Ultrasound Detection of Heel Enthesitis: A Comparison with Magnetic Resonance Imaging

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ABSTRACT. ***Objective.*** Seronegative arthropathies are associated with inflammatory enthesopathy. The involvement of Achilles tendon and plantar aponeurosis is common, with strong tendency toward fibrosis and calcification. This study tests the diagnostic efficacy of ultrasound (US) in depicting enthesitis, and compares sonographic images with magnetic resonance images (MRI).

Methods. We studied 32 patients with a diagnosis of seronegative arthropathies, 22 men, 10 women, mean age 29 years. They had heel enthesopathy without typical conventional radiographic evidence. T1 and T2 weighted and short-tau inversion recovery (STIR) MRI sequences were obtained in axial and sagittal planes. An HDI 3000 ATL US device equipped with 12 MHz linear transducer was used to examine the enthesis. Three independent observers assessed the reliability of sonographic images by using video recording of the US examinations.

Results. US images of enthesitis showed loss of normal fibrillar echotexture of tendon (100%), lacking the homogeneous pattern, with blurring of tendon margins (56.2%) and irregular fusiform thickening (84.3%). The affected tendons showed intratendinous lesions with ill defined focal tendon defects filled with a mixture of fluid, fat, and/or granulation tissue, with loss of their tightly packed echogenic dots. MRI showed tendon enlargement (62.5%) with loss of the normal flattened hypointense appearance, focal thickening and rounded configuration at the insertion site (31.2%), intermediate T1 and high T2 signals, and diminished signals within the pre-Achilles fat pad due to inflammatory edema. Among all patients, 40.6% developed osteitis.

Conclusion. MRI was not sensitive compared to US in detecting early changes of enthesopathy. Fatty degeneration appeared late in MRI, while it was detected earlier using US. MRI was not able to detect any calcification process at the insertion site, while US images clearly showed the very early signs of the calcification process. We recommend use of US for early diagnosis and in treatment and followup of patients with tendon enthesopathy, to accurately identify and diagnose different pathologic and biomechanical changes. (J Rheumatol 2003;30:774–8)

Key Indexing Terms:
ULTRASONOGRAPHY MAGNETIC RESONANCE IMAGING
ENTHESITIS ARTHRITIS ACHILLES TENDON

An enthesis is a site of insertion of a tendon, ligament, fascia muscle, or articular capsule into bone. An alteration at the attachment site is termed enthesopathy. The seronegative arthropathies are characterized by inflammatory enthesopathy: inflammation of the attachment site to the bone with strong tendency to fibrosis and calcification[1,2].

Enthesopathy can be also occupational, metabolic, or drug induced, or a result of an infectious or degenerative process. Heel involvement at the insertion of the Achilles tendon and/or plantar fascia aponeurosis is common. Entheseal changes also occur at cartilagenous articulations such as the discovertebral junction, the symphysis pubis, and the manubristernal junction[3].

The diagnosis of enthesitis in clinical practice is usually based on typical conventional radiographic findings, which are not helpful in most of the cases[3-5]. The radiographic picture in enthesitis may show erosions, frequent new bone formation, peripheral ossification, and eventually transarticular ossification[6].

Histologically, the insertion of the tendon, ligaments, or joint capsule may be divided into 4 identifiable zones, which blend into each other and represent the transition of the tendon at its insertion into bone. The first of these zones is the actual tendon or ligament, the second is the unmineralized fibrocartilage, the third the mineralized fibrocartilage, and the fourth is the bone[3].

Recently, ultrasound (US) has been used for the assessment of enthesopathy; magnetic resonance imaging (MRI) has also been used to assess enthesitis. We compared the diagnostic efficacy of US and MRI in subjects with seronegative arthropathies and enthesopathy.

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MATERIALS AND METHODS

From a population based recruitment, 32 patients (22 men, 10 women, mean age 29 yrs) with a diagnosis of seronegative arthropathies were selected for study. The mean disease duration was 3.4 years. They had heel enthesopathy without typical conventional radiographic evidence. Informed consent was obtained from all patients.

MRI was performed using the Toshiba Flexart, 0.5 Tesla superconducting magnet (Toshiba, Tokyo, Japan). A surface coil was used with decreased field of view to enhance spatial resolution. All T1 and T2 weighted and short-tau inversion recovery (STIR) sequences were obtained in axial and sagittal planes, with the patient lying supine with the ankle in neutral position.

An axial localizer spin echo (SE) scan was performed. The sequence parameters were: repetition time (TR)/echo time (TE) = 300/20, slice thickness 5 mm, gap between slices 2 mm, matrix 128 × 256, and field of view (FOV) 15 cm.

Axial locator images were used as a guide to obtain true sagittal images of the ankle, with TR/TE = 500/15, slice thickness 3.5 mm, gap between slice 1 mm, matrix 192 × 256 and FOV 20 cm.

T2 weighted images were obtained in axial orientations planed on sagittal images, with TR/TE = 4000/120, slice thickness 4 mm, gap between slices 1 mm, matrix 192 × 256, and FOV 20 cm.

Fat suppression images were obtained in axial and sagittal planes, with TR/TE = 300/30, slice thickness 3 mm, gap between slices 0.6 mm, matrix 192 × 256, and FOV 15 cm.

An HDI 3000 ATL US device (Advanced Technology Laboratories, Camden, NJ, USA) equipped with a 12 MHz linear transducer was used to examine the enthesis. All US examinations were performed by the same investigator, who was not aware of the patient's clinical diagnosis. US images were obtained in longitudinal and transverse planes together with dynamic scans[5-8]. Each baseline examination was performed twice to determine intraobserver variability. Moreover, within a 3 month period, all patients in the study were examined for a second time by another investigator to determine interobserver variability.

We assessed interobserver variability of sonographic readings by using video recording of US examinations and comparing enthesis images obtained sequentially by 3 independent observers (a sonographer, a radiologist, and a rheumatologist), who were blinded to the patients' names or clinical diagnosis.

Agreement between readers in the interpretations of US and MRI was statistically assessed using the weighted kappa ranges from 0 (no agreement beyond chance) to 1–0 (perfect agreement beyond chance).

RESULTS

Ultrasound images of enthesis showed loss of normal fibrillar echotexture of the tendon in 32 patients (100%), lacking the homogeneous pattern, with blurring of the tendon margins (18 patients; 56.2%) and irregular fusiform thickening (27 patients; 84.3%). Figures 1-3 show intratendinous lesions with ill defined focal tendon defects filled with a mixture of fluid, fat, and/or granulation tissue, with loss of their tightly packed echogenic dots, denoting loss of normal fibrillar echotexture of the tendon.

US examination detected very early calcification foci of the tendons (27 patients; 84.3%), whereas MRI examination failed to identify their presence (Figure 1).

MRI of the affected tendon, using the fat suppression technique (STIR), showed tendon enlargement in 20 patients (62.5%), with loss of the normal flattened hypointense appearance (Figure 1B), focal thickening and rounded configuration at the insertion site in 10 patients (31.2%), and intermediate T1 signals, associated with irreversible fatty infiltration, in 32 patients (100%) (Figure 1A). Further, we noted diminished signals within the pre-Achilles fat pad due to associated inflammatory edema in 2 patients (6.6%).

Thirteen patients (40%) showed bone edema — focal hyperintensity signals of the posterior part of the calcaneal bone denoting osteitis (Figure 1B).

Kappa calculations for interobserver variability were negligible and yielded excellent coefficients of r = 0.93 at baseline, r = 0.72 for US, and r = 0.82 for MRI.

Table 1 summarizes the findings for US and MRI examinations of enthesis in each patient.

DISCUSSION

There are few data about which imaging modality is most appropriate in any given rheumatic disease. Only rarely have the diagnostic values of different imaging techniques in various conditions been compared. Recent advances in US technology, the availability of high speed computers, and the development of high resolution US transducers have enabled detailed depiction of tendons, ligaments, and fascial structures. US is a quickly evolving diagnostic technique, and its place in patient management is becoming increasingly helpful[9-14].

Tendons are particularly suitable for US examination. They are easily distinguishable from surrounding tissues because of their high collagen density[7]. Also, minute bone surface and tendon abnormalities may be depicted because of the better lateral resolution of US[9,10]. Further, high frequency US transducers allow good spatial resolution of < 0.2 mm of tendon thickness[7].

Several studies have used sonography to estimate the degree of tendon abnormalities, to differentiate between functional and morphologic conditions, and to help in diagnosis of various tendon lesions — acute and chronic tendinitis, peritendinitis, and nodular tendinitis[15-21].

In our study, sonography provides information that helps to accurately diagnose clinical Achilles tendinopathy and to identify different pathologic and biomechanical changes in the Achilles tendon. US images of enthesis (Figures 1-3) showed loss of normal fibrillar echotexture of the tendon, a lack of the homogeneous pattern, blurring of the tendon margins, irregular fusiform thickening, and intratendinous lesions with ill defined focal tendon defects filled with a mixture of fluid, fat, and/or granulation tissue, with loss of their tightly packed echogenic dots. US examination detected early calcification foci of the tendons, whereas MRI examination failed to identify their presence[21,22].

MRI was not sensitive compared to US in detecting the early changes of enthesopathy. On MRI, it was difficult to compare the pathology of both sides or to perform a dynamic examination of the tendons. In MRI, the disruption of the tendon was manifested as a retracted soft tissue swelling with increased signals on both T1 and T2 weighted sequences. The presence of focal high intensity signals as indicator of fatty degeneration appeared late in the MR images, while it was

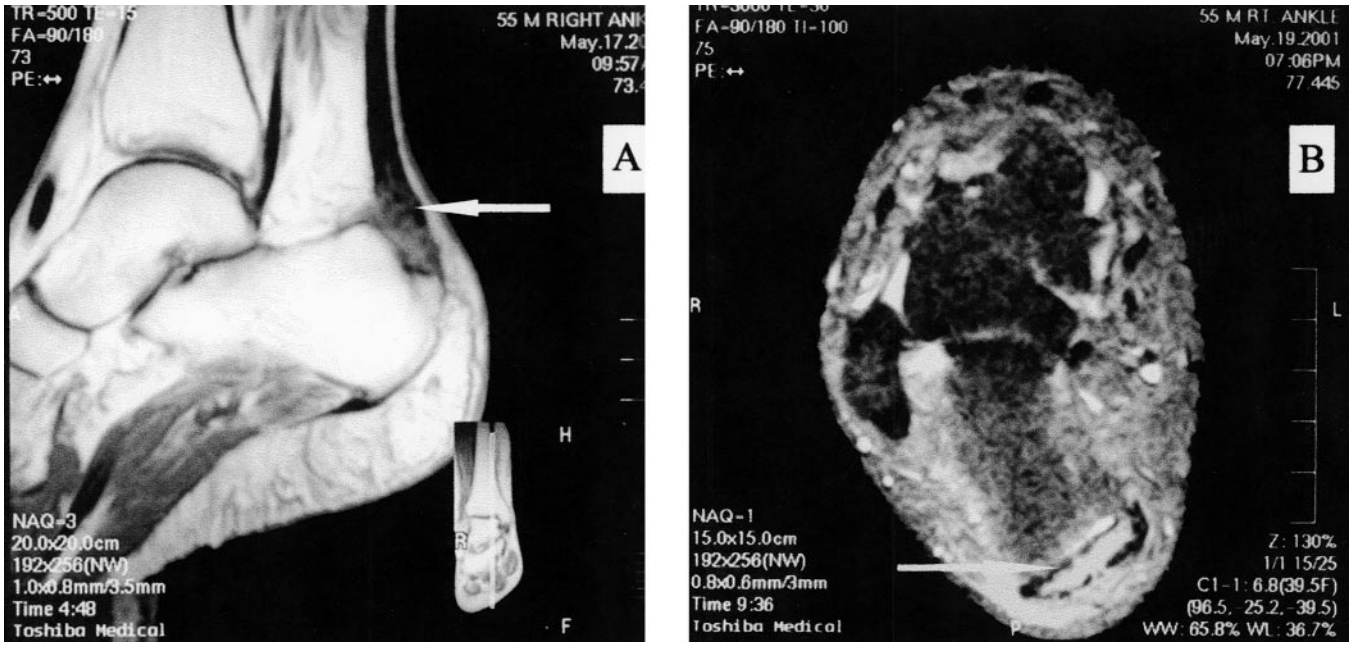

Figure 1. A. T1 weighted sagittal MR image of the heel showing tendinitis, intermediate intensity of the tendoachilles, and increased tendon thickness. B. Axial STIR sequence showing abnormal high intensity signals. C. Sagittal US image (12 MHz) showing thickened tendoachilles (1.08 cm) with minute calcific foci (large arrow) that were not detected on the MRI.

detected earlier in US images, appearing as hyperechoic intratendinous lesions[22-27].

Entheseal inflammatory changes may lead to bone proliferation, osseous erosion, and peripheral ossification. Radiographically, the increased bone formation was manifested as osteosclerosis associated with ligamentous ossification. The MR images were neither sensitive nor specific in detecting the calcification process at the insertion site of the Achilles tendon, while US images clearly showed the very early signs of the calcification process (Figure 1).

US is a simple and reliable bedside diagnostic technique to detect early enthesopathy. The US images showed a highly sensitive ability to detect and characterize even the minimal pathological and structural changes of tendon. It is a low cost technique, widely available, and reproducible, and offers a reliable tool for immediate clinical correlation, tendon measurement, and dynamic real-time bilateral comparison.

We found US images to be even more sensitive than MRI in the detection of enthesitis in patients with early inflammatory seronegative arthropathies. We recommend the application of US examination for early detection, diagnosis, treatment, and followup of patients with tendon enthesopathy.

REFERENCES

1. Niepel GA, Sitaji S. Enthesopathy. Clin Rheum Dis 1979;5:857-87.
2. Ball J. Enthesopathy of rheumatoid and ankylosing spondylitis. Ann Rheum Dis 1970;30:213-23.
3. Danda D, Shyam Kumar NK, Cherian R, Cherian AM. Enthesopathy: clinical recognition and significance. Natl Med J India 2001;14:90-2.
4. Cooper RR, Misol S. Tendons and ligament insertion. A light and electron microscopic study [review]. J Bone Joint Surg Am 1970;52:1-20.
5. Lin J, Fessel DP, Jackobson JA, Weadock WG, Hayes CW. An illustrated tutorial of musculoskeletal sonography: Part 3, lower extremity. AJR Am J Roentgenol 2000;175:1313-21.
6. Marlet W, Braunstein GM, Borlaza G, Good AF, Griffin PE. Radiological features of Reiter disease. Radiology 1979;132:1-10.
7. Grassi W, Fillipucci E, Farina A, Salaffi F, Cervini C. Sonographic imaging of tendons. Arthritis Rheum 2000;43:969-76.
8. Ramussen OS. Sonography of tendons. Scand J Med Sci Sports 2000;10:360-4.
9. Backhaus M, Burmester GR, Gerber T, Grassi W, Machold KP, Swen WA. Guidelines for musculoskeletal ultrasound in rheumatology. Ann Rheum Dis 2001;60:641-9.

Table 1. Ultrasound and MRI findings in patients with enthesitis.

Patient	Age/Sex	Diagnosis	US Findings				MRI Findings				
			Fibrillar Echo Pattern	Tendon Thickness	Tendon Margins	Calcification*	Signal Intensity	Tendon Thickness	Tendon Margins	Fat Degeneration	Bone Edema
1	26 M	ReA	Lost	↑	Ill defined	+	↑	↑	D	+	+
2	28 M	ReA	Lost	↑	D	+	↑	↑	D	+	+
3	23 M	Reiter's	Lost	↑	Ill defined	+	↑	↑	Ill defined	+	None
4	32 M	Sacroiliitis	Lost	Normal	Ill defined	+	↑	↑	D	+	+
5	27 M	Spondylitis	Lost	↑	Ill defined	+	↑	↑	Ill defined	+	None
6	23 F	Spondylitis	Lost	↑	D	+	↑	Normal	D	+	None
7	34 F	ReA	Lost	↑	Ill defined	+	↑	↑	Ill defined	+	+
8	29 M	Hepatitis	Lost	↑	Ill defined	+	↑	Normal	D	+	None
9	28 M	Reiter's	Lost	Normal	D	+	↑	↑	D	+	+
10	20 M	ReA	Lost	↑	Ill defined	None	↑	↑	D	+	None
11	30 M	Ulcerative colitis	Lost	↑	D	+	↑	Normal	D	+	None
12	28 F	Sacroiliitis	Lost	↑	Ill defined	None	↑	Normal	D	+	None
13	28 F	Scleroderma	Lost	↑	Ill defined	+	↑	↑	Ill defined	+	+
14	21 F	Ulcerative colitis	Lost	↑	D	+	↑	Normal	D	+	None
15	21 F	ReA	Lost	↑	Ill defined	+	↑	↑	D	+	+
16	27 M	ReA	Lost	↑	Ill defined	+	↑	Normal	D	+	None
17	28 F	ReA	Lost	↑	Ill defined	+	↑	↑	Ill defined	+	+
18	30 M	Reiter's	Lost	↑	Ill defined	+	↑	↑	D	+	None
19	32 F	ReA	Lost	↑	D	None	↑	Normal	D	+	+
20	27 M	Psoriasis	Lost	↑	Ill defined	+	↑	↑	Ill defined	+	None
21	25 M	ReA	Lost	↑	Ill defined	None	↑	Normal	Ill defined	+	None
22	28 M	ReA	Lost	Normal	Ill defined	+	↑	Normal	D	+	None
23	39 F	Sacroiliitis	Lost	↑	Ill defined	+	↑	↑	D	+	None
24	33 M	Spondylitis	Lost	↑	D	+	↑	↑	D	+	+
25	35 F	ReA	Lost	↑	D	+	↑	↑	Ill defined	+	+
26	36 M	ReA	Lost	↑	Ill defined	+	↑	↑	Ill defined	+	+
27	30 M	Psoriasis	Lost	Normal	D	+	↑	Normal	D	+	None
28	35 M	ReA	Lost	↑	D	None	↑	↑	D	+	+
29	34 M	Sacroiliitis	Lost	↑	D	+	↑	↑	Ill defined	+	None
30	33 M	Spondylitis	Lost	Normal	D	+	↑	Normal	D	+	None
31	28 M	Spondylitis	Lost	↑	D	+	↑	↑	D	+	None
32	30 M	ReA	Lost	↑	D	+	↑	Normal	D	+	None

MRI failed to detect calcification of the enthesis. ↑: increased, D: defined tendon margins, +: detected/present.

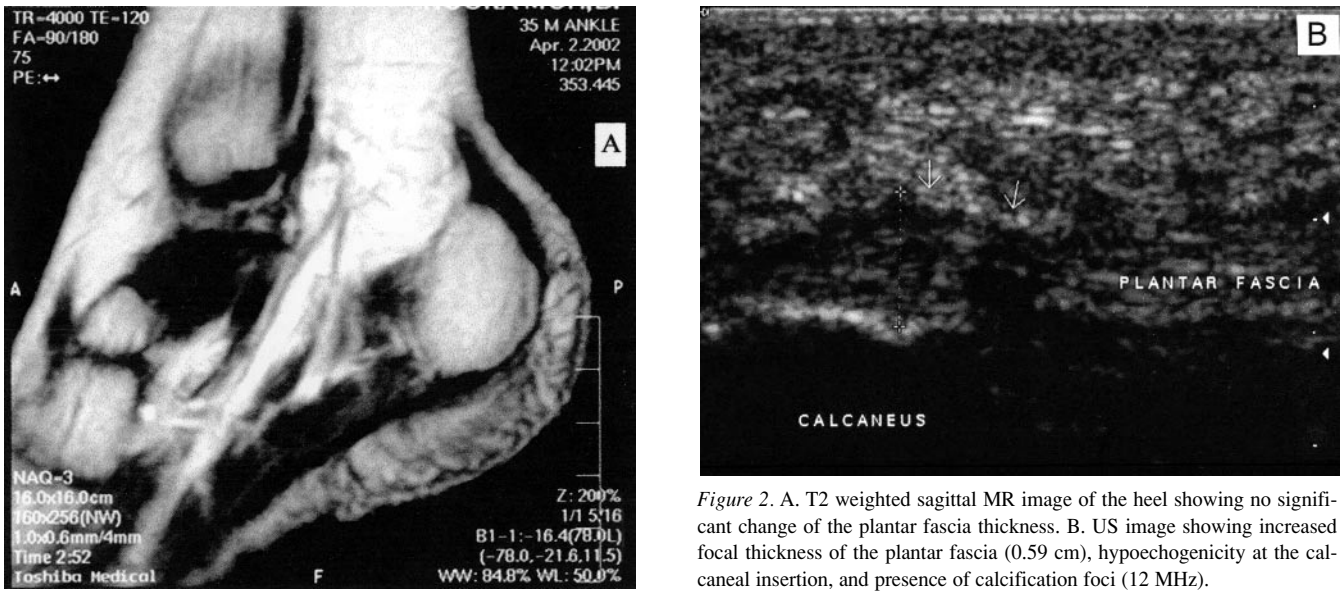

Figure 2. A. T2 weighted sagittal MR image of the heel showing no significant change of the plantar fascia thickness. B. US image showing increased focal thickness of the plantar fascia (0.59 cm), hypoechogenicity at the calcaneal insertion, and presence of calcification foci (12 MHz).

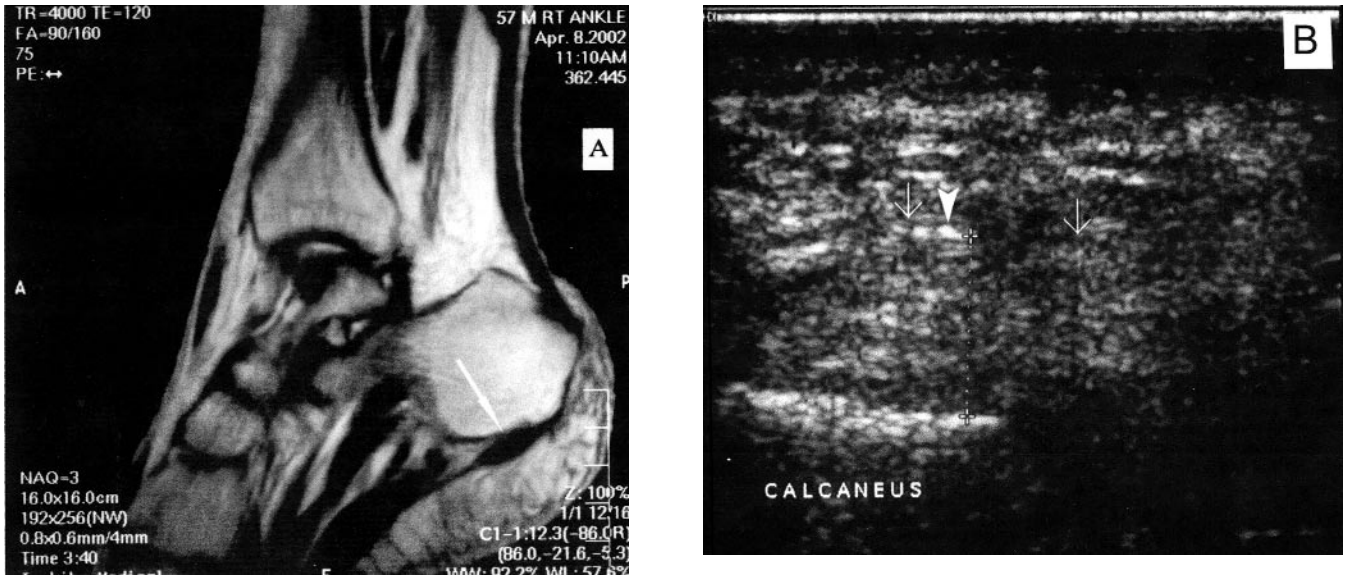

Figure 3. A. Sagittal T2 weighted MR image of the heel showing only focal thickening of the plantar fascia near its insertion. B. US image of the plantar fascia showing diffuse thickening (1.04 cm) through its whole length and presence of several calcification foci (arrowhead) (12 MHz).

10. Backhaus M, Kamradt T, Sandrock D, et al. Arthritis of the finger joints: a comprehensive approach comparing conventional radiography, scintigraphy, ultrasound and contrast-enhanced magnetic resonance imaging. Arthritis Rheum 1999;42:1232-45.
11. Kamel M, Moghazy K, Eid H, Mansour R. Ultrasonographic diagnosis of de Quervain's tenosynovitis. Ann Rheum Dis 2002;61:1034-5.
12. Swen WAA, Jacobs JWG, Neve WC, Bal D, Bijlsma JWJ. Is sonography performed by the rheumatologist as useful as arthrography executed by the radiologist for the assessment of full thickness rotator cuff tears? J Rheumatol 1998;25:1800-6.
13. Kamel M, Kotob H. Ultrasonographic assessment of local steroid injection in Tietze's syndrome. Br J Rheumatol 1997;36:547-50.
14. Kamel M, Kotob H. High frequency ultrasonographic findings in plantar fasciitis and assessment of local steroid injection. J Rheumatol 2000;27:2139-41.
15. Kainberger F, Engel A, Barton P, Huebsch P, Neuhold A, Salomonowitz E. Injury of Achilles tendon: diagnosis with sonography. AJR Am J Roentgenol 1990;155:1031-6.
16. Kainberger F, Fialka V, Breitenseher M, et al. Differential diagnosis of diseases of the Achilles tendon. A clinico-sonographic concept. Radiology 1996;36:38-46.
17. Rockett MS, Waitches G, Sudakoff G, Barge M. Use of ultrasonography versus magnetic resonance imaging for tendon abnormalities around the ankle. Foot Ankle Int 1998;19:604-12.
18. Waitches GM, Rockett M, Barge M, Sudakoff G. Ultrasonographic-surgical correlation of ankle tendon tears. J Ultrasound Med 1998;17:249-56.
19. Grassi W, Cervini C. Ultrasonography in rheumatology: An evolving technique. Ann Rheum Dis 1998;57:268-71.
20. Fornage BD. Achilles tendon ultrasound examination. Radiology 1986;159:759-64.
21. McGonagle D, Marzo-Ortega H, O'Connor P, et al. The role of biomechanical factors and HLA-B27 in magnetic resonance imaging–determined bone changes in plantar fascia enthesopathy. Arthritis Rheum 2002;46:489-93.
22. Kamel M, Moghazy K. Ultrasonographic detection of enthesitis: A comparison with MRI [abstract]. Arthritis Rheum 2001;44 Suppl:S95.
23. Rawool NM, Nazarian LN. Ultrasound of the ankle and foot [review]. Semin Ultrasound CT MR 2000;21:275-84.
24. O'Reilly MA, Masoouh H. The sonographic diagnosis of pathology in the Achilles tendon. Clin Radiol 1993;48:202-6.
25. Gibbon WW, Cooper JR, Radcliffe GS. Distribution of sonographically detected tendon abnormalities in patients with a clinical diagnosis of chronic Achilles tendinosis. J Clin Ultrasound 2000;28:61-6.
26. Gondolf-Zink B, Scheiderer W, Eisenlauer G. Sonography of Achilles tendon changes in athletes. Sportverletz Sportschaden 1987;1:96-9.
27. Swen WAA, Jacobs JWG, Hubach PC, Klasens JH, Algra PR, Bijlsma JWJ. Comparison of sonography and magnetic resonance imaging for the diagnosis of partial tears of finger extensor tendons in rheumatoid arthritis. Rheumatology 2000;39:55-62.