corticosteriods has influenced our results since most animal studies indicate that intratendinous injection of corticosteroid results in collagen necrosis followed by a decrease in tensile strength of the tendons, no study shows correlation between those and eventual US findings.

We suspect that the sensitivity we report is high because of the possibility of anisotropy in the patient group compared to the volunteer group. As we retrospectively reviewed static, digital images, it is possible that the artifact anisotropy might be present for some symptomatic elbows. The extensor carpi radialis brevis tendons have an oblique course from depth to surface and are prone to anisotropy, which accounts for the well-known pitfall in US assessment for tendons. Therefore, we believe that the high sensitivity of hypoechoic region in our study is based on the fact that the US imaging for all symptomatic elbows had not been scored in real time.

Based on the present study, it is unlikely that patients with chronic lateral epicondylitis would present without gray-scale or color Doppler findings. However, presentation with sonographic findings is not consistent and some can even be found in healthy volunteers. Although, Struijs et al found that gray scale sonographic findings had been identified and clinical diagnosis confirmed in only 75% of the imaged symptomatic patients (12), Du Toit et al. recently concluded that the lack of both neovascularity and gray scale changes on ultrasound examination substantially increases the probability that the condition is not present and should prompt the clinician to consider other causes for lateral elbow pain[9). Some other authors have found neovascularity at almost every symptomatic tendon Zeisg et al. 21/22 (10), Alfredson et al. 25/25 (13), Pederson et al. 9/20 (4).

Although it is well known that in the acute phase of the disease, US changes can sometimes precede clinical symptoms of lateral epicondylitis, conversely, symptoms can sometimes proceed US changes (6, 12). Particularly for patients who are candidates for invasive therapy or operative treatment (chronic form), a low false positive rate is extremely important. The proposed combination neovascularity and gray-scale change is diagnostically superior to identify the chronic tennis elbow. For a clinician US is an important screening test. If the US is positive the patient should be planned for the therapeutic treatment of the lateral epicondylitis. If the US is negative the patient should be scheduled for the MRI arthrography of the wrist.

Confirmation of the disease, and in the case of absence of US findings, the exclusion of other causes, is recommended before subjecting the patient to any sort of invasive therapy. The duration, sort, location, extension and severity of abnormality determines the sort and extent of therapy, including a possible resection which should be based on the above mentioned ultrasound findings including the concordant pain during compression with a US probe as a gold standard.

This study has limitations because the interpretation of the US findings in the patients was performed retrospectively. Each hypoechoic region seen on the static, digital images of a symptomatic elbow was interpreted as being positive while each hypoechoic region seen in the volunteers had been corrected for anisotropy. Consequently a part of those hypoechoic regions found in the symptomatic elbows can be explained as result of anisotropy. However, by calculating gray scale changes with and without hypoechoic regions we have been able to determine the range within which the gray scale changes should be corrected for anisotropy (a sensitivity between 83-98, both with a specificity of 90; a PPV of 98 with an NPV between 47-83). Our control sample was younger and on the small side, so that the PPV values are probably inflated. A further limitation is that sonoelastography was not included in the diagnostic work-up of the patients or the volunteers because at that time the machine did not have that function, making it not possible for us to further compare our results with those in the literature (14).

In conclusion, a convex boundary of the extensor tendons, an erosive cortex of the lateral epicondyle, internal calcifications, a tear or neovascularity have a high diagnostic accuracy. If a patient shows one of these findings, one can confirm the diagnosis. However, the combination of gray scale and color Doppler changes is diagnostically superior to identify chronic lateral epicondylitis. Although absence of US findings in patients with positive clinical signs and concordant pain induced by US probe compression on the origin of the extensor tendons could indicate the absence of chronic lateral epicondylitis in acute cases (duration less than six months), it is wise to exclude other possible causes for the pain in the same region.

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