ORIGINAL ARTICLE

Scoring ultrasound synovitis in rheumatoid arthritis: a EULAR-OMERACT ultrasound taskforce-Part 2: reliability and application to multiple joints of a standardised consensus-based scoring system

Lene Terslev,1 Esperanza Naredo,2 Philippe Aegerter,3 Richard J Wakefield,4 Marina Backhaus,5 Peter Balint,6 George A W Bruyn,7 Annamaria Iagnocco,8 Sandrine Jousse-Joulin,9 Wolfgang A Schmidt,10 Marcin Szkudlarek,11 Philip G Conaghan,4 Emilio Filippucci,12 Maria Antonietta D’Agostino13,14

ABSTRACT

Objectives To test the reliability of new ultrasound (US) definitions and quantification of synovial hypertrophy (SH) and power Doppler (PD) signal, separately and in combination, in a range of joints in patients with rheumatoid arthritis (RA) using the European League Against Rheumatism–Outcomes Measures in Rheumatology (EULAR-OMERACT) combined score for PD and SH.

Methods A stepwise approach was used: (1) scoring static images of metacarpophalangeal (MCP) joints in a web-based exercise and subsequently when scanning patients; (2) scoring static images of wrist, proximal interphalangeal joints, knee and metatarsophalangeal joints in a web-based exercise and subsequently when scanning patients using different acquisitions (standardised vs usual practice). For reliability, kappa coefficients (κ) were used.

Results Scoring MCP joints in static images showed substantial intraobserver variability but good to excellent interobserver reliability. In patients, intraobserver reliability was the same for the two acquisition methods. Interobserver reliability for SH (κ=0.87) and PD (κ=0.79) and the EULAR-OMERACT combined score (κ=0.86) were better when using a ‘standardised’ scan. For the other joints, the intraobserver reliability was excellent in static images for all scores (κ=0.8–0.97) and the interobserver reliability marginally lower. When using standardised scanning in patients, the intraobserver was good (κ=0.64 for SH and the EULAR-OMERACT combined score, 0.66 for PD) and the interobserver reliability was also good especially for PD (κ range=0.41–0.92).

Conclusion The EULAR-OMERACT score demonstrated moderate-good reliability in MCP joints using a standardised scan and is equally applicable in non-MCP joints. This scoring system should underpin improved reliability and consequently the responsiveness of US in RA clinical trials.

Key messages

What is already known about this subject?
- No consensus existed until now on a single ultrasound (US) scoring system for rheumatoid arthritis (RA) clinical trials.

What does this study add?
- A consensus-based US scoring system has been validated in multiple joints and has been shown to be highly reliable.

How might this impact on clinical practice?
- This highly reliable consensus-based scoring system should improve responsiveness and increase the uptake of US in RA clinical trials.

INTRODUCTION

Growing data suggest that ultrasound (US) is a valuable tool for assessing and classifying joint involvement and measuring disease activity based on the detection and scoring of synovitis in patients with rheumatoid arthritis (RA). The benefit of US in the evaluation and monitoring of patients with RA is mainly based on its greater sensitivity in detecting synovitis compared with clinical examination. Colour Doppler (CD) and power Doppler (PD) modes are able to detect pathological synovial blood flow, which reflects the inflammatory activity in the joint and has predictive value in relation to radiographic progression of structural damage and in relation to disease flare. In addition, US-detected synovitis aids more...
accurate early diagnosis of RA to enable earlier treatment. As RA clinical trials need objective and feasible methods for assessing inflammation response and with clinical practice focusing on tight control of disease activity, it has become imperative to improve the reliability of US in quantifying synovitis. Many scoring systems have been proposed, however, a recent literature review highlighted the lack of an expert-derived consensus.

The Outcomes Measures in Rheumatology (OMERACT) US Working Group in collaboration with an US working party of the European League Against Rheumatism (EULAR) conducted a series of US studies in order to understand possible reasons for a low agreement in detecting synovitis and to develop and validate an expert-derived consensus for scoring synovitis. The validation process, outlined in supplementary figure 1 in the supplementary online material, was carried out in a multistep approach (four steps) from 2005 to 2014. The first two steps are described in a companion paper in which exercises in static images and in clinical setting revealed that the causes for the inconsistencies and the hampered reliability in scoring synovitis among rheumatologists from different European countries were related to several sources of variability such as the perception and weighting of the different US components (ie, synovial hypertrophy (SH), Doppler activity and also effusion) used for describing and grading the inflammatory process as well as the differences in the US acquisition technique. Based on these discrepancies, the elementary components were redefined by Delphi consensus. It was agreed: (1) not to include effusion as an inflammatory component, as it was considered to be an inconsistent finding, frequently detected in healthy subjects or in inactive RA joints; (2) to redefine synovitis based on SH and Doppler only and (3) to score them semiquantitatively (0–3) both separately and in combination using the novel EULAR-OMERACT combined score. These steps were performed using metacarpophalangeal (MCP) joints as a model.

Having established these basic steps, the group moved to the second part of the validation process which is presented in this paper. The objectives were: (1) to evaluate the reliability of the EULAR-OMERACT combined score for grading synovitis in MCP joints, as well as the definition and quantification of SH and PD individually; (2) to test the reliability of a standardised consensus-based acquisition method compared with a ‘usual practice’ scanning method and (3) to evaluate the reliability of the new definitions for SH, PD and the EULAR-OMERACT combined score in non-MCP joints.

### METHODS

Twelve US-experienced rheumatologists, who participated in the first part of the standardisation process, participated in the following steps: (1) testing the validity of the new proposed definitions for scoring SH and PD separately and in combination (the EULAR-OMERACT PDUS score) on static images of MCP joints; (2) applying the same definitions and scoring systems in a real-time patient-based reliability exercise, by comparing a consensus-based scanning acquisition method previously obtained to a ‘usual practice’ scanning method and (3) testing the reliability of the new definitions and of the EULAR-OMERACT combined score in non-MCP joints (wrist, proximal interphalangeal (PIP), knee and metatarsophalangeal (MTP)) in both reading static images and scanning patients.

In all the reliability exercises, the participants used both a semiquantitative (SQ) (0–3) and a binary score (yes/no). The definitions and the scoring systems used are presented in table 1.

All patients participating in the reliability exercises fulfilled the American College of Rheumatology classification criteria for RA and were attending the rheumatology department of Ambroise Paré hospital in Boulogne-Billancourt (France). Patients were selected based on the absence of joint deformities and the willingness to take part. The studies were conducted in accordance with the Declaration of Helsinki and each participant gave written informed consent.

#### Step 1. Web-based exercise

A set of high-quality US images of synovitis of MCP joints were selected from an anonymised register of patients with RA by two independent ultrasonographers (MADA and EN) in order to ensure inclusion of a broad range of synovitis severity. A random selection of images was shown twice in order to assess the intra-reader reliability.

#### Step 2. Patients-based exercise: scanning patients according to a different scanning approach

The experts performed a bilateral US scanning of the second–fifth MCP joints in eight different patients. The dorsal aspect of the joints was examined twice in two rounds over 2 days. In the first round, using a ‘standardised acquisition method’, the US examinations were performed using a longitudinal dorsal scan on the middle of the joint, first, in GS and then PD, to detect joint morphological abnormalities and synovial flow respectively. In the second round, a ‘usual practice (free) acquisition approach’ of the dorsal side of the MCP joint was used. In the standardised scan, the maximal grading was to be assessed in the midline. In the ‘usual practice’ scan method, the examiner recorded the maximal grading from any area of the joint.

#### Step 3. Testing the new definitions and the reliability of the EULAR-OMERACT combined score and of SH and PD individually in non-MCP joints

A set of high-quality US images of synovitis of wrist, PIP, knees and MTP joints from patients with RA was evaluated using images from the same register and applying the same approach as described in step 1.
Table 1  Definitions of severity grades (0–3) for each elementary component and for the EULAR-OMERACT combined score

| Synovitis | SH (greyscale) | Doppler (PD) | Combined score* (greyscale SH + PD) |
|-----------|----------------|--------------|-----------------------------------|
| Grade 0 (normal) | No SH independently of the presence of effusion | No Doppler signal | No SH and no PD signal |
| Grade 1 (minimal) | Minimal hypoechoic SH† up to the level of the horizontal line connecting bone surfaces between the metacarpal head and the proximal phalanx | Up to three single Doppler spots OR up to one confluent spot and two single spots OR up to two confluent spots | Grade 1 hypoechoic SH and ≤ grade 1 PD signal |
| Grade 2 (moderate) | Moderate hypoechoic SH‡ extending beyond joint line but with the upper surface concave (curved downwards) or hypertrophy extending beyond the joint line but with the upper surface flat | >Grade 1 but ≤50% Doppler signals in the total greyscale background | Grade 2 hypoechoic SH and ≤ grade 2 PD signal; or grade 1 SH and a grade 2 PD signal |
| Grade 3 (severe) | Severe hypoechoic SH‡ with or without effusion extending beyond the joint line but with the upper surface convex (curved upwards) | >Grade 2 (>50% of the total greyscale background) | Grade 3 hypoechoic SH and ≤ grade 3 PD signal; or grade 1 or 2 SH and a grade 3 PD signal |

*EULAR-OMERACT combined score.
†Independently of the presence of effusion.
‡EULAR-OMERACT, European League Against Rheumatisms–Outcomes Measures in Rheumatology; PD, power Doppler; SH, synovial hypertrophy.

After the exercise on static images, the experts performed bilateral US scanning of the wrist, PIP, knee and MTP joints in six different patients twice in two rounds over 2 days (first day wrist and PIP joints, second day knee and MTP joints), using predefined joint positions as follows:

- **Wrist joints** (ie, radiocarpal and midcarpal joints were evaluated as a single site): palms facing down and wrist positioned flat on the examining table, as neutral as possible but relaxed; shoulder and elbow relaxed; elbow rested on the table. Scanning at the level of the radio-lunate joint.
- **PIP joints**: palms facing down and wrist positioned flat on the examining table, as neutral as possible but relaxed, scanned on the dorsal midline aspect.
- **Knee joints** (ie, suprapatellar and parapatellar recesses were scored as a single site): knee 30° flexed and scanning on suprapatellar midline for the suprapatellar recess; knee extended and scanning the parapatellar areas using the retinacula as a landmark for the parapatellar medial and lateral recesses. Doppler signal was recorded only in the medial and lateral parapatellar recesses.
- **MTP joints**: foot placed resting (with knee 30° flexed) over its plantar aspect. Scanning recorded on the dorsal midline aspect.

For all examinations, identical ESAOTE Technos MPX (Genoa, Italy) US machines with an 8–14 MHz linear array transducer were used with identical PD settings (frequency of 10.1 MHz, pulse repetition frequency of 750 Hz and Doppler gain of 50–53 dB). Each patient was assigned to one machine and the sonographers then rotated from one machine to the next in a predefined sequence with 10 min allocated for scanning and recording the findings on a standard score sheet. Participants were blinded to the patients’ clinical details (ie, presence or not of active disease).

**STATISTICAL ANALYSIS**

The intraobserver and interobserver reliability of scoring static and dynamic images were assessed according to weighted Kappa coefficients (κ) relying on absolute differences and in order to take into account the magnitude of discrepancy between categories. Intraobserver coefficients were evaluated on pairs of measures performed by the same sonographer at each site, while interobserver coefficients were exclusively based on the first measure of those pairs. Interobserver reliability was studied by calculating the mean κ for all pairs (ie, Light’s κ). Kappa values were evaluated according to Landis and Koch. Percentage of observed agreement (ie, percentage of observations that obtained the same score) and prevalence of the observed lesions were also calculated. Statistical analysis was performed using the R software (http://www.r-project.org/).

**RESULTS**

**Step 1. Testing the definition and reliability of the EULAR-OMERACT combined score on static images**

Thirty-six images of MCP joints were scored. Table 2 shows the observed agreement, prevalence and κ values results. The agreement was good for the novel definitions of synovitis components (SH and PD) both separately and in combination (EULAR-OMERACT combined score) with the best obtained for PD alone.
Table 2: Prevalence of observed lesions, observed agreement, intraobserver and interobserver reliabilities when scoring synovitis in metacarpophalangeal joints on static images

| Intraobserver | Interobserver |
|---------------|--------------|
| **Prevalence % (min–max)** | **Observed agreement (min–max)** | **Kappa range (min–max) (y/n) + 95% CI** | **Kappa range (min–max) (0–3) + 95% CI** | **Mean kappa (mean)** | **Mean kappa (0–3) + 95% CI** |
| **SH** Grade 0: 9–34 | 0.31–0.94 | −0.01–0.94 (−0.31–0.31 to 0.82–1) | 0.06–0.96 (−0.42–0.27 to 0.9–1) | Grade 0: 22 | 0.76 |
| Grade 1: 11–33 | | | | Grade 1: 21 | 0.57 (0.35 to 0.57) |
| Grade 2: 8–47 | | | | Grade 2: 35 | 0.78 (0.54 to 0.78) |
| Grade 3: 38–67 | | | | Grade 3: 23 | |
| **PD** Grade 0: 59–71 | 0.5–1 | −0.03–1.0 (−0.34–0.29 to 0.77–1) | 0.01–1.0 (−0.28–0.26 to 1–1) | Grade 0: 66 | 0.88 |
| Grade 1: 4–15 | | | | Grade 1: 10 | 0.97 (0.8 to 0.97) |
| Grade 2: 11–9 | | | | Grade 2: 15 | 0.98 (0.80 to 0.98) |
| Grade 3: 5–14 | | | | Grade 3: 9 | |
| **Combined score** \* (SH+PD) Grade 0: 13–70 | 0.39–1 | −0.01–1.0 (−0.24–0.4 to 1–1) | 0.06–1.0 (−0.0–0.4 to 1–1) | Grade 0: 32 | 0.81 |
| Grade 1: 4–60 | | | | Grade 1: 20 | 0.80 (0.51 to 0.80) |
| Grade 2: 8–45 | | | | Grade 2: 28 | 0.79 (0.57 to 0.79) |
| Grade 3: 6–67 | | | | Grade 3: 20 | |

\*EULAR-OMERACT combined score.
EULAR-OMERACT, European League Against Rheumatisms–Outcomes Measures in Rheumatology; PD, power Doppler; SH, synovial hypertrophy.
Surprisingly, the intraobserver reliability showed a great variability between the 12 sonographers for all parameters. Similar results were seen for the binary score. The interobserver reliability was good to excellent for the SQ score of SH, PD and the EULAR-OMERACT combined score. For the binary score, the reliability was good to excellent for PD and the EULAR-OMERACT combined score, but only moderate for SH (table 2). When comparing the interobserver reliability for the SQ score with the binary score for PD and the EULAR-OMERACT combined score, reliability showed almost identical \( \kappa \) values—the highest \( \kappa \) values were seen for the PD score (SQ PD score: \( \kappa=0.98 \) and binary PD score: \( \kappa=0.97 \)). For SH, the binary score was considerably lower (\( \kappa=0.57 \)) than the SQ score (\( \kappa=0.78 \)).

**Step 2. Testing the definition and reliability of the EULAR-OMERACT combined score in patients**

No major differences were recorded in the intraobserver reliability when scanning in a patient-based exercise for the ‘standardised scan’ and ‘usual practice scan’ (slightly better for the standardised scan) for all synovitis components (SH and PD) and the EULAR-OMERACT combined score, and for both binary and SQ grading (table 3).

However, interobserver reliability for both SQ and binary scores for all components was better when using the standardised scan approach (table 4). The \( \kappa \) values were good for SQ PD (\( \kappa=0.79 \)) but excellent for SH and the EULAR-OMERACT combined score (\( \kappa=0.87 \) and 0.86, respectively). The SQ score performed slightly better than the binary score for PD (SQ score: \( \kappa=0.79 \); binary \( \kappa=0.76 \)) and the EULAR-OMERACT combined score (SQ score: \( \kappa=0.86 \); binary \( \kappa=0.85 \)).

Only the PD grading for both the binary score and the SQ score had better interobserver reliability in static images than when scanning patients with a standardised scan (tables 2 and 4).

**Step 3. Testing the definition and reliability of the EULAR-OMERACT combined score in other joints**

In the web-based exercise on static images, 100 images of wrist, PIP, knee and MTP joints were included representing a broad range of different degrees of synovitis. Table 5 shows the observed agreement, prevalence and reliability of the different degrees of SH, PD and the EULAR-OMERACT combined score. When scoring static images, the intraobserver reliability was good to excellent for SH and PD (better for SQ grading than binary) and excellent for the EULAR-OMERACT combined P score (\( \kappa=0.84 \)). The interobserver reliability was good for all components (better for binary score than SQ grading) and best for PD (binary=0.88 and SQ=0.86). Table 6 shows the inter-reader reliability for the synovitis components and the EULAR-OMERACT combined score according to the different joints. The inter-reader reliability for the EULAR-OMERACT combined score in the wrist was \( \kappa=0.61 \), for the PIPs \( \kappa=0.75 \), for knees \( \kappa=0.55 \) and for the MTPs \( \kappa=0.58 \).

When evaluating the EULAR-OMERACT combined score in patients, the intraobserver reliability was good with almost identical values for the binary and SQ scores for all single components and in combination, ranging from 0.64 to 0.66 (table 5). The interobserver reliability was moderate to good for all components (0.43–0.61) and best for the SQ PD score (0.61) (table 5).

Supplementary figure 2 (online file) shows image examples on the EULAR-OMERACT combined score applied to PIP, MTP, knee and wrist joints.

Following the results of this multistep project, the group agreed on the following procedures for scoring synovitis by US: (1) The presence of a hypoechoic SH is mandatory for defining the presence of an US-detected synovitis and for grading Doppler activity. (2) Grading synovitis, at joint level, should be performed by using the SQ EULAR-OMERACT score (based on the combined presence of both GS SH and Doppler (table 1)).

(3) If different areas of severity are present in the same joint, the final severity grade is given by the area with the maximum of severity. (4) The acquisition and grading of synovitis by US should be performed by using a dorsal approach. (5) A standardised scan, with the position of the probe in the midline, should be recommended in the case of multicentre clinical trials using US, although it might underestimate the real inflammatory activity of the joint.

**DISCUSSION**

Over the last 10 years, the EULAR-OMERACT US group has worked on standardising the US detection, acquisition and grading of synovitis in patients with RA using a stepwise approach. In the first step, the group developed: (1) new definitions of the elementary components and a novel scoring system based on the grade of severity of SH and PD both separately and in combination: the EULAR-OMERACT combined score; and (2) a standardised image acquisition technique.12 In the second part of this multistep validation process, the reliability of these new definitions and of the scoring system for SH and PD separately, and EULAR-OMERACT combined was tested in static images, then in patients on MCP and non-MCP joints. The participation of the same multinational team in every step of the validation process added value to the consistency of the results.

The new definitions for grading SH and PD independently and combined (EULAR-OMERACT combined score) considerably improved the reliability when scoring both static images and patients. In these studies, PD was chosen as the optimal Doppler modality for the particular US machines used for depicting inflammation, but PD may be substituted by CD in the presented scoring system when working with machines where CD is more sensitive than PD.23 The interobserver reliability for the EULAR-OMERACT combined score in static images was good to excellent. In patients, the intraobserver reliability of the EULAR-OMERACT combined score showed some
Table 3  Prevalence of observed lesions, observed agreement and intraobserver reliability when scoring synovitis in MCP joints in patients with RA: standardised scan acquisition versus free scan acquisition

|                     | Standardised scan |                     | Free scan |                     |
|---------------------|-------------------|---------------------|-----------|---------------------|
|                     | Prevalence % (min–max) | Observed agreement (min–max) | Kappa (min–max) + 95% CI | Prevalence % (min–max) | Observed agreement (min–max) | Kappa (min–max) + 95% CI |
|                     |                   | Binary (y/n) | Semiquantitative (0–3) |                   | Binary (y/n) | Semiquantitative (0–3) |
| SH                  |                   |               |                     |                   |               |                     |
| Grade 0: 0–80       | 0.65–1            | 0.22–1 (0.21–0.3 to 0.8–1) | 0.26–1 (0.25–0.29 to 0.8–1) | Grade 0: 0–55    | 0.65–1            | 0.38–1 (0.36–0.3 to 0.81–1) | 0.29–1 (−0.21–0.3 to 0.6–1) |
| Grade 1: 5–45       |                   | 0.39–1 (0.34–0.43 to 0.7–1) | 0.32–1 (0.29–0.34 to 0.8–1) | Grade 1: 5–55    |                   | 0.50–0.95           | 0.0–1 (−0.01–0.03 to 0.6–1) | 0.44–0.94 (0.21–0.44 to 0.87–0.97) |
| Grade 2: 0–50       |                   |                   |                     | Grade 2: 5–65    |                   |                     |
| Grade 3: 0–15       |                   |                   |                     | Grade 3: 0–5     |                   |                     |
| PD                  |                   |               |                     |                   |               |                     |
| Grade 0: 0–55–95    | 0.65–1            | 0.22–1 (0.21–0.3 to 0.8–1) | 0.26–1 (0.25–0.29 to 0.8–1) | Grade 0: 0–55    | 0.65–1            | 0.38–1 (0.36–0.3 to 0.81–1) | 0.29–1 (−0.21–0.3 to 0.6–1) |
| Grade 1: 0–30       |                   | 0.39–1 (0.34–0.43 to 0.7–1) | 0.32–1 (0.29–0.34 to 0.8–1) | Grade 1: 5–55    |                   | 0.50–0.95           | 0.0–1 (−0.01–0.03 to 0.6–1) | 0.44–0.94 (0.21–0.44 to 0.87–0.97) |
| Grade 2: 0–10       |                   |                   |                     | Grade 2: 0–15    |                   |                     |
| Grade 3: 0–5        |                   |                   |                     | Grade 3: 0–20    |                   |                     |
| Combined score* (SH+PD) | 0.65–1            | 0.22–1 (0.21–0.3 to 0.8–1) | 0.26–1 (0.25–0.29 to 0.8–1) | Grade 0: 0–55    | 0.65–1            | 0.38–1 (0.36–0.3 to 0.81–1) | 0.29–1 (−0.21–0.3 to 0.6–1) |
| Grade 1: 0–80       | 0.40–1            | 0.39–1 (0.34–0.43 to 0.7–1) | 0.32–1 (0.29–0.34 to 0.8–1) | Grade 0: 0–60    | 0.50–0.95           | 0.0–1 (−0.11–0.3 to 0.92–1) | 0.40–0.93 (0.40–0.52 to 0.76–0.95) |
| Grade 1: 10–45      |                   | 0.39–1 (0.34–0.43 to 0.7–1) | 0.32–1 (0.29–0.34 to 0.8–1) | Grade 1: 5–43    |                   |                     |
| Grade 2: 0–50       |                   |                   |                     | Grade 2: 0–70    |                   |                     |
| Grade 3: 0–15       |                   |                   |                     | Grade 3: 0–20    |                   |                     |

*EULAR-OMERACT combined score.

EULAR-OMERACT, European League Against Rheumatisms–Outcomes Measures in Rheumatology; MCP, metacarpophalangeal; PD, power Doppler; RA, rheumatoid arthritis; SH, synovial hypertrophy.
|               | Standardised scan | Free scan |
|---------------|-------------------|-----------|
|               | Prevalence (%)     | Binary (yes–no) mean | Kappa + 95% CI | Observed agreement | Kappa + 95% CI | Semiquantitative (0–3) mean | Kappa + 95% CI | Observed agreement | Kappa + 95% CI |
| SH Grade 0:   | 47                | 0.63      | 0.87 (0.86 to 0.9) | 0.46             | 0.87 (0.86 to 0.89) | 0.63 | 0.69 (0.66 to 0.7) | 0.41 | 0.71 (0.69 to 0.73) |
| SH Grade 1:   | 28                | 0.46      |                |                  |                  |                  |                  |                  |                  |
| SH Grade 2:   | 22                | 0.46      |                |                  |                  |                  |                  |                  |                  |
| SH Grade 3:   | 3                 | 0.46      |                |                  |                  |                  |                  |                  |                  |
| PD Grade 0:   | 84                | 0.88      | 0.76 (0.73 to 0.79) | 0.83             | 0.79 (0.76 to 0.8) | 0.84 | 0.70 (0.68 to 0.72) | 0.78 | 0.75 (0.72 to 0.77) |
| PD Grade 1:   | 8                 | 0.83      |                |                  |                  |                  |                  |                  |                  |
| PD Grade 2:   | 6                 | 0.83      |                |                  |                  |                  |                  |                  |                  |
| PD Grade 3:   | 1                 | 0.83      |                |                  |                  |                  |                  |                  |                  |
| Combined score* (SH+PD) | Grade 0: 47 | 0.62 | 0.85 (0.84 to 0.87) | 0.45             | 0.86 (0.8 to 0.89) | 0.64 | 0.74 (0.73 to 0.76) | 0.40 | 0.73 (0.72 to 0.76) |
| Combined score* (SH+PD) | Grade 1: 29 | 0.62 | 0.85 (0.84 to 0.87) | 0.45             | 0.86 (0.8 to 0.89) | 0.64 | 0.74 (0.73 to 0.76) | 0.40 | 0.73 (0.72 to 0.76) |
| Combined score* (SH+PD) | Grade 2: 21 | 0.62 | 0.85 (0.84 to 0.87) | 0.45             | 0.86 (0.8 to 0.89) | 0.64 | 0.74 (0.73 to 0.76) | 0.40 | 0.73 (0.72 to 0.76) |
| Combined score* (SH+PD) | Grade 3: 3 | 0.62 | 0.85 (0.84 to 0.87) | 0.45             | 0.86 (0.8 to 0.89) | 0.64 | 0.74 (0.73 to 0.76) | 0.40 | 0.73 (0.72 to 0.76) |

MCP, metacarpophalangeal; PD, power Doppler; RA, rheumatoid arthritis; SH, synovial hypertrophy.
*EULAR-OMERACT combined score.
EULAR-OMERACT, European League Against Rheumatisms–Outcomes Measures in Rheumatology
Table 5  Prevalence of observed lesions, observed agreement and intraobserver and interobserver reliabilities when scoring synovitis in non-MCP joints on static images and in patients

| Component         | Static images | Patients |
|-------------------|---------------|----------|
|                   | Intra         | Inter    | Intra         | Inter    |
|                   | Kappa range (min–max) (95% CI) | Observed agreement | Mean kappa (95% CI) | Kappa range (min–max) (95% CI) | Observed agreement | Mean kappa (95% CI) | Prevalence % (mean) |
|                   |               |          |               |          |          |          |                  |
| SH score (0–3)    | 0.73–0.9 (0.75–0.91 to 0.72–0.94) | 0.6–0.95 | 0.6 (0.35 to 0.59) | 0.57     | Grade 0: 18% Grade 1: 23.9% Grade 2: 31.6% Grade 3: 26.6% | 0.4–0.82 (0.16–0.38 to 0.60–0.83) | 0.54–0.88 | 0.51 (0.24 to 0.38) | 0.59 Grade 0: 60.4 Grade 1: 20.8 Grade 2: 14.7 Grade 3: 4.1 |
| SH detection (yes/no) | 0.64–0.84 (0.63–0.88 to 0.73–0.86) | 0.68 (0.54 to 0.78) | 0.47–0.84 (0.36–0.63 to 0.77–1) | 0.43 (0.36 to 0.49) | Grade 0: 60.4 Grade 1: 20.8 Grade 2: 14.7 Grade 3: 4.1 |
| PD score (0–3)    | 0.9–1 (0.94–0.99 to 1–1) | 0.88–1 | 0.86 (0.72 to 0.86) | 0.84     | Grade 0: 24.1% Grade 1: 27.4% Grade 2: 29.2% Grade 3: 25.4% | 0.48–0.88 (0.42–0.71 to 0.83–0.98) | 0.76–0.94 | 0.61 (0.42 to 0.61) | 0.79 Grade 0: 80.4 Grade 1: 10.2% Grade 2: 8.2 Grade 3: 1.2 |
| PD detection (yes/no) | 0.9–1 (0.94–0.99 to 1–1) | 0.88 (0.80 to 0.95) | 0.47–0.9 (0.3–0.61 to 0.77–1) | 0.53 (0.43 to 0.60) | Grade 0: 80.4 Grade 1: 10.2% Grade 2: 8.2 Grade 3: 1.2 |
| Combined score* (0–3) | 0.75–1 (0.73–1 to 0.96–1) | 0.69–1 | 0.65 (0.41 to 0.65) | 0.63     | Grade 0: 14.9% Grade 1: 14.9% Grade 2: 34.2% Grade 3: 28% | 0.42–0.81 (0.44–0.66 to 0.72–0.94) | 0.54–0.88 | 0.52 (0.36 to 0.52) | 0.60 Grade 0: 61.4 Grade 1: 19.1 Grade 2: 15.2 Grade 3: 4.3 |
| Combined score* (SH+PD) (yes/no) | 0.75–0.82 (0.71–0.87 to 0.72–0.84) | 0.6 (0.5 to 0.58) | 0.45–0.84 (0.32–0.58 to 0.72–0.94) | 0.51 (0.36 to 0.54) | Grade 0: 61.4 Grade 1: 19.1 Grade 2: 15.2 Grade 3: 4.3 |

*EULAR-OMERACT combined score.

PD, power Doppler signal; SH, synovial hypertrophy.
Table 6  Interobserver reliability results for detection and scoring of synovitis components and for the combined PD US score according to the different joints in static images and in patients

| Joint    | Static images | Patients |
|----------|---------------|----------|
|          | Wrist | PIP | Knee | MTP | Wrist | PIP | Knee | MTP |
| SH score (0–3) | Mean kappa | Mean kappa | Mean kappa | Mean kappa | Mean observed agreement | Mean kappa | Mean observed agreement | Mean kappa | Mean observed agreement | Mean kappa |
| SH detection (yes/no) | Mean kappa | Mean kappa | Mean kappa | Mean kappa | Mean observed agreement | Mean kappa | Mean observed agreement | Mean kappa | Mean observed agreement | Mean kappa |
| PD score (0–3) | Mean kappa | Mean kappa | Mean kappa | Mean kappa | Mean observed agreement | Mean kappa | Mean observed agreement | Mean kappa | Mean observed agreement | Mean kappa |
| PD detection (yes/no) | Mean kappa | Mean kappa | Mean kappa | Mean kappa | Mean observed agreement | Mean kappa | Mean observed agreement | Mean kappa | Mean observed agreement | Mean kappa |

| Combined score* (0–3) | Meanobserved agreement | Mean kappa |
|-----------------------|-------------------------|---------|
| Combined score* (SH+PD) (yes/no) | Meanobserved agreement | Mean kappa |

*EULAR-OMERACT combined score.

MTP, metatarsophalangeal; NA, non-applicable; PD, power Doppler signal; PIP, proximal interphalangeal; SH, synovial hypertrophy.
and defining the threshold of normality. The use of a consensus process, based on the analysis of disagreement and exploration of factors affecting reliability, represents a major advantage of this programme of work. The inclusion of clear definitions of each synovial component and the application of a standardised scanning approach has ensured a highly robust process.

Though the current study did not address possible intermachine variability. This may be a problem in clinical practice best solved by using the best equipment giving the patient optimal evaluation.\(^{23}\) In multicentre trials, the quality of the machines may be different but is almost equivalent as a prerequisite. In addition, the patient is examined always with the same equipment and same settings minimising the variability.

In our study, the reliability of the EULAR-OMERACT combined score was comparable to that of the elementary component minimising the variability. The reliability was further improved when a standardised EULAR-OMERACT scoring process, the EULAR-OMERACT group have developed in daily practice.

In conclusion, using an expert-derived consensus process, the EULAR-OMERACT group have developed a standardised EULAR-OMERACT combined scoring system using both PD and SH components into account in the evaluation of synovitis of multiple RA joints, which is highly reliable when applied in scanning patients. The reliability was further improved when a standardised scanning procedure was used. The application of the proposed EULAR-OMERACT combined score and the new definition of synovitis based on the presence of SH and PD, as well as a standardised scanning approach for synovitis in RA, will ensure a greater degree of homogeneity and comparability in future US studies and facilitate the development of a Global EULAR-OMERACT Synovitis Scoring system at patient level for monitoring RA activity in clinical trials and routine care. The group is currently working on establishing an optimal reduced joint set for scoring synovitis in patients with RA using the EULAR-OMERACT combined score.

Author affiliations
\(^1\)Rheumatology department, Centre for Rheumatology and Spine Diseases, Rigshospitalet-Glostrup, Copenhagen, Denmark
\(^2\)Rheumatology and Joint and Bone Research Unit, Hospital Universitari Fundacion Jimenez Diaz, Madrid, Spain
\(^3\)Rheumatology and Joint and Bone Research Unit, Hospital Universitari Fundacion Jimenez Diaz, Madrid, Spain
\(^4\)Public Health Department, APHP, Hôpital Ambroise Paré, Boulogne-Billancourt; INSERM U1173, Versailles-Saint-Quentin University, Montigny le Bretonneaux, France
\(^5\)Leeds Institute of Rheumatic and Musculoskeletal Medicine, University of Leeds and NIHR Leeds Musculoskeletal Biomedical Research Unit, Leeds, UK
\(^6\)Department of Internal Medicine, Rheumatology and Clinical Immunology, Park-Klinik Weissensee, Berlin, Germany
\(^7\)National Institute of Rheumatology and Physiotherapy, Budapest, Hungary
\(^8\)Department of Rheumatology, MC Groep Hospitals, Lelystad, the Netherlands
\(^9\)Rheumatology Unit, Università di Torino, Torino, Italy
\(^10\)Department of Rheumatology, CHRU de Brest, Brest, France
\(^11\)Medical Centre for Rheumatology, Immanuel Krankenhaus, Buch, Berlin, Germany
\(^12\)Department of Rheumatology, Zealand’s University Hospital at Kåge, Copenhagen, Denmark
\(^13\)Clinica Reumatologica, Università Politecnica delle Marche, Jesi, Ancona, Italy
\(^14\)Rheumatology Department, APHP, Ambroise Paré Hospital, Boulogne-Billancourt, France
\(^15\)INSERM U1173, Laboratoire d’Excellence INFLAMEX, UFR Simone Veil, Versailles-Saint-Quentin University, Montigny le Bretonneaux, France

Contributors MADA designed the study. All authors contributed to the acquisition of data and have read and revised the manuscript. PA and MADA performed all statistical analysis and interpretation of data. LT and MADA drafted the manuscript.

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