Ultrasonography detection of early bone erosions in the metacarpophalangeal joints of patients with rheumatoid arthritis

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Abstract

Objective

To compare ultrasonography (US) and magnetic resonance imaging (MRI) in their capability to detect bone erosions in early-advanced rheumatoid arthritis, where no erosion was evident on conventional radiography (X-ray).

Methods

Metacarpophalangeal (MCP), radiocarpal and ulnocarpal joints of 13 patients with rheumatoid arthritis, with bone erosion that was not detected by conventional X-ray, were examined by US and MRI. Ten controls underwent examination of the same joints by US.

Results

None of the controls showed bone erosions at US examination. No significant difference between US and MRI in detecting bone erosion was observed in wrist joints, whereas a significantly higher number of erosions was detected by US in MCPjoints.

Conclusion

US is at least as sensitive as MRI in detecting bone erosions in MCP and wrist joints. Since US examination is a more easily available and less expensive procedure than MRI, our findings justify its use as a diagnostic tool for early arthritis. In addition US may also be utilized in the follow up of patients with an established diagnosis of inflammatory arthritis.

Key words

Bone erosions, rheumatoid arthritis, ultrasonography, magnetic resonance imaging.

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Introduction

Rheumatoid arthritis (RA) is often a progressive erosive disease which can lead, over a variable number of years, to severe disability. Bone erosions are the hallmark of severe progressive arthritis and the cause of joint destruction and deformity. The majority of erosions occur during the first two years of the disease, but may progress even during the following 10-15 years (1, 2). Recently, new drugs effective in reducing or halting disease progression have enlarged the range of treatment options available to physicians. Therefore, early diagnosis and identification of potentially erosive cases and their prompt treatment with effective drugs is of the utmost importance (3).

Among the established risk factors for a negative prognosis (erosions and disability) is the presence of erosions at diagnosis. Studies have shown that patients with active, polyarticular, rheumatoid factor (RF)-positive RA have a 70% probability of developing joint damage or erosions within 2 years of the onset of disease (4). The presence of joint erosions is generally assessed by traditional X-rays (1,5), but recently more sensitive techniques have been employed to study bone erosions in RA patients, particularly at diagnosis.

Magnetic resonance imaging (MRI) is an excellent tool for detecting synovitis and is better than X-rays for showing bone changes in the majority of patients with early RA (6-8). Bone marrow edema, which is visualized by MRI, has been demonstrated to be related to the degree of synovitis and to be the forerunner of erosions. In addition, MRI is more sensitive than traditional X-ray examination for detecting early erosions (9,10). However, despite its ability to reveal erosions earlier and in a much greater number of patients than conventional radiography, the technique has several disadvantages connected with its availability, costs and radiology cooperation issues.

Ultrasonography (US), thanks to the introduction of the multi-frequency linear array transducer and new software packages, is a promising methodology in bone erosion detection. Many studies have demonstrated that US detects more erosions in the joints of RA patients than does conventional radiography, especially in early disease. Comparison with MRI and retrospective reviews of radiographs have confirmed the specificity of the additional lesions detected by sonography (11-14). Recently, US examination of joints has become widely available. This technique has reduced costs and can be performed directly by the rheumatologist with no need for the equipment and the expertise of a radiology department.

The important differences between US and MRI in terms of equipment, costs, duration of the examinations, and the non-rheumatological expertise required, prompted us to compare them in assessing bone erosions in patients with RAin the early-advanced phase of disease, where conventional X-rays failed to reveal them. Imaging focused on the study of metacarpophalangeal (MCP) and radio-ulno-carpal joints of both hands.

Patients and methods

Patients

Thirteen consecutive patients (11 females, 2 males), mean age 61 years (range 39-78), who fulfilled the American College of Rheumathology criteria for RAand who were negative for hand bone erosions by conventional X-ray entered the study. The mean disease duration was 18 months (range 3-52). Eight patients were rheumatoid factor (RF)-positive. All patients but one were on treatment with single or combination disease-modifying antirheumatic drugs (DMARDs). The demographic characteristics and treatments of patients are showed in Table I.

As controls we selected 10 subjects (7 females, 3 males), with a mean age of 58 years (range 46-72), who presented to the US Unit for pain in joints other than the hands. RA was excluded by clinical and laboratory tests in all controls.

MRI examination

MRI was performed with a 1.5 and 1 Tesla superconducting magnet (GE Signa Horizon LX; General Electric Medical Systems, Milwaukee, USA), equipped with a transmit-receive, 20

Table I. Demographic characteristics and treatments of patients.

Pts.	Sex	Age (years)	RF	ESR (mm/h)	CRP (mg/dl)	Disease duration (mos.)	Treatment
1	F	71	+	52	2.41	22	MTX+MP+HCQ
2	F	64	-	20	0.6	27	MTX+MP+HCQ
3	F	60	-	48	1.9	52	MTX+MP
4	F	66	+	27	0.42	40	MTX+MP+SSZ+HCQ
5	M	78	-	12	0.38	11	HCQ
6	M	53	+	14	0.9	14	MTX+MP
7	F	71	+	38	2.57	3	MP+HCQ
8	F	71	-	7	0.5	4	NSAIDs
9	F	58	+	10	0.2	27	MTX
10	F	49	-	19	3.11	4	MTX
11	F	66	+	39	3.91	3	MTX+SSZ
12	F	39	+	30	1.82	9	MTX
13	F	54	+	50	0.82	24	MTX+CSA

ESR: erythrocyte sedimentation rate (normal value < 15 mm/h); CRP: C-reactive protein (normal value < 0.8 mg/dl); MTX: methotrexate; MP: methylprednisolone; HCQ: hydroxychloroquine; SSZ: sulfasalazine; CSA: cyclosporine; NSAIDs: non-steroidal anti-inflammatory drugs.

cm diameter circumferential surface coil. The patients underwent imaging in a prone position, with the arm extended above the head and the wrist positioned in the center of the coil.

In all the patients, the imaging protocol consisted of three coronal pulse sequences: T1-weighted fast spin-echo (T1 FSE), T2* weighted gradient-echo fat suppressed (T2* GRE), T1-weighted fast spin–echo fat suppressed gadolinium enhanced, and axial pulse sequence T1-weighted fast spin-echo fat-suppressed gadolinium enhanced. The imaging parameters for the T1-weighted coronal images were repetition time (TR) 400 ms, echo time (TE) 10.2 ms, matrix 256 x 256, field of view (FOV) 18 cm, slice thickness 3 mm, slice gap 1 mm, number of excitations (NEX) 4. The T1w coronal and axial FSE fat suppressed after Gd-DTPA enhancement parameters were similar, but the repetition time (TR) was 540 ms. The T2*w coronal GRE fat-suppressed parameters were TR 400 ms, TE 11.5 ms, flip angle (FA) 30°, FOV18 cm, matrix 256 x 256, NEX 2, slice thickness 3 mm, slice gap 0.3 mm.

An intravenous bolus injection of gadolinium-DTPA (0.1 mmol/Kg body weight, Magnevist, Shering, Berlin, Germany) was performed after completion of the pulse sequences FSE T1w and GRET2*w. The images were printed on radiographic acetate film and stored.

Multiple coronal scans were carried out on all MCP, radiocarpal and ulnocarpal joints.

Definition of bone erosions by MRI

Bone erosions were defined as bone defects with sharp margins visible on 2 planes with a cortical break seen in at least 1 plane on T1w sequences. Erosion in the wrists and metacarpo-phalangeal joints were recorded. The MRI scans were assessed by two radiologists. Each radiologist was unaware of the other operator score's and differences in scoring were resolved by consensus.

US examination

Sonography was performed by a Siemens Omnia multifrequency linear probe 7.5–13 mHz and the images were photographed and printed using a Sony printer and recorded on an opto-magnetic disk. The patient was positioned in front of the operator with his/her hands resting on the bed. The standard procedure included: longitudinal and transverse, dorso-ventral and lateral scans of the radio-carpal and ulnocarpal joints and all the MCP joints of both hands.

The US examinations were assessed by two sonographists; neither was aware of the other operator's score, and differences in scoring were resolved by consensus.

Definition of bone erosions by US

To limit artefacts, erosion was defined as the disruption of the bone cortex (diameter ≥ 2 mm) with loss of material and clearly visible posterior reverberation in the longitudinal and transverse scans. Irregularities of the cortical profile were not considered as erosions. Neither the sonographists nor the radiologists had access to the results of their colleagues until after the end of the study.

Ethics

All patients gave their informed consent, and approval was obtained from the Ethical Committees of the two hospitals involved in the study.

Statistical analysis

Non-parametric analysis of paired (Wilcoxon test) and unpaired (Mann-Whitney U test) data was performed. Pearson's correlation coefficient was calculated for the relationship among variables. The Statistica for Windows package (Statsoft Inc., Tulsa, OK, USA) was used to perform the statistical analysis.

Results

None of the control subjects showed bone erosion at US examination.

No significant difference between US and MRI in detecting bone erosions was observed in the wrist joints, whereas a significantly higher number of erosions was detected by US in the MCP joints (Fig.1). MCPbone erosions were detected in RApatients both by US (13 cases out of 13) and MRI (12 cases out of 13). The number of patients with erosions and the number of erosions are shown in Table II. No significant difference was observed in the the number of erosions in the dominant and non-dominant hands (data not shown). In addition, no significant association was found between the disease duration and the number of erosions. Finally, no significant difference in the number of erosions between RF-positive and RF-negative cases was observed, even if a trend towards a higher number of erosions in the MCP joints was observed in RF-positive patients (wrist joint, $p = 0.621$; MCPjoints, $p = 0.065$).

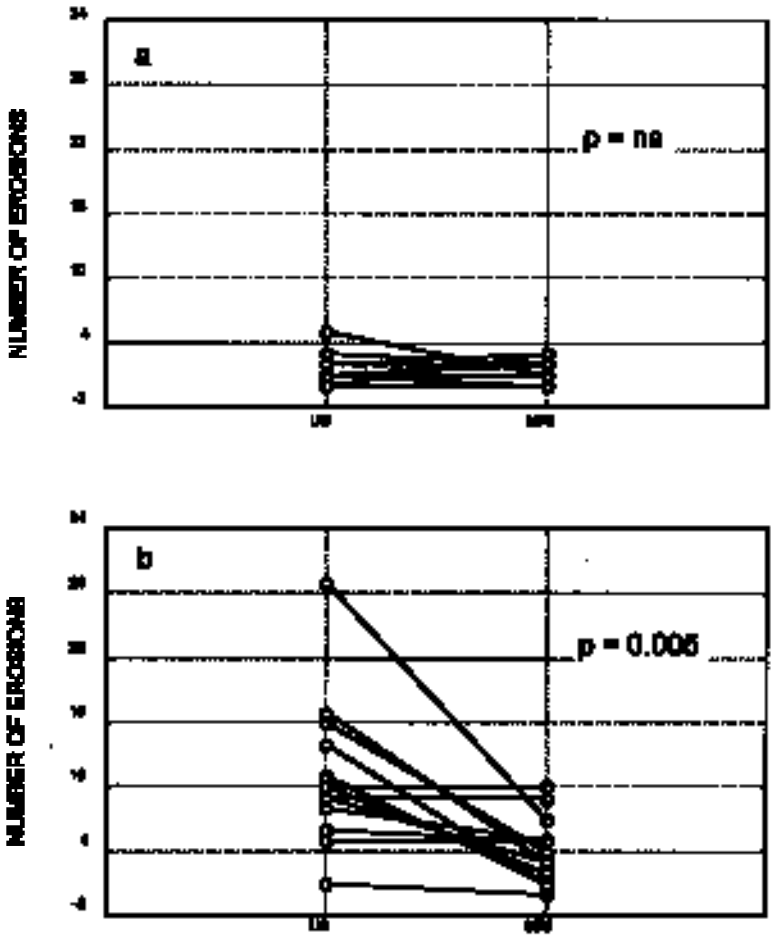

Fig. 1. Comparison of US and MRI in the detection of erosions (**a**) at the wrist and (**b**) at the MCP joints.

Table II. Number of patients with erosions and number of erosions detected by US and MRI.

		Ultrasonography		Magnetic resonance imaging	
	Rheumatoid factor (RF)	No. of pts. with erosions	Total no. of erosions	No. of pts. with erosions	Total no. of erosions
Radiocarpal joint	+	5	8	4	5
	-	1	2	2	2
Ulnocarpal joint	+	5	8	6	8
	-	3	4	3	5
MCPjoint	+	8	108	8	42
	-	5	37	4	14

Discussion

The main finding of our study was that US examination is at least as sensitive as MRI in detecting bone erosions in RApatients in the early-advanced stage of the disease. The higher sensitivity of MRI and US compared to conventional X-ray examination had already been established in many studies (6-8, 11, 12). Since RA often leads to disability in the patient and because of the availability of new effective biological agents that can stop both the clinical disease activity and the radiographically demonstrated process of bone erosion, early diagnosis of erosive progression is mandatory (3).

Recently MRI has been proposed as the imaging evaluation of choice (15) at diagnosis in order to obtain an earlier definition of erosive disease. The role of MRI as standard practice in the diagnostic assessment of early arthritis in patients with negative radiographic findings is limited by many factors: MRI equipment is not readily available in rheumatology outpatient clinics and the interpretation of MRI images of joints and soft tissues needs an expert radiologist; furthermore, the procedure is time-consuming and expensive.

Therefore, the use of US might represent a feasible alternative. Our study demonstrates that, as far as wrist and MCP joints are concerned, US is not inferior to MRI in erosion detection.

Indeed, for the MCP joints US appears to be even more sensitive than MRI. This result seems to be in contrast with the data reported by Backhaus *et al.* (6) in a large prospective study. These authors found that MRI was more sensitive than US, particularly in detecting early erosions. It is noteworthy that they employed a 3D MRI with slice thickness of 1 mm, whereas we utilized the more conventional 2D MRI (axial and coronal images) with a slice thickness of 3 mm and slice gaps from 0.3 to 1 mm. This is probably the reason for the lower sensitivity of MRI in our study.

We found no significant correlation between the disease duration and the number of erosions. This result confirms previous reports stating that most bone erosions occur during the first years of disease and their rate of progression decreases or remains stable thereafter (16). In our study RF-positive patients did not show a higher number of erosions, even if a trend in this direction was found as far as the MCP joints were concerned. This finding is probably related to the number of patients investigated.

US examination is less expensive than other imaging modalities; the time required to perform it is similar to MRI, but longer than conventional X-ray (6). US equipment is now available in almost all rheumatology outpatient settings and can be directly used by the

rheumatologist without the need for a radiologist.

On the basis of these considerations, and taking into account the results of our study and others, we recommend that US examination be performed during the diagnosis of early arthritis cases in all patients or, at the very least, in those without erosions on conventional X-ray examination. In addition, due to the availability of this imaging technique, US examination could be utilized in the follow-up monitoring of patients with established diagnosis of inflammatory arthritis.

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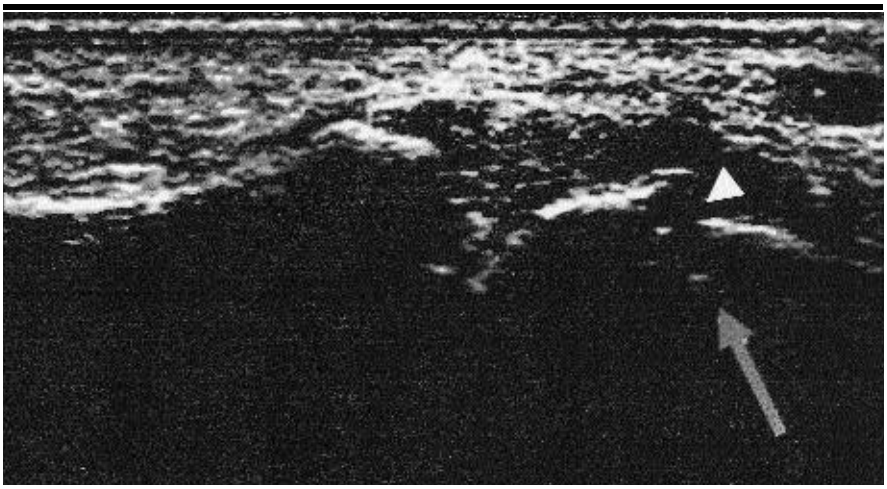
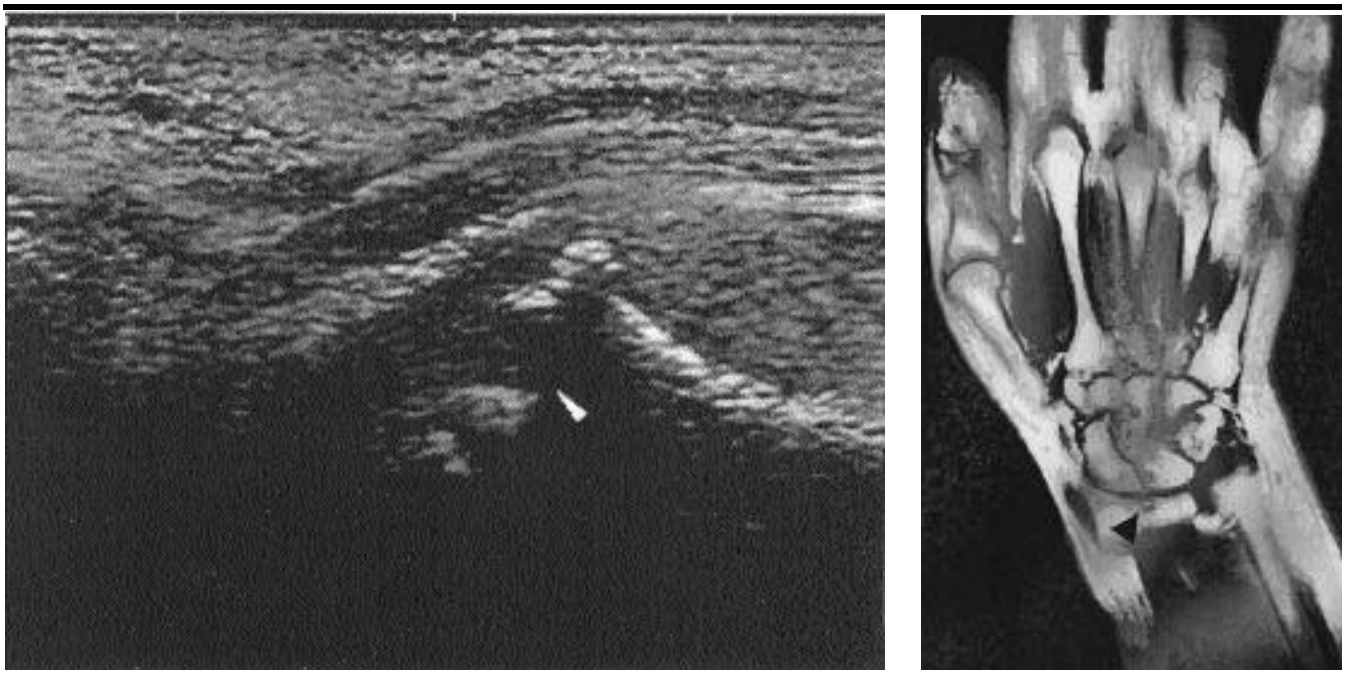


Fig. 2. US imaging of bone erosions: view of second metacarpophalangeal joint. A large erosion can be seen with a "break" in the bone cortex (**arrowhead**) and posterior reverberation (**arrow**).



(a) **(b)**

Fig. 3. Corresponding US (**a**) and MRI (**b**) images of a wrist (radial side) erosion (**arrowhead**).

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