Ultrasound imaging for the rheumatologist XXXV. Sonographic assessment of the foot in patients with osteoarthritis

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ABSTRACT

Objective. *The aims of our study were to investigate the prevalence of ultrasound (US) abnormalities in the foot of patients with osteoarthritis (OA) and to compare them with clinical findings.*

Methods. *Consecutive patients with foot OA were investigated by clinical and US examinations. Bilateral US of the midfoot and forefoot joints was performed by using a Logiq9 machine, equipped with a multi-frequency linear probe, operating at 14 MHz; in addition, power Doppler was applied (frequency 7.5 MHz; gain 50%; PRF 750 Hz). Clinical evaluation included the registration of demographic data, disease duration, current treatment undergone, joint swelling and tenderness. US study included the assessment of both inflammatory (joint effusion, synovial hypertrophy, local pathologic vascularisation at PD, big-toe bursitis) and structural (osteophytes, MTP joints subluxation) abnormalities.*

Results. *One hundred patients were studied. At midfoot level, clinical examination demonstrated signs suggestive for joint inflammation (tenderness and/or swelling) in at least one joint in 43/200 feet (21.5%) of 23 patients; US showed inflammatory abnormalities in 87/200 feet (43.5%) of 63 patients and structural lesions in 100/200 feet (50%) of 70 patients. At forefoot level, clinical examination found inflammatory signs in at least one joint in 128 feet (64%) of 64 patients; US showed inflammatory abnormalities in at least one joint in 176 feet (88%) of 88 patients and structural lesions in 189 feet (86%) of 86 patients.*

Conclusions. *US is a useful imaging tool for analysing both inflammatory and structural damage lesions at foot joints level in OA. In addition, it demonstrated to be more sensitive than clinical examination in the detection of inflammatory abnormalities.*

Introduction

Osteoarthritis (OA) is an extremely common rheumatic disease that affects most peripheral joints. Both structural damage lesions and inflammatory abnormalities are present during the disease course, with evidence of a wide set of changes that involve all joint structures. The common active disease process, indeed, affects all tissues of the joint and determines dysregulation of normal tissue turnover and repair, leading to a failure of the whole joint (1, 2). The most common pathologic aspects are characterised by hyaline cartilage damage, bone and capsule hypertrophy and episodic synovitis (3). The foot is involved with a variable frequency according to the joint sites, hindfoot OA being uncommon, but forefoot OA is a frequent joint disease, particularly at the level of the first metatarsophalangeal joint, that represents the prime site of OA changes. Hallux valgus and hallux rigidus are extremely common problems, especially in women, and seem to be dependent on metatarsal deformities due to the use of inappropriate modern footwear (3). This results in the appearance of both radiographic manifestations and symptoms that may lead to relevant discomfort associated with pain, difficulty in walking and local deformations. Radiography represents the gold standard imaging modality for assessing OA joints and it is particularly valuable in detecting some structural osteoarthritis lesions. However, it is not

able to show soft tissue changes and demonstrate the presence of inflammatory abnormalities occurring in OA (1). It has been demonstrated that musculoskeletal ultrasound (US) is a valuable tool for imaging most musculoskeletal changes in rheumatic diseases (4). Over the last few years, its role has been underlined also in OA, due to its ability in showing early and late findings related both to inflammation and structural damage (1, 5-8). The fact that it is a safe tool has contributed to its increasingly widespread use, and it is now considered as a bedside procedure in rheumatology (9). Notwithstanding its increasing applications in the assessment of various abnormalities occurring in OA and its increased sensitivity with respect to clinical examination in detecting joint involvement in rheumatic diseases, its role in assessing foot lesions in OA is still to be defined.

The aims of our study were to investigate the prevalence of US abnormalities in the feet of patients with OA and to compare them with clinical findings.

Patients and methods

Consecutive patients with clinical and radiographic signs of OA involving the feet were included in the present study, independently of disease duration and severity of clinical signs of foot involvement. All patients were investigated both by clinical assessment and US examination in both feet. The study was conducted in 4 Italian units of rheumatology (Sapienza Università di Roma, Università Politecnica delle Marche, Università di Pisa and Università di Pavia).

Prior to US evaluation, clinical assessment was performed by an expert rheumatologist who registered the demographic data, disease duration and current treatment undergone. In addition, the presence/absence of joint swelling and tenderness (by palpation and active/passive mobilisation of the foot) were recorded, both at midfoot and forefoot level. The list of the assessed joints is reported in Table I.

The presence of any other rheumatic disease and the history of either severe trauma or surgery of the foot were the criteria for exclusion from the study.

Table I. Joints evaluated by clinical assessment and ultrasonographic examination.

Midfoot	Sub-talar (talo-calcanear) joint
	Talo-navicular joint
	Navicular-cuneiform (medial, intermediate, lateral)
	Calcaneo-cuboidal joint
	Cubo-navicular joint
	Inter-cuneiform joint (medial, lateral)
	Cuboido-cuneiform joint
	Medial cuneiform-metatarsal joint (I-V)
Forefoot	Metatarsophalangeal joints (I-V)
	I Interphalangeal joint
	Proximal-interphalangeal joints (II-V)
	Distal-interphalangeal joints (II-V)

Table II. Patients clinical and demographic characteristics and treatment assumed.

Number of patients	n=100
Gender (female/male)	57/43
Age in years (mean ± SD)	65.4 ± 10.8
Disease duration in months (mean ± SD)	13.7 ± 11.05
Therapy (n /%)	
Analgesic drugs	55 (55%)
NSAIDs	37 (37%)
Chondroprotective drugs	10 (10%)

The study was conducted according to the Declaration of Helsinki and local regulations, and informed consent was obtained from all patients.

Ultrasound

Prior to patients' enrolment, the US examination methodology was clarified among sonographers and a consensus was obtained on scanning protocol and image interpretation. In the 4 units participating in the study, US examination was separately and independently performed by a single ultrasonographer who was a rheumatologist experienced in musculoskeletal US and was blinded to the clinical and laboratory findings.

Bilateral US of the midfoot and forefoot joints was performed the same day of the clinical evaluation by using a Logiq9 machine (General Electrics Medical Systems, Milwaukee, WI), equipped with a multi-frequency linear probe, operating at 14 MHz. In addition, power Doppler (PD) was applied (frequency 7.5 MHz; gain 50%; PRF 750 Hz). The same equipment settings, which had been previously standardised, were used in all cases. At the beginning of each scanning session at different joint sites, the focus was positioned at the level of the region of interest. Colour gain was adjusted just below the degree that caused the appearance of noise artefacts (10). The colour box was positioned at the level of the joint area to be examined, enlarging the box to the upper part of the image. Table I reports the list of the joints examined, both at midfoot and forefoot levels.

Patients were asked to adopt a supine position with the foot resting on the examination table and the knee flexed at 60°. After the gel was applied to the skin to provide an appropriate acoustic interface, US examinations were carried out, paying attention so as not to apply probe pressure on the anatomical structures under examination. According to the EULAR guidelines for musculoskeletal US in rheumatology, in all cases, longitudinal and transverse multiplanar scans were performed at the level of the dorsal, lateral and medial aspects of the foot, depending on the joint subjected to examination (11) (Table I). During the same scanning session, US was initially performed in B-mode modality with the aim of detecting morphological changes and immediately afterwards using PD technique searching for local abnormal vascularisation. According to commonly used international definitions of pathological findings and including the assessment of both inflammatory and structural abnormalities, the following changes were registered: joint effusion, synovial hypertrophy, local pathologic

Table III. US-detected inflammatory and structural abnormalities at midfoot level.

	Patients	Feet	Joint * effusion	Synovial hypertrophy*	PD signal*	Osteophytes*
Subtalar joint (n / %)	16 / 16	16 / 8.8	16 / 100	2 / 12.5	0	16 /100
Talonavicular joint (n / %)	16 / 16	22 / 11	22 / 100	6 / 27.3	2 / 9	18 / 81.8
Navicular-cuneiform joint (n / %)						
- Medial	27 / 27	30 / 15	29 / 96.6	3 / 10	0	15 / 50
- Intermediate	29 / 29	43 / 21.5	43 / 100	4 / 9.3	0	21 / 48.8

*the percentage of abnormalities is calculated on the basis of the number of feet involved.

Table IV. US-detected inflammatory and structural abnormalities at forefoot level.

	Patients	Feet	Joint * effusion	Synovial hypertrophy*	PD signal*	Bursitis* (big toe)	Osteophytes*	Subluxation*
I MTP (n / %)	78 / 78	167 / 39	73 / 43.7	44 / 26.3	2 / 1.2	11 / 6.6	167 / 100	27 / 16.1
II MTP (n / %)	35 / 35	53 / 26.5	44 / 83	52 / 98.1	15 / 28.3	–	35 / 66	0
III MTP (n / %)	48 / 48	60 / 30	60 / 100	37 / 61.6	2 / 3.3	–	28 / 46.6	0
IV MTP (n / %)	13 / 13	17 / 8.5	17 / 100	6 / 35.3	0	–	10 / 58.8	0
V MTP (n / %)	22 / 22	26 / 13	25 / 96.1	1 / 3.8	0	–	24 / 92.3	2 / 7.7

*the percentage of abnormalities is calculated on the basis of the number of feet involved.

vascularisation at PD, big-toe bursitis, osteophytes, metatarsophalangeal (MTP) joints subluxation (12-14). All lesions were registered according to a dichotomous (presence/absence) score. Single joints were considered involved when at least one abnormality was detected by US. In addition, the most frequently involved joint both at midfoot and forefoot level was registered.

Statistical analysis

The statistical calculations were made using Statistical Package for Social Sciences 13.0 (SPSS, Chicago, IL, USA) and GraphPad 5.0 (La Jolla, CA, USA). Normally distributed variables were summarised using the mean±SD, and non-normally distributed variables by the median and range. Wilcoxon's matched pairs test and paired t-test were performed. Univariate comparisons between nominal variables were calculated using chi-square (χ^2) test or Fisher's exact test, where appropriate. Two-tailed *p*-values were reported; *p*-values less than or equal to 0.05 were considered significant.

Results

Patients' clinical and demographic characteristics, as well as the treatment undergone at the time of enrolment, are reported in Table II.

A total of 200 feet (100 patients) were examined both by clinical examination and US assessment.

Results of US-detected abnormalities are reported separately for midfoot and forefoot in Tables III and IV, respectively. Relationships between US and clinical findings indicative of foot joints inflammation are reported in tables 5 and 6 for midfoot and forefoot assessment, respectively.

At midfoot level, clinical examination demonstrated signs suggestive of joint inflammation (tenderness / swelling) in at least one joint in 43/200 feet (21.5%) of 23 patients. US showed inflammatory abnormalities in 87/200 feet (43.5%) of 63 patients, and demonstrated that the most frequently involved articular sites were the subtalar, talonavicular and navicular-cuneiform medial and intermediate joints, where the most common pathologic US finding was joint effusion, that was present globally in 55.3% of the joints examined; synovial hypertrophy was found in 9% of the midfoot joints and positive PD signal in 0.6%. The analysis of the single abnormalities at different joint sites demonstrated that effusion was present from 96.6% to 100% of the involved joints; synovial hypertrophy was detected from 9.3% to 27.3% of the involved articular sites; finally, PD-detected pathological vascularisation was present only in 9% of the involved joints and exclusively at talonavicular joint level Table III). US-detected structural lesions were shown in 100/200 feet (50%) of 70 patients with a global evidence of osteophytes in 34% of the examined joints. Particularly, 100% of the involved joints presented the evidence of osteophytes at subtalar joint level; the other midfoot joints showed osteophytes from 48.8% to 81.8% of the involved cases (Table III).

At forefoot level, clinical examination found inflammatory abnormalities in at least one joint in 128 feet (64%) of 64 patients; in all cases MTP joints were involved. Only 4 patients showed involvement of proximal interphalangeal (PIP) joints and 3 of DIP distal interphalangeal (DIP) joints. US showed inflammatory abnormalities in at least one joint in 176 feet (88%) of 88 patients. At MTP joints level, globally joint effusion (Fig. 1a) was the most frequent US finding (90.3% of the examined joints), followed by synovial hypertrophy (Fig. 1a-c) (50%), positive PD signal (Fig. 1c) (6.8%) and hallux bursitis (3.9%). The analysis of the different abnormalities showed that effusion was found from 43.7% to 100% of the involved joints; synovial hypertrophy was present from 3.8% to 98.1%

of involved articular sites; PD signal was positive only the I, II and III MTP joints (1.2%–28.3%); and hallux bursitis was preset in 6.6% of the involved joints (Table IV). At PIP joints level, US inflammatory signs were identified in 15 patients (15%, 20 feet) and were only represented by the finding of joint effusion. One patient showed the concomitant involvement of right II, III and IV PIP. Only 2 patients showed the involvement of DIP joints (II DIP bilaterally and right III DIP, respectively). US showed the presence of structural lesions in 189 feet (86%) of 86 patients. In particular, 100% of the involved I MTP joints were the site of osteophytes and 16.1% of subluxation; osteophytes were detected from 46.6% to 92.3% of the other involved MTP joints; subluxation, that was found exclusively at the level of the V MTP joints, was rare (7.7% of involved joints) (Table IV).
In addition, the analysis of the relationships between US and clinical findings indicative of foot joints inflammation demonstrated that 49 patients negative for clinical midfoot involvement showed US abnormalities; on the contrary, only in 5 patients without any US-detected lesions, clinical examination demonstrated signs suggestive of joint inflammation (Table V). At forefoot level, correlations between US abnormalities and clinically-detected findings showed that 56 patients negative to clinical examination were positive to US findings; only 8 patients without any sonographic evidence of abnormalities were positive to clinical assessment (Table VI).

Discussion

As far as we know, this is the first ultrasonographic study focused on the evaluation of the foot in patients with OA. US demonstrated a wide range of abnormalities that were related both to joint inflammation and structural damage lesions. Forefoot disease, in particular, is a very frequent cause of complaint for a huge number of OA patients who usually refer persistent symptoms at MTP joints that may lead to impairment and possible disability. This feature of disease often requires particular attention by the clinicians who may,

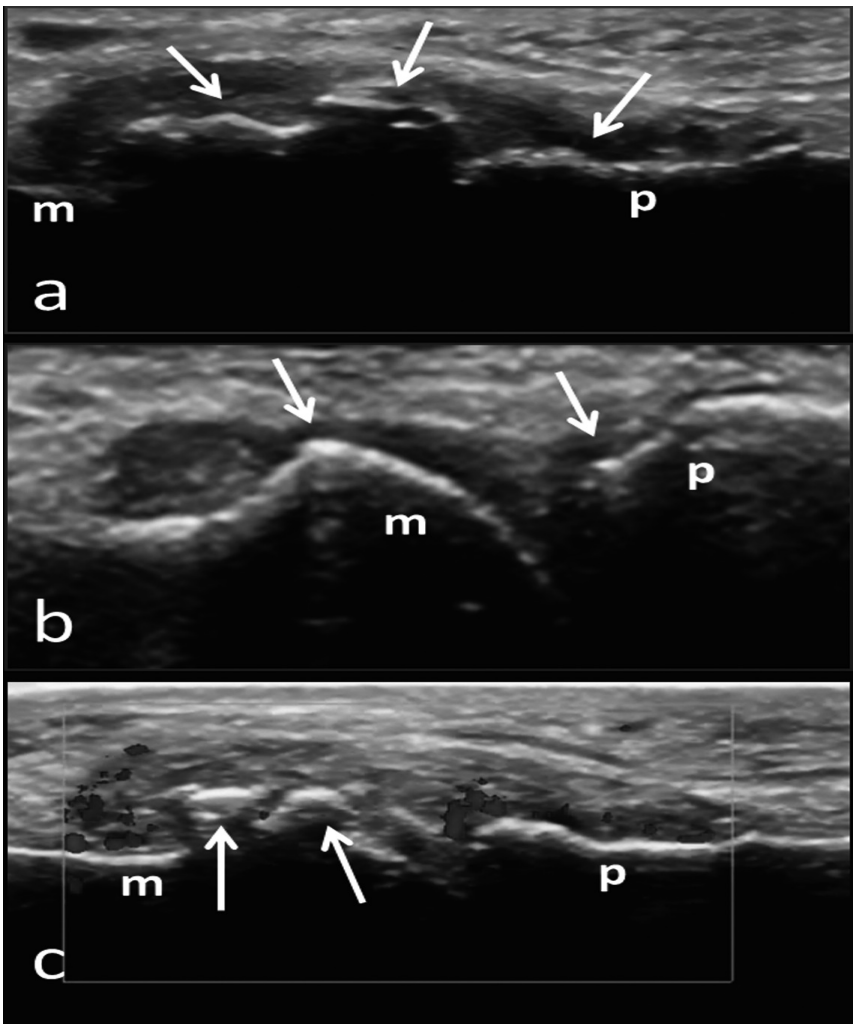

Fig. 1. Ultrasound of the foot in osteoarthritis. **a.** longitudinal dorsal scan of the I MTP joint: evidence of large osteophytes (↑). **b.** longitudinal dorsal scan of the II MTP joint: presence of synovial hypertrophy, joint effusion and small osteophytes (↑). **c.** Power Doppler US of the I MTP joint; longitudinal dorsal scan: moderate pathological hypervascularisation of the synovial membrane, indicative of active synovitis; large osteophytes (↑) are also present. m: metatarsal bone. p: proximal phalanx.

Table V. Relationships between US and clinical findings indicative of foot joints inflammation at midfoot level.

		Clinical findings		
		Presence (n. feet)	Absence (n. feet)	Total
Midfoot	US findings			
	Presence (n. feet)	38	49	87
	Absence (n. feet)	5	108	113
	Total	43	157	200

Table VI. Relationships between US and clinical findings indicative of foot joints inflammation at forefoot level.

		Clinical findings		
		Presence (n. feet)	Absence (n. feet)	Total
Forefoot	US findings			
	Presence (n. feet)	120	56	176
	Absence (n. feet)	8	16	24
	Total	128	72	200

therefore, consider the role of US in the management of OA patients.

The present study, for the first time showed that midfoot is a possible site for pathology in OA, demonstrating that 43.5% of the joints presented with signs of inflammatory abnormalities that were mainly represented by joint effusion. Interestingly, pathologic findings were detected also in joints without any clinical evidence of inflammatory involvement. This particular feature confirms the results obtained by previous studies that have underlined the higher sensitivity of US with respect to clinical examination in the detection of joint inflammation, with the capability of US to detect subclinical synovitis (15-21). In addition, US was able to demonstrate the presence of osteophytes in 34% of the joints at midfoot level. Again, this finding is of particular interest, being the midfoot considered a relatively uncommon site for OA.

At forefoot level, US demonstrated a very high incidence of inflammatory findings that, as expected, were mainly present at MTP joints. Unlike the midfoot joints, MTP involvement was represented both by joint effusion and synovial hypertrophy, with possible presence also of local pathological vascularisation at PD. The finding of synovitis at the MTP joint level appears particularly valuable, since MTP joints is a target site for OA. Thus, US can be considered a useful tool for indicating the presence of inflammatory abnormalities since early disease. Indeed, the increased value of US seems to be related, again, to its higher sensitivity with respect to clinical examination in detecting subclinical inflammatory joint findings (15, 16). Failure to detect synovitis could delay treatment and lead to joint impairment. Thus, clinicians may be cautious in determining the presence or absence of synovitis on the basis of clinical examination alone; this aspect reflects the need for US to help increase their diagnostic confidence (17). In addition, our study demonstrated an extensive involvement of the forefoot, with evidence of diffuse structural lesions that were mainly characterised by frequent detection of osteophytes.

The limitation of our study is represented by the lack of data on cartilage damage assessment. Indeed, a noteworthy limitation of US is represented by the incomplete evaluation of hyaline cartilage which is the target tissue in OA. Particularly, the sonographic evaluation of that anatomic structure is based on the use of appropriate acoustic windows which, at foot level, do not permit an extensive assessment of it. Cartilage evaluation was, therefore, excluded by our analysis that was mainly focused on the detection of the other main pathological features of disease.

In conclusion, the present study showed that US is a useful imaging tool for analysing both inflammatory and structural damage lesions at the foot joint level in OA. The foot is a complex anatomic area with a huge number of joints that are difficult to assess by physical examination. On the contrary, US is able to distinguish the various possible articular sites involved and can detect a wide set of lesions (22, 23). In addition, it demonstrated that it was more sensitive than clinical examination in the detection of inflammatory abnormalities, therefore supporting the emerging evidence for its widespread application in OA. Overall, the use of US in foot OA patients provides additional information to be integrated with clinical history and physical examination and which help in the management of the disease, indicating the presence of inflammatory findings as well as of structural damage lesions since early disease. Due to its non-invasiveness and limited costs and based on the high prevalence of OA, US can be routinely used to discriminate between different subsets of disease, helping in the characterisation of patients with a more aggressive pathology as well as in finding the subjects with a more severe prognosis. The widespread use of US in the assessment and management of patients with foot OA is therefore recommended.

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