The 2017 EULAR standardised procedures for ultrasound imaging in rheumatology

Ingrid Möller,[1,2] Iustina Janta,[3] Marina Backhaus,[4] Sarah Ohrndorf,[5] David A Bong,[1,2] Carlo Martinoli,[6] Emilio Filippucci,[7] Luca Maria Sconfienza,[8,9] Lene Terslev,[10] Nemanja Damjanov,[11] Hilde Berner Hammer,[12] Iwona Sudol-Szopinska,[13,14] Walter Grassi,[7] Peter Balint,[15] George A W Bruyn,[16] Maria Antonietta D'Agostino,[17,18] Diana Hollander,[19] Heidi J Siddle,[20] Gabriela Supp,[21] Wolfgang A Schmidt,[22] Annamaria Iagnocco,[23] Juhani Koski,[24] David Kane,[25] Daniela Fodor,[26] Alessandra Bruns,[27] Peter Mandl,[28] Gurjit S Kaeley,[29] Mihaela Micu,[30] Carmen Ho,[31] Violeta Vlad,[32] Mario Chávez-López,[33] Georgios Filippou,[34] Carmen Elena Cerón,[35] Rodina Nestorova,[36] Maritza Quintero,[37] Richard Wakefield,[20] Loreto Carmona,[38] Esperanza Naredo[39]

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For numbered affiliations see end of article.

Correspondence to
Dr Esperanza Naredo, Department of Rheumatology, Severo Ochoa Hospital, Madrid 28033, Spain; enaredo@ser.es

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ABSTRACT

Background In 2001, the European League Against Rheumatism developed and disseminated the first guidelines for musculoskeletal (MS) ultrasound (US) in rheumatology. Fifteen years later, the dramatic expansion of new data on MSUS in the literature coupled with technological developments in US imaging has necessitated an update of these guidelines.

Objectives To update the existing MSUS guidelines in rheumatology as well as to extend their scope to other anatomic structures relevant for rheumatology.

Methods The project consisted of the following steps: (1) a systematic literature review of MSUS evaluable structures; (2) a Delphi survey among rheumatologist and radiologist experts in MSUS to select MS and non-MS anatomic structures evaluable by US that are relevant to rheumatology, to select abnormalities evaluable by US and to prioritise these pathologies for rheumatology and (3) a nominal group technique to achieve consensus on the US scanning procedures and to produce an electronic illustrated manual (ie, App of these procedures).

Results Structures from nine MS and non-MS areas (ie, shoulder, elbow, wrist and hand, hip, knee, ankle and foot, peripheral nerves, salivary glands and vessels) were selected for MSUS in rheumatic and musculoskeletal diseases (RMD) and their detailed scanning procedures (ie, patient position, probe placement, scanning method and bony/other landmarks) were used to produce the App. In addition, US evaluable abnormalities present in RMD for each anatomic structure and their relevance for rheumatology were agreed on by the MSUS experts.

Conclusions This task force has produced a consensus-based comprehensive and practical framework on standardised procedures for MSUS imaging in rheumatology.

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INTRODUCTION

Over the last two decades, increasing numbers of rheumatologists worldwide have incorporated musculoskeletal (MS) ultrasound (US) into their clinical practice as both a valuable diagnostic and monitoring tool[1–6] and a means to guide interventions (injections and biopsies).[7 8] MSUS is a multiplanar and dynamic imaging modality. It has a number of benefits over other imaging techniques; of particular note, it is safe and well tolerated by patients and provides point-of-care scanning allowing immediate and direct correlations between imaging findings and clinical data, which can improve the management of patients with rheumatic and musculoskeletal diseases (RMDs). The increasing miniaturisation of scanning machines and hence portability have improved access to the use of MSUS in different clinical settings. MSUS has been applied to a wide range of RMD including inflammatory and degenerative joint diseases, crystal arthropathy, connective tissue diseases, vasculitis and regional pain syndromes.

In 2001, the European League Against Rheumatism (EULAR) developed and disseminated the first Guidelines for Musculoskeletal Ultrasound in Rheumatology based on both the available literature at the time and the expert opinion of a panel of European rheumatologists highly experienced in MSUS.[9] These guidelines set the technical standards for the use of MSUS in rheumatology and established a standardised MSUS scanning method in RMD. They have been widely used in clinical practice and research by the rheumatology community and have been widely cited in the literature. However, since their inception, there have been significant developments in technology and an increasing literature base with respect to validation and clinical application of MSUS for RMD, including the first incorporation of MSUS findings in rheumatological disease classification criteria.[10–13] Furthermore, scientific rheumatology and radiology societies such as EULAR, the American College of Rheumatology (ACR), the Pan American League of Association for Rheumatology (PANLAR), the European Society of Musculoskeletal Radiology (ESSR), the European Musculoskeletal Ultrasound Study Group (EURO-MUSCULUS) and the Ultrasound Study Group in Physical and Rehabilitation Medicine (USPRM) have produced evidence and expert

opinion-based recommendations on the use of MSUS in the clinical management of RMD.[14–19]

To this end, a new EULAR-endorsed task force was created with the following objectives:

1. To update the standardised scanning procedures (ie, patient position, probe placement and scanning method) for MSUS assessment of the joint areas accessible to US evaluation involved in RMD;
2. To produce standardised imaging procedures (ie, patient position, probe placement and scanning method) for US assessment of other articular and non-articular accessible anatomic structures of importance in rheumatology;
3. To select and prioritise the abnormalities evaluable by MSUS present in RMD;
4. To create an electronic illustrated manual (ie, application (App)) of these images and technique procedures accessible to all with interest in performing MSUS in their practice.

METHODS

The task force was composed of a steering group (ie, the convenors (IM and MB), two rheumatologists with high expertise in MSUS and anatomy (EN and DB), the methodologist (LC) and two fellows (IJ and SO)) and a panel consisting of 28 rheumatologists and radiologists highly experienced in MSUS performance, teaching and research in RMD. These task force members have been involved in education in MSUS within EULAR and in international multicentre research projects under the OMERACT (Outcome Measures in Rheumatology) initiative over the past 10–15 years and have worked and published on standardisation of MSUS scanning methods and definitions and criteria for MSUS abnormalities. In addition, the task force included two health professionals (HP) experienced in MSUS (ie, a podiatrist (HS) and a radiographer (GS)) and one patient representative (DH). The members of the task force represented 22 countries in Europe, the Americas and Asia (Austria, Bulgaria, Canada, Colombia, Denmark, France, Finland, Germany, Hungary, Hong Kong, Ireland, Italy, México, Netherlands, Norway, Poland, Romania, Serbia, Spain, UK, USA and Venezuela).

The project consisted of the following steps: (1) a systematic scoping review (SSR) on how MSUS is performed and what pathologies can be assessed by MSUS in RMD; (2) a Delphi survey aiming at selecting MS and non-MS anatomic structures evaluable by US and relevant to RMD, selecting pathologies evaluable by US and prioritising these abnormalities for rheumatology and (3) a nominal group technique was convened to achieve consensus on the scanning procedures summarised from the literature review for the MS and non-MS anatomic structures selected in the previous Delphi step and to produce the corresponding images for the EULAR US Scanning App.

Scoping review

A scoping literature review was performed by two fellows (IJ and SO) under the supervision of the steering group. Both fellows conducted the literature search independently and disagreement was resolved by discussion with the steering group. The systematic search strategy was based on the following PICO (Population, Intervention, Comparator, Outcome)-adapted components: body parts, ultrasound and scanning procedures. Online supplementary table 1 shows the synonyms used for each component. The search excluded animal studies, prenatal or postpartum US and surgery-related studies. Owing to the great number of synonyms for body parts, we divided the review into two separate searches, one for MS structures, mainly related to joints, and second for non-MS structures, that is, salivary glands, vessels and nerves.

The literature search was performed in Medline and Embase from their inception on the 1 May 2015. Online supplementary table 2 shows the literature search strategy. References identified were imported into a bibliographic manager (EndNote(R)) and duplicates were removed. The remaining articles were assessed by title and abstract to identify eligible studies, that is, those in which a description of scanning procedures of RMD-related body parts were detailed. Only articles in English, German, French, Spanish and Italian were retained.

Data about the examined area, patient position, probe placement, scanning method, landmarks and pathologies were extracted from each article using a predefined data collection form. The results were provided to the full expert panel. The review did not include an evaluation for the risk of bias of the individual studies as the objective was not to evaluate the diagnostic value of the technique but to collect narrative formulae of procedures. An update of the literature search was performed at the end of the project.

Delphi survey

The steering group developed an English-language survey that included six MS anatomic areas, that is, shoulder, elbow, wrist and hand, hip, knee and ankle and foot, and three non-MS organs/systems, that is, peripheral nerves, salivary glands and large vessels. For each anatomic area/organ/system, a variable number of structures and pathologies (1–14 per structure) derived from the literature review were included. These included 39 structures for the shoulder, 36 for the elbow, 15 for the wrist, 17 for the hand, 28 for the hip, 41 for the knee, 64 for the ankle, 12 for the foot, 20 for the peripheral nerves, 3 for the salivary glands and 18 for the large vessels.

The questionnaire consisted of nine tables (ie, one table for each MS anatomic area/non-MS organ/system) with the recipients required to respond to four statements. The first two statements addressed whether the respondent actually assessed the structure ('Examination included in my practice') and his/her satisfaction with that visualisation ('Quality of visualization of the structure'). The second two statements evaluated the respondents' opinion as to whether that visualisation enabled them to detect pathology ('Capability of evaluation of the abnormality') and if it was relevant to their practice ('Relevance for rheumatology clinical practice').

The questionnaire was sent by email to a broad group of rheumatologist and radiologist experts in MSUS in RMD. An explanation of the purpose of the survey was provided along with the questionnaire. The Delphi participants included rheumatologists with more than 5 years of experience in MSUS and EULAR level 2 in MSUS competency, European Federation of Societies for Ultrasound in Medicine or Biology (EFSUMB) level 3 in MSUS competency or faculty members of international MSUS courses organised by other societies and radiologists from a list provided by the ESSR based on their proven expertise in practice, teaching and research in MSUS.

The surveyed experts were asked to rate each statement on a 1–5 Likert scale as follows: 1=never and 5=always for the statement 'Examination included in my practice'; 1=very poor and 5=excellent for the statements 'Quality of visualization of the structure' and 'Capability of evaluation of the abnormality' and 1=minimal and 5=maximal for the statement 'Relevance for rheumatology clinical practice'. Those structures that scored both ≥3 for the statement 'Examination included in my practice'

and ≥4 for the statement 'Quality of visualization of the structure' by ≥70% of the respondents were selected for the subsequent steps. Those pathologies of the selected structures by the first two statements that scored ≥4 by ≥70% of the respondents for both statements 'Capability of evaluation of the abnormality' and 'Relevance for rheumatology clinical practice' were selected.

Nominal group technique

A subgroup of the task force panel composed of 14 rheumatologists (including those from the steering group), 3 radiologists, the methodologist, the patient and 2 HP attended a 2-day meeting in Madrid (Spain). The tables with the selected anatomic structures obtained from the Delphi survey and their US scanning method extracted from the literature review were sent by email to these panellists 3 weeks before the nominal meeting.

During the meeting, participants worked in small groups to define optimal US scanning procedures regarding patient position, probe placement, scanning method and bony landmarks of the selected structures. These experts scanned healthy models using seven top-end US machines (LOGIQ E9 XDclear; GE Medical Systems Ultrasound and Primary Care Diagnostics, Wauwatosa, Wisconsin, USA) equipped with a multifrequency linear matrix array transducer (ML6–15 MHz) used for the shoulder, elbow, wrist, hip, knee, ankle, salivary glands, vessels and peripheral nerves in deep areas and a multifrequency linear hockey-stick transducer (L8–18 MHz) used for the hand, feet, vessels and peripheral nerves in superficial areas. Grey-scale and power/colour Doppler settings were optimised for the different joints assessed. The results of the small work groups were then presented to the group as a whole to achieve consensus regarding the production of the final images.

Production of the US scanning App

The final phase of the nominal group meeting consisted of photographing of the US scanning procedures and the capture of static US images and videos for the online US scanning App.

Patient and HP perspective

The patient representative was asked to participate in the small and large group discussions as well as the scanning and recording sessions and to provide her feedback from the patient's perspective in order to obtain optimal imaging with the least discomfort to the patient. The HP were also instructed to give their opinion on the procedures from their unique perspective.

Statistical analysis

Simple descriptive and summary statistics were calculated from the responses to the survey.

RESULTS

Scoping review

The literature search resulted in 7706 articles, of which 176 articles were selected for detailed review and 47 articles provided the most relevant information.[20–74] Online supplementary figure 1 shows the study flowchart for the article selection. The main reason for the article exclusion after full-text review was the lack of standardised examination description. The resulting tables with the description of the scanning procedures as they were presented to the panel are available on request.

Delphi survey

A total of 227 international MSUS experts who fulfilled the selection criteria were identified and were sent the Delphi survey. One hundred thirteen experts (107 rheumatologists, 6 radiologists; 86 European, 27 non-European) responded to the survey (response rate 49.8%).

General recommended procedures for MSUS assessment in RMD

MSUS is a real-time, highly dynamic imaging technique. The 'dynamic' nature refers to the ability to visualise the structure of interest while it is in motion or being actively stressed and to the necessity of moving the probe and, therefore, the US beam. The ability to produce optimal US images, either as a single image or as a cine clip, is dependent on the examiner's anatomic knowledge, his/her technical proficiency and the quality and correct adjustment of the settings of the equipment. General recommended procedures for MSUS in RMD are presented in box 1 and online supplementary text. HP and a patient perspective are shown in online supplementary text and online supplementary tables 3 and 4.

Standardised procedures for MSUS assessment in RMD

Structures from nine anatomic areas/organs/systems (ie, shoulder, elbow, wrist and hand, hip, knee, ankle and foot, peripheral nerves, salivary glands and large vessels) were selected for MSUS in RMD as well as detailed scanning procedures (ie, patient position, probe placement, scanning method and bony/other landmarks) shown as downloadable text in the EULAR US Scanning App (www.eular.org; http://ultrasound.eular.org/).

Abnormalities evaluable by MSUS in RMD and prioritisation for rheumatology

The US-evaluable and relevant for rheumatology abnormalities present in RMD for each anatomic structure are displayed in online supplementary tables 5–14. Although the detection of features of Sjögren syndrome in salivary glands was considered highly relevant for >80% of the participants in the survey, less than 70% of them considered US highly capable to evaluate this pathology.

US scanning App

The final product of the task force was the elaboration of the EULAR US Scanning App which is a comprehensive electronic illustrated manual of didactic image acquisition in rheumatological MSUS. This tool displays the procedures (ie, images and/or videos on patient position, probe placement, scanning method, sonoanatomy and anatomical landmarks as well as additional downloadable text corresponding to these aspects for each structure ordered by anatomic region, anatomical location and type of structure) for MSUS assessment of the principal joint areas and non-articular anatomic regions of importance in RMD (www.eular.org; http://ultrasound.eular.org/).

DISCUSSION

The increasing utility of MSUS in rheumatology has led to a dramatic increase in the demand for education in the appropriate use of this imaging modality among rheumatologists worldwide. The rheumatologist as an ultrasonographer has the unique advantage of correlating the clinical picture with the imaging in a more advanced way and we have not made enough of the advantages of this heretofore. As all imaging assessments, MSUS is highly dependent on operator expertise mainly owing to the intrinsic real-time nature of image acquisition. Standardisation of the scanning procedures is an important requisite for

Box 1 General recommended procedures for MSUS assessment in RMD

- MSUS includes two principal modes: B-mode (or grey scale) that provides us with morphological information of the anatomic structures and Doppler mode (colour Doppler or power Doppler) that allows us to evaluate blood flow.
- MSUS should be performed with high-resolution linear transducers (ie, probes) with frequencies between 6 and 14 MHz for deep/intermediate areas to ≥15 MHz for superficial areas.
- Tissue harmonic imaging, spatial compound imaging, extended field of view (panoramic) and virtual convex imaging are some of the software capabilities that may be useful in MSUS.
- When scanning a joint, the probe should be oriented as perpendicular or parallel to the bony cortical surface (bony acoustic landmark) so that the cortical margin appears bright, sharp and hyperechoic.
- A dynamic scanning technique by means of slight movements of translation (side-to-side, back-to-front), angulation and rotation of the probe should be carried out in order to allow the best visualisation of the structure(s) of interest.
- MS structures should be evaluated as they move smoothly either actively or passively.
- To avoid anisotropy (ie, hypoechoic/anechoic appearance of a normally hyperechoic structure that mainly affects tendons) and the common pitfalls that accompany it, the probe should be continuously adjusted to maintain the beam perpendicular to the tendon fibres especially in insertional regions.
- When the long axis of the structure of interest corresponds to the cranial-caudal orientation of the anatomic position, the most proximal aspect of the structure is usually placed on the left-hand side of the screen. However, other options are acceptable as long as the movement of the image on the screen is kept parallel to the direction of the probe on the patient. Our preference for short axis is to align the structure of interest on the screen as if the observer is looking at the patient.
- Probe compression can be helpful in distinguishing a compressible liquid collection from a non-compressible solid. Little or no compression is important when performing Doppler examination to avoid cessation of flow in small vessels.
- A generous amount of gel should be used for superficial structures especially when little or no pressure is indicated.
- The machine setting for B-mode and Doppler mode should be properly adjusted to optimise the US image acquisition process.[68 69]
- Note: MSUS, musculoskeletal ultrasound; RMD, rheumatic and musculoskeletal disease.

the skilled and safe use of this technique in clinical practice and research.

Fifteen years after the publication of the Guidelines for Musculoskeletal Ultrasound in Rheumatology,[9] a thorough revision of the procedures for US imaging in rheumatological practise with the inclusion of new anatomic regions relevant to RMD was performed by an international panel of experts in MSUS. The principal aim was to enhance the standardisation and improve the quality of the scanning of anatomic structures evaluable by US and relevant for rheumatology through a consensus process among rheumatologists and radiologists who practice, teach and pursue research in MSUS in RMD. As expected, many of the US scans resulting from our task force were similar to those published by the ESSR 7 years ago.[21] However, our product is broader in terms of anatomic areas and structures and includes static images and videos on patient position, probe placement, scanning method and sonoanatomy. In addition, the task force has created an illustrated online App of these techniques as a useful educational tool accessible to all with interest in incorporating MSUS into their practice. It is the goal of this panel and its sponsor, EULAR, that this application will become a primary teaching and reference resource for rheumatologists, radiologists, non-medical HP[75] and other specialties involved in the management of RMD worldwide, and as a result, enhance the standardisation of the ultrasound assessment.

To achieve this, the pathologies evaluable by MSUS and relevant for rheumatology were elucidated through the Delphi survey process. The objective of our task was to collect expert opinion on the technical capability of US to assess abnormalities in RMD and the degree of priority of US assessment of these abnormalities in their clinical practice and not to establish evidence-based indications for MSUS as some scientific societies have done and published.[14–19] We selected anatomic structures that scored >3 by the majority of the respondents regarding the inclusion in their practice to ensure that there was sufficient experience with the visualisation of that structure which, in turn, enabled us to consistently score the second statement as to the respondents' perception of the quality of that visualisation. The acceptance value for this criterion was purposefully set lower than the other criteria in order to capture new structures that now with advances in the overall knowledge of rheumatic diseases, along with advances in instrumentation and the ultrasound skillset including anatomic knowledge, are now becoming part of MSUS in RMD. Our results indicated an advanced level of US practise among our respondents and a great interest in a wide spectrum of MSUS pathologies detectable in RMD. The use of MSUS for evaluation of the non-MS structures, that is, the peripheral nerves, salivary glands and large vessels, was relatively limited which we felt could be related either to a general lack of experience along the respondents or, possibly, a lack of evidence validating their use. It was the opinion of the panel that standardisation of the scanning procedures for these structures would further facilitate their clinical application in MSUS practice and encourage further research into this group of structures as they relate to RMD.

Some limitations of our project should be mentioned. The number of radiologists who participated in the Delphi survey and consensus meeting was small compared with that of rheumatologists. This can be explained by the dramatic expansion and implementation of MSUS among the rheumatologists, who are highly motivated to collaborate in the enhancement of MSUS use in practice and research. In addition, other MS specialists (eg, physiatrics, pain physicians, sport physicians) who could have enriched the procedures, particularly for certain pathologies, were missing. Furthermore, for logistic reasons, only a subgroup of the experts involved in the Delphi process were able to participate in the nominal group meeting where the detailed scanning method was agreed on and established. However, we believe that this subgroup was sufficiently representative of the entire community of MSUS experts.

Finally, the addition of the patient and the HP to the panel has provided a unique perspective providing technical and practical advice in improving the US experience for the patient, whose

active involvement in US investigations should be essential,[76] and all participants.

In conclusion, we expect this enhanced consensus-based comprehensive and practical framework for MSUS procedures in rheumatology to be a valuable educational tool and provide a standard reference for MSUS practice and research in RMD. EULAR and EFSUMB offer a structured curriculum to be followed to achieve competency in MSUS in rheumatology.

Author affiliations
[1]Department of Rheumatology, Instituto Poal de Reumatología, Barcelona, Spain
[2]Barcelona University, Barcelona, Spain
[3]Department of Rheumatology, Hospital General Universitario Gregorio Marañón, Madrid, Spain
[4]Department of Internal Medicine - Rheumatology and Clinical Immunology, Park-Klinik Weissensee, Berlin, Germany
[5]Department of Rheumatology and Clinical Immunology, Charité University Medicine, Berlin, Germany
[6]Department of Radiology-III, IRCCS AOU San Martino-IST, University of Genoa, Genoa, Italy
[7]Department of Rheumatology, Università Politecnica delle Marche, Ancona, Italy
[8]Unit of Diagnostic and Interventional Radiology, IRCCS Istituto Ortopedico Galeazzi, Milano, Italy
[9]Department of Biomedical Sciences for Health, University of Milano, Milano, Italy
[10]Centre for Rheumatology and Spine Diseases, Rigshospitalet, Copenhagen, Denmark
[11]Institute of Rheumatology, University of Belgrade School of Medicine, Belgrade, Serbia
[12]Department of Rheumatology, Diakonhjemmet Hospital, Oslo, Norway
[13]Department of Radiology, National Institute of Geriatrics, Rheumatology and Rehabilitation, Warsaw, Poland
[14]Imaging Diagnostic Department, Warsaw Medical University, Warsaw, Poland
[15]3rd Department of Rheumatology, National Institute of Rheumatology and Physiotherapy, Budapest, Hungary
[16]Department of Rheumatology, MC Groep Hospitals, Lelystad, The Netherlands
[17]Rheumatology Department, Hôpital Ambroise Paré (APHP), Boulogne-Billancourt, France
[18]INSERM U1173, Laboratoire d'Excellence INFLAMEX, UFR Simone Veil, Versailles-Saint-Quentin University, Saint-Quentin en Yvelines, France
[19]EULAR PARE Patient Research Partner, Amsterdam, The Netherlands
[20]Leeds Teaching Hospitals NHS Trust, Leeds Institute of Rheumatic and Musculoskeletal Medicine, University of Leeds, Chapel Allerton Hospital, Leeds, UK
[21]Joint and Bone Center for Diagnosis, Research, and Therapy of Musculoskeletal Disorders, Medical University of Vienna, Vienna, Austria
[22]Immanuel Krankenhaus Berlin, Medical Center for Rheumatology, Berlin, Germany
[23]Dipartimento Scienze Cliniche e Biologiche - Reumatologia, Università degli Studi di Torino, Turin, Italy
[24]Department of Internal Medicine, Mikkeli Central Hospital, Mikkeli, Finland
[25]Department of Medicine-Rheumatology, Trinity College, Dublin, Ireland
[26]Department of Internal Medicine, "Iuliu Hatieganu", University of Medicine and Pharmacy, Cluj-Napoca, Romania
[27]Department of Rheumatology, University of Sherbrooke, Québec, Canada
[28]Division of Rheumatology, 3rd Department of Internal Medicine, Medical University of Vienna, Vienna, Austria
[29]Division of Rheumatology, University of Florida College of Medicine, Jacksonville, Florida, USA
[30]Rheumatology Division, 2nd Rehabilitation Department, Rehabilitation Clinical Hospital, Cluj-Napoca, Romania
[31]Rheumatology and Clinical Immunology Division, University of Hong Kong, Hong Kong SAR, China
[32]Department of Rheumatology, Sf. Maria Clinical Hospital, Bucharest, Romania
[33]Department of Biomedical Research, Universidad Autónoma de Aguascalientes, Aguascalientes, México
[34]Department of Medicine, Surgery and Neurosciences, Rheumatology Section, University of Siena, Siena, Italy
[35]Department of Rheumatology, Medicarte, Medellín, Colombia
[36]Rheumatology Centre 'St Irina', Sofia, Bulgaria
[37]Department of Rheumatology, Universidad de Los Andes, Mérida, Venezuela
[38]Instituto de Salud Musculoesquelética (InMusc), Madrid, Spain
[39]Department of Rheumatology, Joint and Bone Research Unit, Hospital Universitario Fundación Jiménez Díaz and Autónoma University, Madrid, Spain

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