Fast track algorithm: how to differentiate a 'scleroderma pattern' from a 'non-scleroderma pattern'

Vanessa Smith, Amber Vanhaecke, Ariane L. Herrick, Oliver Distler, Miguel G. Guerra, Christopher P. Denton, Ellen Deschepper, Ivan Foeldvari, Marwin Gutierrez, Eric Hachulla, et al.

Autoimmunity Reviews 18 (2019) 102394

Contents lists available at ScienceDirect

Autoimmunity Reviews

journal homepage: www.elsevier.com/locate/autrev

Fast track algorithm: How to differentiate a "scleroderma pattern" from a "non-scleroderma pattern"

Vanessa Smith[a,b,c,*,1], Amber Vanhaecke[a,b,1], Ariane L. Herrick[d,e], Oliver Distler[f], Miguel G. Guerra[g], Christopher P. Denton[h], Ellen Deschepper[i], Ivan Foeldvari[j], Marwin Gutierrez[k], Eric Hachulla[l], Francesca Ingegnoli[m,n], Satoshi Kubo[o], Ulf Müller-Ladner[p], Valeria Riccieri[q], Alberto Sulli[r], Jaap M. van Laar[s], Madelon C. Vonk[t], Ulrich A. Walker[u], Maurizio Cutolo[r], for the EULAR Study Group on Microcirculation in Rheumatic Diseases

[a] Department of Internal Medicine, Ghent University, Ghent, Belgium
[b] Department of Rheumatology, Ghent University Hospital, Ghent, Belgium
[c] Unit for Molecular Immunology and Inflammation, VIB Inflammation Research Center (IRC), Ghent, Belgium
[d] Division of Musculoskeletal & Dermatological Sciences, The University of Manchester, Salford Royal NHS Foundation Trust, Manchester, UK
[e] NIHR Manchester Biomedical Research Centre, Manchester University NHS Foundation Trust, Manchester Academic Health Science Centre, Manchester, UK
[f] Department of Rheumatology, University Hospital Zurich, Zurich, Switzerland
[g] Rheumatology Department, Centro Hospitalar Vila Nova de Gaia/Espinho, Vil Nova de Gaia, Portugal
[h] Department of Rheumatology, University College London, Royal Free Hospital, London, UK
[i] Biostatistics Unit, Department of Public Health, Ghent University, Ghent, Belgium
[j] Centre for Paediatric and Adolescent Rheumatology, Hamburg, Germany
[k] Division of Musculoskeletal and Rheumatic Disorders, Instituto Nacional de Rehabilitación, Mexico City, Mexico
[l] Univ. Lille, CHU Lille, Département de Médecine Interne et Immunologie Clinique, Centre de Référence des Maladies Systémiques et Auto-Immunes Rares du Nord-Ouest (CERAINO), LIRIC, INSERM, Lille, France
[m] Department of Clinical Sciences and Community Health, University of Milan, Milan, Italy
[n] Division of Rheumatology, ASST G. Pini, Milan, Italy
[o] The First Department of Internal Medicine, University of Occupational and Environmental Health, Fukuoka, Japan
[p] Department of Rheumatology and Clinical Immunology, Justus-Liebig University of Giessen, Campus Kerckhoff, Bad Nauheim, Germany
[q] Department of Internal Medicine and Medical Specialties, Sapienza University of Rome, Italy
[r] Research Laboratory and Academic Division of Clinical Rheumatology, Department of Internal Medicine, University of Genoa, IRCCS San Martino Polyclinic Hospital, Genoa, Italy
[s] Department of Rheumatology and Clinical Immunology, University Medical Center Utrecht, Utrecht, the Netherlands
[t] Department of Rheumatology, Radboud University Medical Center, Nijmegen, the Netherlands
[u] Department of Rheumatology, University Hospital Basel, Basel, Switzerland

ARTICLE INFO

Keywords:
EULAR Study Group on Microcirculation in Rheumatic Diseases
Capillaroscopy
Reliability
"Scleroderma patterns"
Novices

ABSTRACT

Objectives: This study was designed to propose a simple "Fast Track algorithm" for capillaroscopists of any level of experience to differentiate "scleroderma patterns" from "non-scleroderma patterns" on capillaroscopy and to assess its inter-rater reliability.

Methods: Based on existing definitions to categorise capillaroscopic images as "scleroderma patterns" and taking into account the real life variability of capillaroscopic images described standardly according to the European League Against Rheumatism (EULAR) Study Group on Microcirculation in Rheumatic Diseases, a fast track

Abbreviations: ACR, American College of Rheumatology; CI, Confidence Interval; EULAR, European League Against Rheumatism; EULAR SG MC/RD, EULAR Study Group on Microcirculation in Rheumatic Diseases; EUSTAR, European Scleroderma Trials and Research group; NVC, nailfold videocapillaroscopy; SSc, systemic sclerosis

* Corresponding author at: Department of Rheumatology, Ghent University Hospital, Corneel Heymanslaan 10, 9000 Ghent, Belgium.
E-mail addresses: vanessa.smith@ugent.be (V. Smith), amber.vanhaecke@ugent.be (A. Vanhaecke), ariane.herrick@manchester.ac.uk (A.L. Herrick), oliver.distler@usz.ch (O. Distler), mlgomesg@gmail.com (M.G. Guerra), c.denton@medsch.ucl.ac.uk (C.P. Denton), ellen.deschepper@ugent.be (E. Deschepper), foeldvari@t-online.de (I. Foeldvari), dr.gmarwin@gmail.com (M. Gutierrez), ehachulla2@yahoo.fr (E. Hachulla), francesca.ingegnoli@unimi.it (F. Ingegnoli), kubosato@med.uoeh-u.ac.jp (S. Kubo), u.mueller-ladner@kerckhoff-klinik.de (U. Müller-Ladner), valeria.riccieri@uniroma1.it (V. Riccieri), albertosulli@unige.it (A. Sulli), j.m.vanlaar@umcutrecht.nl (J.M. van Laar), madelon.vonk@radboudumc.nl (M.C. Vonk), ulrich.walker@usb.ch (U.A. Walker), mcutolo@unige.it (M. Cutolo).
[1] Vanessa Smith and Amber Vanhaecke contributed equally to this study.

https://doi.org/10.1016/j.autrev.2019.102394
Received 11 May 2019; Accepted 17 May 2019
Available online 11 September 2019

Experts
Algorithm

decision tree, the "Fast Track algorithm" was created by the principal expert (VS) to facilitate swift categorisation of an image as "non-scleroderma pattern (category 1)" or "scleroderma pattern (category 2)". Mean inter-rater reliability between all raters (experts/attendees) of the 8th EULAR course on capillaroscopy in Rheumatic Diseases (Genoa, 2018) and, as external validation, of the 8th European Scleroderma Trials and Research group (EUSTAR) course on systemic sclerosis (SSc) (Nijmegen, 2019) versus the principal expert, as well as reliability between the rater pairs themselves was assessed by mean Cohen's and Light's kappa coefficients.
Results: Mean Cohen's kappa was 1/0.96 (95% CI 0.95–0.98) for the 6 experts/135 attendees of the 8th EULAR capillaroscopy course and 1/0.94 (95% CI 0.92–0.96) for the 3 experts/85 attendees of the 8th EUSTAR SSc course. Light's kappa was 1/0.92 at the 8th EULAR capillaroscopy course, and 1/0.87 at the 8th EUSTAR SSc course.
Conclusion: For the first time, a clinical expert based fast track decision algorithm has been developed to differentiate a "non-scleroderma" from a "scleroderma pattern" on capillaroscopic images, demonstrating excellent reliability when applied by capillaroscopists with varying levels of expertise versus the principal expert and corroborated with external validation.

1. Introduction

The "scleroderma pattern" on capillaroscopy has been incorporated into the 2013 American College of Rheumatology (ACR)/ European League Against Rheumatism (EULAR) classification criteria, as well as in criteria to facilitate a (very) early diagnosis of systemic sclerosis (SSc) [1–3]. Its importance is based on the fact that the combination of a "scleroderma pattern" and SSc specific antibodies has the highest performance characteristics to discern in a Raynaud's phenomenon population who will and who will not develop SSc [4].

In 1973 and more detailed in 1981, Maricq et al. was the first to describe key capillary abnormalities of a "scleroderma pattern" using "wide-field" capillary microscopy as "enlargement of capillary loops, loss of capillaries ('loop drop-out'), disruption of the normal capillary architecture and haemorrhages" [5,6]. Moreover, in her seminal quantitative study she measured with the stereomicroscopic technique the apical diameter of "definitely enlarged" capillaries, and found a mean apical diameter of 47.7 μm ± 5.8 to be specific for scleroderma spectrum diseases [7]. This finding was adopted and further developed by Cutolo et al. who likewise defined "giant capillaries" with the

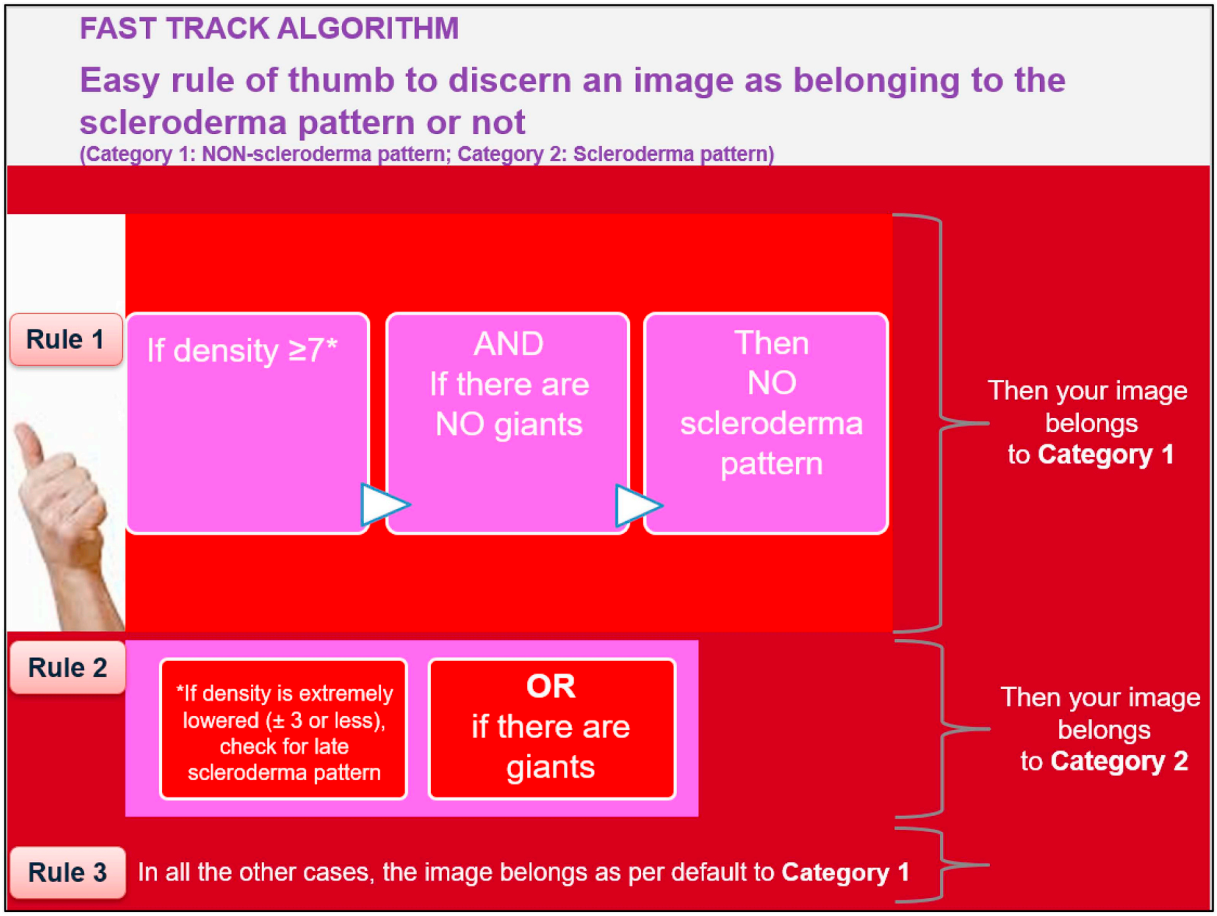

Fig. 1. The "Fast Track algorithm".
The Fast Track algorithm" consists of three easy rules: 1) **Rule 1**: a capillary density ≥ 7 capillaries AND the absence of giant capillaries allows the rater to call the capillaroscopic image a "non-scleroderma pattern (category 1)"; 2) **Rule 2**: an extremely lowered capillary density (≤ 3 capillaries) in combination with abnormal shapes (i.e. "late scleroderma pattern") OR the presence of giant capillaries allows the capillaroscopist to call the capillaroscopic image "a scleroderma pattern (category 2)"; 3) **Rule 3**: if the image does not meet rule number 1 or rule number 2 then the image is automatically classified as a" non-scleroderma pattern (category 1)".

Table 1
Mean Cohen's kappa (95% CI) and Light's kappa for the groups of raters at the 8th EULAR course on capillaroscopy in Rheumatic Diseases (Genoa 2018).

Group of raters	Mean Cohen's kappa (95% CI)	Light's kappa
Expert raters (n = 6)	1	1
Attendees (n = 135)	0.96 (0.95–0.98)	0.92
"Novices" (n = 68)	0.98 (0.96–0.99)	0.95
"Moderately experienced" (n = 53)	0.96 (0.93–0.99)	0.91
"Experienced" (n = 14)	0.93 (0.85–1)	0.84

CI: Confidence Interval.

nailfold videocapillaroscopic (NVC) technique as homogeneously enlarged capillaries with a normal shape and apical diameter over 50 μm [8]. The presence of these giant capillaries on NVC is interesting, as it allows distinction between SSc and non-SSc with over 95.6% specificity [9,10]. Of note, giant capillaries are the hallmark of the "early" and "active" scleroderma patterns, whilst the "late" scleroderma pattern is characterised by the combination of severe loss of capillaries combined with abnormal shapes ("[neo-] angiogenesis") [7,8].

Even though the classification of a capillaroscopic image as "scleroderma pattern" or not has a high inter-rater reliability between trained capillaroscopists, to the untrained rheumatologist this classification may be very challenging [11–13]. One of the reasons may be the vast variety of non-specific abnormalities of capillaroscopic characteristics (i.e. of capillary density, capillary dimension, capillary morphology and haemorrhages) that may be found in the general population (see below and in Supplementary File 1).

To facilitate the non-trained capillaroscopist in easily classifying an image as "scleroderma pattern" or "non-scleroderma pattern", the EULAR Study Group on Microcirculation in Rheumatic Diseases (EULAR SG MC/RD), a non-profit international network of expert centres established in 2014 which has as its main (research) focus to facilitate standardization of different non-invasive techniques, decided to create a swiftly trainable decision tree, the "Fast Track algorithm", based on existing definitions to categorise capillaroscopic images into the category of "scleroderma patterns" or into the category of "non-scleroderma patterns". Additionally, the EULAR SG MC/RD decided to assess the reliability of raters using this decision tree to classify capillaroscopic images. The key advantage of a fastly trainable, reliable decision tree would be that any capillaroscopist of any level of experience would be able to use this, knowing that he/she would rate likewise to a principal capillaroscopy expert, without the need to evaluate each single capillaroscopic characteristic that can be evaluated in capillaroscopy for research aims (see below and Supplementary File 1).

2. Methods

2.1. "Fast Track algorithm"

Based on the standard interpretation of capillaroscopic images by the EULAR SG MC/RD, more specifically of the following capillaroscopic characteristics: capillary density, capillary dimension, presence of abnormal capillary shapes and presence of haemorrhages (see Supplementary File 1) and based on the key elements of the "scleroderma pattern", a decision tree (i.e. the "Fast Track algorithm") was consented by two founding members of the EULAR SG MC/RD (VS, MC) (see Fig. 1). The "Fast Track algorithm" consists of three easy rules: 1) Rule number 1: the presence of ≥7 capillaries (capillary density) AND the absence of giant capillaries (capillary dimension) allows the rater to call the capillaroscopic image a "non-scleroderma pattern (category 1)"; 2) Rule number 2: the presence of giant capillaries or the presence of an extremely lowered capillary density (≤ 3 capillaries) in combination with abnormal shapes (= "late" scleroderma pattern) allows the capillaroscopist to call the capillaroscopic image a "scleroderma pattern (category 2)"; 3) Rule number 3: if the image does not meet rule number 1 or rule number 2 then the image is automatically classified as a "non-scleroderma pattern (category 1)" (see Fig. 1).

2.2. Capillaroscopic images

Thirty representative NVC images (i.e. 14 images with "scleroderma pattern" and 16 with "non-scleroderma pattern") with good visibility,

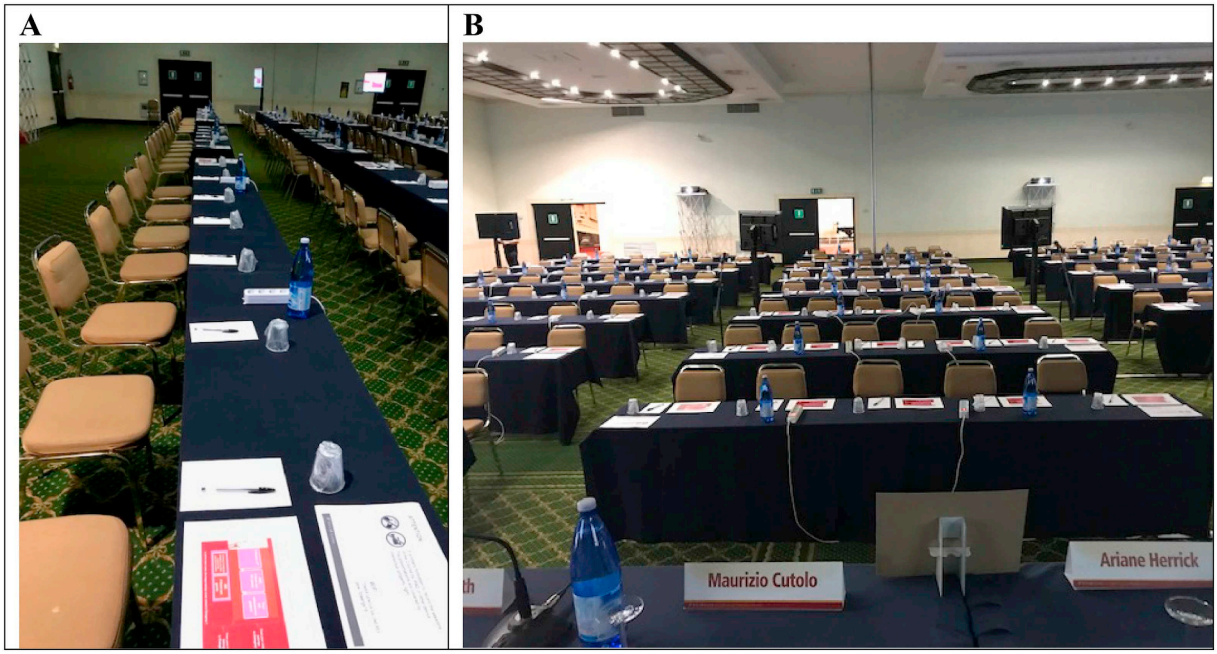

Fig. 2. Examination setting.
After the teaching lecture, the PowerPoint slide of the "Fast Track algorithm" was projected in the room during the whole examination (A) and the attendees had the picture of the "Fast Track algorithm" at hand during the examination (B).

acquired by an optical probe videocapillaroscope equipped with a 200× magnification contact lens, were randomly selected from all NVC examinations of patients referred to the Ghent University Scleroderma Unit between December 2017 and June 2018 (see Supplementary File 2 for the examination set with all capillaroscopic images). In the distal row, the apical diameter of dilated capillaries was reported by a trainee (MG), who had been trained by the principal expert (VS). All images were proofread by the principal expert (VS). Categorisation of images as "scleroderma pattern" or "non-scleroderma pattern" had been executed by the principal expert (VS).

2.3. Procedure of teaching the "Fast Track algorithm" and examining the raters

In the first part of this international multicentre study, a 45 min lasting lecture ("Capillaroscopy in daily practice") was given at the 8th EULAR course on capillaroscopy in Rheumatic Diseases in Genoa (September 2018) to 141 attendees, more specifically 6 experts in capillaroscopy and 135 attendees with varying levels of experience in capillaroscopy: 68 "novices", 53 "moderately experienced" and 14 "experienced" (see Table 1). In this lecture the EULAR SG MC/RD standardly assessed capillaroscopic characteristics (capillary density, capillary dimension, abnormal morphology and haemorrhages) were explained step by step by the principal expert (VS) and for the attendees' information an overview of all possible combinations of each of the capillaroscopic characteristics resulting into either "scleroderma patterns" or oppositely "non-scleroderma patterns" was taught both theoretically and applied to exemplary images (see Supplementary File 1 and 3). The "Fast Track algorithm" was applied to each capillaroscopic image and explained by the teacher, the principal expert (VS). Hence, in this interactive way, the audience was stimulated to actively learn the "Fast Track algorithm" (see Fig. 1). After the teaching lecture, the attendees had the picture of the "Fast Track algorithm" at hand during the examination (see Fig. 1). In addition, the PowerPoint slide of the "Fast Track algorithm" had also been projected in the room during the whole examination (see Fig. 2A and B). The exams existed of 16 pages, containing two capillaroscopic images per page (see Supplementary File 2). Next to an image the attendee was asked to choose between two options by applying a cross, i.e. more specifically category 1 ("non-scleroderma pattern") or category 2 ("scleroderma pattern") (see Supplementary File 2). Collaboration between attendees to execute the exam was not allowed. Two trainees (AV, MG) of the principal expert (VS) as well as the principal expert (VS) and the senior author (MC) supervised the room to avoid any collaboration between attendees in taking the exam. Of note, the raters (experts and attendees) were asked to attest their levels of expertise in capillaroscopy into one of the following categories: "novices" (no experience), "moderately experienced" (< 5 years of experience with capillaroscopy) and "experienced" raters (> 5 years of experience with capillaroscopy).

In a second time, as an external validation, this procedure was repeated during the 8th European Scleroderma Trials and Research group (EUSTAR) course on SSc in Nijmegen (February 2019) on 88 attendees, more specifically 3 experts and 85 attendees with varying levels of knowledge of capillaroscopy: 47 "novices", 29 "moderately experienced" and 9 "experienced" (see Table 2).

2.4. Statistical analysis

Inter-rater agreement for each rater versus the principal expert (VS), i.e. "mean index of reliability", was calculated for the group of experts, "novices", "moderately experienced" raters and "experienced" raters, both at the 8th EULAR course on capillaroscopy in Rheumatic Diseases and for reasons of external validation, as well at the 8th EUSTAR course on SSc. To this end, the mean Cohen's kappa value was reported, which is estimated by taking the mean of all Cohen's kappa statistic scores between raters and the principal expert (VS) (see Fig. 3A) [14].

Additionally, the agreement between all possible rater pairs, irrespective of the principal expert (VS), was reflected through reporting the Light's kappa. Hence, conceivably, if the algorithms should be representative for the experts (other than the principal expert) then the Light's kappa should be high in between the experts (see Fig. 3B) [14].

Thirdly, to get an idea of the percentage of raters at both courses which had a nearly perfect agreement, which is a kappa of > 0.8 versus the principal expert (VS), the distribution of the individual kappa's was calculated [15].

3. Results

3.1. Raters

Six expert raters (MC, AH, FI, VR, AS, VS [principal expert]) and 135 attendees (68 "novices", 53 "moderately experienced" and 14 "experienced" raters, from 43 different countries) participated at the 8th EULAR course on capillaroscopy in Rheumatic Diseases and 3 expert raters (MC, MV, VS [principal expert]) and 85 attendees (47 novices, 29 moderately experienced and 9 experienced raters, from 22 different countries) participated at the 8th EUSTAR course on SSc.

3.2. Inter-rater reliability

The mean index of reliability (i.e. mean Cohen's kappa) based on 30 images was 1 for the expert raters present at the 8th EULAR course on capillaroscopy in Rheumatic Diseases (n = 6) and 1 for the expert raters present at the 8th EUSTAR course on SSc (n = 3). The mean index of reliability was 0.96 (95% Confidence Interval [CI] 0.95–0.98) for the attendees of the 8th EULAR course on capillaroscopy in Rheumatic Diseases (n = 135) and 0.94 (95% CI 0.92–0.96) for the attendees of the 8th EUSTAR course on SSc (n = 85). Subgroup analysis according to the level of experience of the attendees, demonstrated a mean Cohen's kappa of 0.98 (95% CI 0.96–0.99) and 0.93 (95% CI 0.90–0.96) for "novices" (at the 8th EULAR course on capillaroscopy in Rheumatic Diseases and 8th EUSTAR course on SSc respectively), 0.96 (95% CI 0.93–0.99) and 0.94 (95% CI 0.89–0.98) for "moderately experienced" raters (at the 8th EULAR course on capillaroscopy in Rheumatic Diseases and 8th EUSTAR course on SSc respectively) and 0.93 (95% CI 0.85–1) and 0.97 (95% CI 0.92–1) for "experienced" raters (at the 8th EULAR course on capillaroscopy in Rheumatic Diseases and 8th EUSTAR course on SSc respectively).

Inter-rater agreement for each possible combination of rater pairs (i.e. Light's kappa), irrespective of the principal expert (VS), based on the 30 images was 1 for the expert raters present at the 8th EULAR course on capillaroscopy in Rheumatic Diseases (n = 6) and 1 for the expert raters present at the 8th EUSTAR course on SSc (n = 3). The inter-rater agreement for each possible combination of rater pairs, irrespective of the principal expert was 0.92 for the attendees of the 8th EULAR course on capillaroscopy in Rheumatic Diseases (n = 135) and 0.87 for the attendees of the 8th EUSTAR course on SSc (n = 85). Subgroup analysis demonstrated a Light's kappa of 0.95 and 0.87 for

Table 2
Mean Cohen's kappa (95% CI) and Light's kappa for the groups of raters at the 8th EUSTAR course on SSc (Nijmegen 2019).

Group of raters	Mean Cohen's kappa (95% CI)	Light's kappa
Expert raters (n = 3)	1	1
Attendees (n = 85)	0.94 (0.92–0.96)	0.87
"Novices" (n = 47)	0.93 (0.90–0.96)	0.85
"Moderately experienced" (n = 29)	0.94 (0.89–0.98)	0.88
"Experienced" (n = 9)	0.97 (0.92–1)	0.94

CI: Confidence Interval.

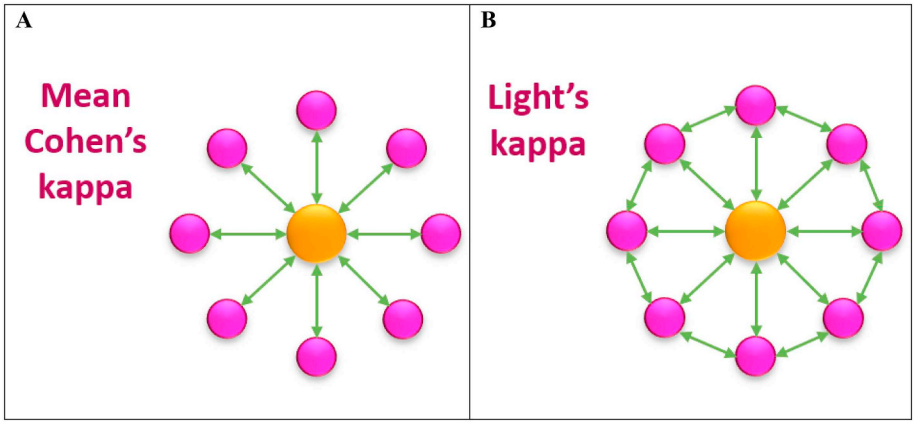

Fig. 3. Inter-rater agreement assessed by kappa coefficients.
Inter-rater agreement was assessed by calculating kappa coefficients, i.e. the mean Cohen's kappa (A) and Light's kappa (B). A) **Mean Cohen's kappa** was calculated to obtain the inter-rater agreement for each rater (expert/ attendees/ "novices"/ "moderately experienced"/ "experienced") versus the principal expert (VS). B) **Light's kappa** was calculated to obtain the inter-rater agreement for each possible combination of agreement between raters and the principal expert (VS).

"novices" (at the 8th EULAR course on capillaroscopy in Rheumatic Diseases and 8th EUSTAR course on SSc respectively), 0.91 and 0.88 for "moderately experienced" raters (at the 8th EULAR course on capillaroscopy in Rheumatic Diseases and 8th EUSTAR course on SSc respectively) and 0.84 and 0.94 for "experienced" raters (at the 8th EULAR course on capillaroscopy in Rheumatic Diseases and 8th EUSTAR course on SSc respectively).

3.3. Percentage of raters with high agreement versus the principal expert

The distribution of the individual kappa's showed that 95% of raters at the 8th EULAR course on capillaroscopy in Rheumatic Diseases in Genoa and 89% of raters at the 8th EUSTAR course on SSc in Nijmegen had a kappa of > 0.8 versus the principal expert (VS).

4. Discussion

This is the first international multicentre study to step forward to the need to find an easy rule of thumb decision tree (i.e. the "Fast Track algorithm") to categorise capillaroscopic images as "scleroderma pattern" or "non-scleroderma pattern". A principal expert (VS) had first classified 30 images, taken with a nailfold videocapillaroscope with a 200× magnification, as "scleroderma pattern" or "non-scleroderma pattern", the latter comprising perfectly normal images but also images with non-specific abnormalities. Then, in two renowned international training courses (the 8th EULAR course on capillaroscopy in Rheumatic Diseases and the 8th EUSTAR course on SSc) course raters (experts and attendees of different level of experience ["novices", "moderate experienced", "experienced"]) had been trained in 45 min by the principal expert to categorise images in the exact same way as the principal expert through exemplary teaching the "Fast Track algorithm". Subsequently, both in the pilot study at the 8th EULAR course on capillaroscopy in Rheumatic Diseases in Genoa, as well as in the external validation study at the 8th EUSTAR course on SSc in Nijmegen, an excellent inter-rater reliability, not only versus the principal expert rater (mean Cohen's kappa) but also in between the raters themselves (Light's kappa) was found in categorizing capillaroscopic images as "scleroderma pattern" or as "non-scleroderma pattern". Hence, we strongly feel that this "Fast Track algorithm" may be used safely as a teaching tool in daily practice to capillaroscopists with any level of experience, with the aim to have certainty to categorise a capillaroscopic image as a "scleroderma pattern" in the same way that an expert rater does.

This swiftly trainable and reliable decision tree is important, certainly as the "scleroderma pattern" is a criterion in the new 2013 ACR/EULAR classification criteria for systemic sclerosis [3]. Correct attribution (vis à vis a principal expert as repère point) of a capillaroscopic image to the "scleroderma pattern" category is key to correctly denote a patient to meet the criterion of "abnormal capillaroscopy" of the 2013 ACR/EULAR criteria [3].

One of the advantages of the "Fast Track algorithm" is that only simple capillaroscopic characteristics were needed to teach the raters, more specifically, capillaroscopic characteristics that have attested through literature to have a high inter-rater reliability: "capillary density" (number of capillaries), "giant capillaries" (capillaries with an apical diameter ≥ 50 μm) and "abnormal shapes" [13,16–24]. Rather than trying to train the eye of the rater to interpret capillaroscopic images according to any combination of all existing capillaroscopic characteristics that are being used nowadays in research which may be quite challenging to the untrained capillaroscopists (see Supplementary File 1), with the "Fast Track algorithm" the capillaroscopist only has to check three rules which automatically lead him/her to a correct categorisation, more specifically into a "scleroderma pattern or "non-scleroderma pattern".

Additionally, we want to draw attention to the fact that the aim of this study was not to assess discriminatory characteristics of capillaroscopy to differentiate between healthy controls, primary Raynaud's patients and patients with secondary Raynaud's phenomenon due to SSc. Landmark work on this issue has already been done [4,25,26]. Moreover, such a research question would have needed a totally different statistical approach with calculation of receiver operating curves and calculation of sensitivity and specificity of capillaroscopy to discriminate healthy controls and primary from secondary Raynaud's phenomenon due to SSc. In contrast, our intention was to assess an expert designed decision tree, the "Fast Track algorithm", with the aim to enable every capillaroscopist of any level of experience to differentiate within groups of clinically relevant capillaroscopic patterns, more specifically between "the scleroderma patterns" versus the "non-scleroderma patterns".

5. Conclusion

For the first time, a clinical expert based fast track decision algorithm has been developed to differentiate a "non-scleroderma" from a "scleroderma pattern" on capillaroscopic images. This algorithm demonstrated an excellent reliability when applied by capillaroscopists with varying levels of expertise versus the principal expert, at the 8th EULAR course on capillaroscopy in Rheumatic Diseases in Genoa and corroborated with external validation at the 8th EUSTAR course on SSc in Nijmegen.

Contributors

We are grateful to all attendees of the 8th EULAR course on capillaroscopy in Rheumatic Diseases, held in Genoa, September 2018 and of the 8th EUSTAR course on systemic sclerosis, held in Nijmegen, February 2019, for participating in this study:

Allain Wouterlood Marijke, Department of Internal medicine,

Hôpital Charles LeMoyne, Quebec, Canada; Akshat Pandey, Department of Rheumatology, Apollo Hospitals, Indore, India; Amorosi Beatrice, Department of Dermatology, Istituti Fisioterapici Ospitalieri Roma, Roma, Italy; Arnold Sabrina, Department of Rheumatology, Universitätsklinikum Schleswig-Holstein-Zentrale (UKSH), Lübeck, Germany; Bajo Diana, Department of Rheumatology, Klinički Bolnički Centar (KBC) Split, Split, Croatia; Balbir Alexandra, Department of Rheumatology, Rambam Medical Center, Haifa, Italy; Baric Anastasija, Department of Rheumatology, Clinical Hospital Sisters of Mercy, Zagreb, Croatia; Baron Fatemah, Department of Rheumatology, Galway Hospital, Gaillimh, Ireland; Barreira Sofia, Department of Rheumatology, Hospital de Santa Maria, Centro Hospitalar Lisboa Norte EPE, Lisboa, Portugal; Barrio Nogal Laura, Department of Rheumatology, Hospital Universitario Príncipe de Asturias, Madrid, Spain; Bartosinska Joanna, Department of Dermatology, Medical university of Lublin, Lublin, Poland; Bazela-Zadura Anna, Department of Rheumatology, Pomorskie centrum Reumatologiczne, Przylesie, Poland; Bech Rikke, Department of Dermatology, Aarhus University Hospital, Arhus, Denmark; Begovic Ana, Department of Rheumatology, Klinički Bolnički Centar (KBC) Split, Split, Croatia; Bendjenna Dalila, Department of Rheumatology, CNU Benbadis Constantine, Constantine, Algeria; Benfaremo Devis, Department of Rheumatology, Clinica Medica Universita Politecnica delle Marche, Italy; Bertoldo Eugenia, Department of Rheumatology, AOUI Verona, Verona, Italy; Besseling Rens, Department of Rheumatology, UMCG Groningen, Groningen, The Netherlands; Bevan Martin, Department of Rheumatology, HMT Sancta Maria, Swansea, UK; Bouayed Kenza, Department of Paediatric Rheumatology, Children hospital CHU IBN Rochd, Casablanca, Morocco; Boyadzhieva Vladimira, Department of Rheumatology, UMHAT St Ivan Rilski, Sofia, Bulgaria; Brites Luisa, Department of Rheumatology, Centro Hospitalar e Universitario de Coimbra, Coimbra, Portugal; Broen Jasper, Department of Rheumatology, University Medical Center (UMC) Utrecht, Utrecht, The Netherlands; Carton Charlotte, Department of Rheumatology, Ghent University Hospital, Ghent, Belgium; Cazac Victor, Department of Rheumatology, State University of Medicine and Pharmacy of the Republic of Moldova, Romania; Chetouane-Bennafaa Radia, Department of Rheumatology, Hôpital De Ben Aknoun Boukhroufa Abdelkader, Ben Aknoun, Algeria; Chodorowski Jakub, Department of Dermatology, Own Practice, Lublin, Poland; Ciaffi Jacopo, Department of Rheumatology, Leiden University Medical Center (LUMC), Leiden, The Netherlands; Cirillo Mariateresa, Department of Rheumatology, Humanitas Clinical and Research Center, Milan, Italy; Codina Andreu-Fernandez, Department of Rheumatology, Saint Josephs' Hospital London, London Health Sciences Centre, London, UK; Coleiro Bernard, Department of Rheumatology, Hospital Mater Dei, Belo Horizonte, Malta; Condeiro Ines, Department of Rheumatology, Hospital de Santa Maria, Centro Hospitalar Lisboa Norte EPE, Lisboa, Portugal; Corrado Campochiaro, Department of Rheumatology, San Raffaele Scientific institute Milan, Italy; Crisafulli Francesca, Department of Rheumatology, Spedali Civili di Brescia, Brescia, Italy; Damjanov Nemanja, Department of Rheumatology, University of Belgrade, Belgrade, Serbia; Damyana Yordanova, Department of Rheumatology, St Ivan Rilski Hospital, Sofia, Bulgary; Danczak-Pazdrowska Aleksandra, Department of Dermatology, Poznan University of Medical Sciences, Poznan, Poland; De Angelis Rossella, Department of Clinical and Molecular Sciences, Rheumatology Unit, Carlo Urbani Hospital, Polytechnic University of Marche, Jesi, Ancona, Italy; de Kanter Meeke, Department of Rheumatology, Elisabeth-TweeSteden Ziekenhuis (ETZ), Tilburg, The Netherlands; De Luca Giacomo, Department of Rheumatology, IRCCS San Raffaele Hospital Milan, Milan, Italy; De Moor Michael, Department of Rheumatology, Ghent University Hospital, Ghent, Belgium; de Vries-Bouwstra Jeska, Department of Rheumatology, Leiden University Medical Center (LUMC), Leiden, The Netherlands; Del Galdo Francesco, University of Leeds, Leeds, UK; Depicker Anais, Department of Rheumatology, Ghent University Hospital, Ghent, Belgium; Dhamo Blerina, Department of Rheumatology, Hygeia hospital Tirana, Tirana, Albania; Dharmanand Balebail, Department of Rheumatology, Sakra Hosptial, Bangalore, India; Dias Catarina, Department of Internal medicine, Central Hospital in Madeira Island, Madeira, Portugal; Dudra-Jastrzebska Monika, Department of Dermatology, Medical university of Lublin, Lublin, Poland; Emperiale Valentina Emmanuela, Department of Rheumatology, Hospital Universitario Principe de Asturias, Alcalá de Henares, Spain; Eshak Nouran, Department of Rheumatology, Faculty of Medicine, University of Alexandria, Alexandria, Egypt; Fage Simon W., Department of Dermatology, Aarhus University Hospital, Arhus, Denmark; Farina Eleonora, Università degli Studi di Milano-Bicocca, Milan, Italy; Ferdinand Isabelle, Clinique Notre-Dame De Grâce, Charleroi, Belgium; Fonseca Diogo Miranda, Department of Rheumatology, Centro Hospitalar Vila Nova de Gaia/Espinho, Vil Nova de Gaia, Portugal; Frech Tracy, Department of Internal medicine, University of Utah, Utah, USA; Fretheim Havard, Department of Rheumatology, University of Oslo, Oslo, Norway; Gaidarji Olga, Department of Pediatrics, Institute of mother and child, Warsaw, Poland; Galanopoulos Nikolaos, Department of Rheumatology, Democritus University of Thrace, Alexandroupolis, Greece; Gallo Carolina, Department of Rheumatology, Hospital Clinico San Borja Arriaran, Santiago, Chile; Ganhao Santos Sara, Department of Rheumatology, Centro Hospitalar Sao Joao, Porto, Portugal; Gercik Onay, Department of Rheumatology, Izmir Katip Çelebi University, Izmir, Turkey; Voerman Gerlienke, Radboud University Medical Center (UMC), Nijmegen, The Netherlands; Gheorghe Karina, Department of Rheumatology, Karolinska University Hospital, Stockholm, Sweden; Giryes Sami, Department of Rheumatology, Rambam Medical Center, Haifa, Israel; Glas Kasper, Department of Rheumatology, Leiden University Medical Center (LUMC), Leiden, The Netherlands; Gonçalves Maria Joao, Department of Rheumatology, Centro Hospitalar de Lisboa Ocidental, EPE, Lisboa, Portugal; Gonzalez Benitez Roberto Daniel, Department of Rheumatology, University Hospital Quironsalud Madrid, Madrid, Spain; Gruszecka Katarzyna, Department of Rheumatology, Warsaw Medical University, Warsaw, Poland; Guerboukha Hamida, Department of Rheumatology, Hôpital De Ben Aknoun Boukhroufa Abdelkader, Ben Aknoun, Algeria; Gunnarsson Karin, Department of Rheumatology, Karolinska University Hospital, Stockholm, Sweden; Hajdu-Toth Kata Viktoria, Department of Rheumatology, University of Pécs, Pécs, Hungary; Hellmi Rakhma Yanti, Department of Rheumatology, Kariadi Hospital, Java, Indonesia; Hindi Issam, Department of Rheumatology, Hadassah Medical Center, Jerusalem, Israel; Hinze Tanja, Department of Rheumatology, University Hospital Muenster, Muenster, Germany; Hoeger Antonia, Department of Rheumatology, Zentrum Kinderrheumatology Hamburg, Hamburg, Germany; Host Lauren, Department of Rheumatology, Department of Rheumatology, University College London, Royal Free Hospital, London, UK; Hoxha Ariela, Department of Internal medicine, University-Hospital of Padova, Padova, Italy; Huang Po-Hao, Department of Internal medicine, China Medical University Hospital, Taiwan, China; Ickinger Claudia, Department of Rheumatology, University of the Witwatersrand, Johannesburg, South-Afrika; Isabelle Catherine, Department of Rheumatology, Greenfield Park, Quebec, Canada; Ismail Sherif, Department of Rheumatology, National Research Center Egypt, Cairo, Egypt; Jakubaszek Michal, Department of Rheumatology, National Institute of Geriatrics, Warsaw, Poland; Kedor Claudia, Department of Rheumatology, Charité Universtätsmedizin Mitte, Berlin, Germany; Kersten Brigit, Department of Rheumatology, Radboud University Medical Center (UMC), Nijmegen, The Netherlands; Kerstens Floor, Department of Rheumatology, Sint Maartenskliniek, Nijmegen, The Netherlands; Keskitalo Paula, Department of Rheumatology, University of Oulu, Oulu, Finland; Khan Khalid Ali, Department of Rheumatology, Al Zahra Hospital Dubai, Dubai, United Arab Emirates; Khmelinskii Nikita, Department of Rheumatology, Hospital de Santa Maria, Centro Hospitalar Lisboa Norte EPE, Lisboa, Portugal; Klein-Wieringa Inge, Department of

Rheumatology, Leiden University Medical Center (LUMC), Leiden, The Netherlands; Koulouri Angeliki, Department of Dermatology, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland; Kucharz Eugene, Department of Rheumatology, Medical University of Silesia, Katowice, Poland; Kyllönen Minna Susanna, Department of Internal medicine, University of Oulu, Oulu, Finland; Lazzaroni Maria-Grazia, Department of Rheumatology, Spedali Civili di Brescia, Brescia, Italy; Lemmers Jacqueline, Department of Rheumatology, Radboud University Medical Center (UMC), Nijmegen, The Netherlands; Leone Maria, Department of Scleroderma Unit, University of Perugia, Perugia, Italy; Lescoat Alain, Department of Immunology, Centre Hospitalier Universitaire de Rennes, France; Li Ying Hsuan, Department of Rheumatology, China Medical University Hospital, Taiwan, China; Lopes Carina, Department of Rheumatology, Hospital Egas Moniz, Lisbon, Portugal; Lopez-Ceron Ana, Department of Rheumatology, Hospital Gregorio Marañón, Madrid, Spain; Lötscher Fabian, Department of Rheumatology, Asklepios Klinik Altona, Hamburg, Germany; Luis Mariana, Department of Rheumatology, Centro Hospitalar e Universitario de Coimbra, Coimbra, Portugal; Lukinac Ana Marija, Department of Rheumatology, Clinical Hospital Center Osijek, Osijek, Croatia; Ly Khue, Department of Internal medicine, McGill University, Montreal, Canada; Lynch Bernadette, Department of Rheumatology, University hospital Galway, Galway, Ireland; Machado Ana Rita, Department of Rheumatology, Hospital de Santa Maria, Centro Hospitalar Lisboa Norte EPE, Lisboa, Portugal; Madeira Nathalie, Department of Rheumatology, Instituto Portugues de Reumatologia, Portugal; Mahieu Ine, Ghent University Hospital, Ghent, Belgium; Malgorzata-Michalska Jakubus, Department of Dermatology, Medical university of Lublin, Lublin, Poland; Martinez Robles Elena, Department of Internal medicine, Hopital Cantoblanco, Madrid, Spain; Martins Patricia, Department of Rheumatology, Hospital de Santa Maria, Centro Hospitalar Lisboa Norte EPE, Lisboa, Portugal; Mashru Puneet, Department of Rheumatology, Jaslok Hospital and Research Centre, Mumbai, India; Mazzocchi Daniela, Department of Rheumatology, Azienda Ospedaliera Ospedali di Legnano, Legnano, Italy; Medina Yimy, Department of Internal medicine, National University of Colombia, Bogota, Colombia; Medjadi Mohsine, Department of Rheumatology, E.H Ain El Turck Oran, Oran, Algeria; Melsens Karin, Department of Rheumatology, Ghent University Hospital, Ghent, Belgium; Messiniti Valentina, Department of Rheumatology, Universita della Campania L. Vanvitelli, Italy; Miziolek Bartosz, Department of Dermatology, Medical University of Silesia, Katowice, Poland; Moiseev Alexey, Department of Rheumatology, Lomonosov Moscow State University, Moscow, Russia; Moser Florentin, Department of Rheumatology, St. Olavs hospital, Trondheim University Hospital, Trondheim, Norway; Mrsic Fanika, Department of Rheumatology, Clinical Hospital Sisters of Mercy, Zagreb, Croatia; Neto Agna, Department of Rheumatology, Centro Hospitalar de Lisboa Occidental, Hospital de Egas Moniz, Lisboa, Portugal; Nguyen Thanh Hien Tu, Department of Internal medicine, Hôpital de la cité de la santé, Laval, Canada; Nielsen Christoffer Tandrup, Copenhagen University Hospital, Rigshospitalet, Copenhagen, Denmark; Osman Mohamed, Department of Rheumatology, University of Alberta, Edmonton, Alberta, Canada; Ostrovrsnik Jaka, Department of Rheumatology, University clinical center Ljubljana, Ljubljana, Slovenia; Pacini Greta, Department of Rheumatology, University of Genoa, IRCCS San Martino Polyclinic Hospital, Genoa, Italy; Patanè Massimo, Department of Rheumatology, University of Genoa, IRCCS San Martino Polyclinic Hospital, Genoa, Italy; Pendolino Monica, Department of Rheumatology, Sapienza University of Rome, Rome, Italy; Perdan-Pirkmajar Katja, Department of Rheumatology, University clinical center Ljubljana, Ljubljana, Slovenia; Pettiti Giorgio, Department of Rheumatology, S. Croce e Carle Hospital, Cuneo, Italy; Pflugfelder Johannes, Department of Rheumatology, Marienhospital Stuttgart, Stuttgart, Germany; Pham Michael, Department of Internal medicine, Stanford Hospital, California, United states of America; Phaneuf Maude, Department of Internal medicine, Hopital Honore Mercier, Quebec, Canada; Piette Yves, Department of Rheumatology, Ghent University Hospital, Ghent, Belgium; Pomîrleanu Daniela Cristina, Department of Rheumatology, Grigore T. Popa University of Medicine and Pharmacy, Iaşi, Romania; Pontalti Marco, Department of Rheumatology, AOUI Verona, Verona, Italy; Poriau Stefaan, Department of Rheumatology, AZ Zeno, Knokke, Belgium; Prate Ana Rita, Department of Rheumatology, Centro Hospitalar Universitario de Croacia, Zagreb, Croatia; Predoiu Andreea, Department of Rheumatology, Cluj County Hospital, Cluj-Napoca, Romania; Pretel Ruiz Paula, Department of Rheumatology, Hospital Universitario Principe de Asturias, Madrid, Spain; Priora Marta, Department of Rheumatology, l'Università di Pavia, Pavia, Italy; Radic Mislav, Department of Rheumatology, UH Split, Split, Croatia; Radovits Bea, Department of Rheumatology, Bernhoven Hospital, Bernhoven, The Netherlands; Raquel Miriam, Department of Rheumatology, Hospital de S. João, Porto, Portugal; Rein Siv Elisabeth, Department of Rheumatology, St. Olavs hospital, Trondheim University Hospital, Trondheim, Norway; Reynaert Valerie, Department of Dermatology, Vrije Universiteit Brussel, Brussels University Hospital, Brussels, Belgium; Rinzis Mirela Gabriela, Department of Rheumatology, Sanovil clinic, Sanovil, Romania; Romanowska-Prochnicka Katarzyna, Department of Rheumatology, National institute of geriatrics, Warsaw, Poland; Romao Vasco, Department of Rheumatology, Hospital de Santa Maria, Centro Hospitalar Lisboa Norte EPE, Lisboa, Portugal; Ross Laura, Department of Rheumatology, Saint Vincent's hospital, Melbourne, Australia; Rovera Guido, Department of Rheumatology, Ospedale Ordine Mauriziano di Torino, Umberto I, Italy; Ruiz Danilo, Department of Rheumatology, Federal university of Tocantins, Palmas, Brazil; Russo Barbara, Department of Immunology, University of Geneva, Geneve, Switzerland; Rusu Ioana, Department of Rheumatology, Cluj County Hospital, Cluj-Napoca, Romania; Saavedra Gutierrez Silvana, Department of Rheumatology, Hospital clinico Universidad de Chile, Santiago, Chile; Saidi Narimene, Department of Rheumatology, Algiers hospital, Algiers, France; Sari Alper, Department of Rheumatology, Hacettepe University, Ankara, Turkey; Satis Hasar, Department of Rheumatology, Gazi University, Ankara, Turkey; Schoneveld Leonard, Department of Rheumatology, Bravis hospital, Utrecht, The Netherlands; Seitz Luca, Department of Rheumatology, Hospital Bern, Bern, Switzerland; Senoh Alkemi, Department of Dermatology, Japanese red cross medical center, Tokyo, Japan; Santosa Anindita, Department of Rheumatology, Changi general hospital, Simei, Singapore; Seyed Mardani Seyed Mostafa, Department of Rheumatology, Urmia University of Medical Sciences, Urmia, India; Shah Qutab, Department of Rheumatology, Midlands Regional Hospital Tullamore Offaly, Ireland; Sikora Mariusz, Department of Dermatology, Warsaw Medical University, Warsaw, Poland; Silva Filipa Daniela, Department of Internal medicine, Portugal; Silvestri Valeria, Department of Vascular surgery, Sapienza university of Rome, Rome, Italy; Simopolou Theodora, Department of Rheumatology, University hospital of Larissa, Larissa, Greece; Singh Rajneet, Department of Rheumatology, Galway Hospital, Galway, Ireland; Smits Marijn, Department of Rheumatology, Radboud University Medical Center (UMC), Nijmegen, The Netherlands; Snow Marcus, Department of Rheumatology, University of Nebraska, Lincoln, USA; Soldano Stefano, Department of Internal medicine, University of Genoa, Genoa, Italy; Soto Lilian, Department of Rheumatology, Universidad de Chile, Santiago, Chile; Soyfoo Shahnawaz Muhammad, Department of Rheumatology, Hôpital Erasme ULB, Brussel, Belgium; Spierings Julia, Department of Rheumatology, University Medical Center (UMC) Utrecht, Utrecht, The Netherlands; Steelandt Alexia, Department of Rheumatology, Institut Cochin, Paris, France; Stevens Wendy, Department of Rheumatology, Sint Vincent's Hospital, Melbourne, Australia; Stoilov Nikolay, Department of Rheumatology, Medical university of Sofia, Sofia, Bulgaria; Strugariu Georgiana, Department of Rheumatology, Clinical Rehabilitation Hospital, Lasi, Romania; Suitner

Manon, Department of Rheumatology, Université de Montreal, Montreal, Canada; Supe Marijana, Department of Internal medicine, General Hospital Sibenik, Sibenik, Croatia; Suput Skvarca Dasa, Department of Rheumatology, Ljubljana University Medical Centre, Ljubljana, Slovenia; Suryo Anggoro Kusumo Wibowo, Department of Internal medicine, Universitas Indonesia Cipto Mangunkusumo Hospital, Jakarta, Indonesia; Sy Kane Baïdy, Department of Internal medicine, Cheikh Anta Diop University, Dakar, Senegal; Tarasova Anna, Department of Rheumatology, Russian Medical Academy of Postgraduate Education, Moscow, Rusia; Tardito Samuele, Department of Rheumatology, University of Genoa, IRCCS San Martino Polyclinic Hospital, Genoa, Italy; Tavor Yonit, Department of Rheumatology, Rambam Medical Center, Haifa, Israel; Tenazinha Catarina, Department of Rheumatology, Hospital de Santa Maria, Centro Hospitalar Lisboa Norte EPE, Lisboa, Portugal; Thoma Anna, Department of Rheumatology, Medical Center Prodorso, Zurich, Switzerland; Tjeuw michael, Department of Rheumatology, Private Practice, Sydney, Australia; Trombetta Amelia, Department of Internal Medicine, University of Genoa, IRCCS San Martino Polyclinic Hospital, Genoa, Italy; Valido Ana, Department of Rheumatology, Klinički Bolnički Centar (KBC) Split, Split, Croatia; van den Hoogen Frank, Department of Rheumatology, Radboud University Medical Center (UMC), Nijmegen, The Netherlands; Van Herwaarden Noortje, Department of Rheumatology, Radboud University Medical Center (UMC), Nijmegen, The Netherlands; Van Meerendonck Aniek, Department of Rheumatology, VUMC Amsterdam, Amsterdam, The Netherlands; Van Spil Erwin, Department of Rheumatology, University Medical Center (UMC) Utrecht, Utrecht, The Netherlands; Vanden Bulcke Michael, Department of Rheumatology, Ghent University Hospital, Ghent, Belgium; Verduci Elisa, Department of Rheumatology, ASST Great Metropolitan Niguarda, Italy; Verniers Lucas, Department of Internal medicine, Ghent University Hospital, Ghent, Belgium; Vivar Nancy, Department of Rheumatology, Karolinska University Hospital, Stockholm, Sweden; Voigt Karen, Department of Rheumatology, Universitätsklinikum Hamburg-Eppendorf, Hamburg, Germany; Vos Ine, Department of Rheumatology, GZA Hospital Sint-Augustinus, Antwerp, Belgium; Wiefel Kristin, Department of Rheumatology, University Hospital Dresden, Dresden, Germany; Wojteczek Anna, Department of Internal medicine, Medical University of Gdańsk, Gdansk, Poland; Yokochi Ritsuko, Department of Rheumatology, University of Tokyo, Chiba University Medical Center, Tokyo, Japan; Zampogna Guiseppe, Department of Rheumatology, Azienda Sanitaria dell' Alto Adige, Bolzano, Italy.

Statement of author contribution, agreement and declaration

Vanessa Smith: Ideation of the study, substantial contributions to the design of the study, acquisition of data, analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Amber Vanhaecke: Acquisition of data, analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Ariane L. Herrick: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Oliver Distler: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Miguel Guerra: Acquisition of data, analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Christopher Denton: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Ellen Deschepper: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Ivan Foeldvari: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Marwin Gutierrez: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Eric Hachulla: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Francesca Ingegnoli: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Satoshi Kubo: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Ulf Müller-Ladner: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Valeria Riccieri: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Alberto Sulli: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Jacob M. van Laar: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Madelon C. Vonk: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Ulrich A. Walker: Analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.
Maurizio Cutolo: Substantial contributions to the design of the study, analysis and interpretation of data, drafting of the article, critical revision of the intellectual content, final approval of the version to be published.

Declaration of Competing Interest

Vanessa Smith: Prof. Smith received a research grant from Boehringer Ingelheim; and received research funding from Actelion Pharmaceuticals Ltd., Bayer AG, F. Hoffman-La Roche AG, Galapagos NV and Sanofi.
Amber Vanhaecke: no conflicts of interest to declare for this study.
Ariane L. Herrick: no conflicts of interest to declare for this study.
Oliver Distler: Consultancy relationship and/or research funding from A. Menarini, Acceleron Pharma, Amgen, AnaMar, Bayer, Boehringer Ingelheim, Catenion, CSL Behring, Ergonex, GSK, Inventiva, Italfarmaco, iQvia, Lilly, Medac, Medscape, Mitsubishi Tanabe Pharma, MSD, Novartis, Pfizer, Roche, Blade Therapeutics, CSL Behrings, Target Bio Science and UCB in the area of potential treatments of scleroderma and its complications. In addition, patent mir-29 for the treatment of systemic sclerosis issued (US8247389, EP2331143).
Miguel Guerra: no conflicts of interest to declare for this study.
Christopher Denton: received research grants from GlaxoSmithKline, CSF Behring, and Inventiva and consulting fees from Roche/Genentech, Actelion, GlaxoSmithKline, Sanofi Aventis, Inventiva, CSL Behring, Boehringer-Ingelheim, UCB and Bayer.
Ellen Deschepper: no conflicts of interest to declare for this study.
Ivan Foeldvari: no conflicts of interest to declare for this study.
Marwin Gutierrez: no conflicts of interest to declare for this study.
Eric Hachulla: no conflicts of interest to declare for this study.

Francesca Ingegnoli: no conflicts of interest to declare for this study.
Satoshi Kubo: Dr. Satoshi has received speaking fees from Bristol-Myers, Pfizer, Takeda and Eli Lilly.
Ulf Müller-Ladner: no conflicts of interest to declare for this study.
Valeria Riccieri: no conflicts of interest to declare for this study.
Alberto Sulli: no conflicts of interest to declare for this study.
Jacob M. van Laar: received honoraria from Arthrogen, BMS, Eli Lilly, MSD, Roche, and research grants from Astra Zeneca, MSD, Roche and Thermofisher.
Madelon C. Vonk: received honoraria from Boehringer Ingelheim and Roche and research grants from Actelion Pharmaceuticals Ltd. and Therabel.
Ulrich A. Walker: no conflicts of interest to declare for this study.
Maurizio Cutolo: no conflicts of interest to declare for this study.

Acknowledgements

We are grateful to all attendees of the 8th EULAR course on capillaroscopy in Rheumatic Diseases, held in Genoa, September 2018 and of the 8th EUSTAR course on systemic sclerosis, held in Nijmegen, February 2019, for participating in this study (see “Collaborators” for the list of attendees). We also thank the collaborators of the EULAR Study Group on Microcirculation in Rheumatic Diseases.

A special thanks goes to Ann Van den Broecke and Charlotte Carton for their assistance in completing the database.

Funding source declaration

Prof. Vanessa Smith is a Senior Clinical Investigator of the Research Foundation - Flanders (Belgium) (FWO) [1.8.029.15N]. The FWO was not involved in study design, collection, analysis and interpretation of data, writing of the report, nor in the decision to submit the article for publication.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.autrev.2019.102394.

References

[1] LeRoy EC, Medsger Jr. TA. Criteria for the classification of early systemic sclerosis. J Rheumatol 2001;28(7):1573–6.
[2] Avouac J, Fransen J, Walker UA, Riccieri V, Smith V, Muller C, et al. Preliminary criteria for the very early diagnosis of systemic sclerosis: results of a Delphi Consensus Study from EULAR Scleroderma Trials and Research Group. Ann Rheum Dis 2011;70(3):476–81.
[3] van den Hoogen F, Khanna D, Fransen J, Johnson SR, Baron M, Tyndall A, et al. 2013 classification criteria for systemic sclerosis: an American college of rheumatology/European league against rheumatism collaborative initiative. Ann Rheum Dis 2013;72(11):1747–55.
[4] Koenig M, Joyal F, Fritzler MJ, Roussin A, Abrahamowicz M, Boire G, et al. Autoantibodies and microvascular damage are independent predictive factors for the progression of Raynaud's phenomenon to systemic sclerosis: a twenty-year prospective study of 586 patients, with validation of proposed criteria for early systemic sclerosis. Arthritis Rheum 2008;58(12):3902–12.
[5] Maricq HR, LeRoy EC. Patterns of finger capillary abnormalities in connective tissue disease by "wide-field" microscopy. Arthritis Rheum 1973;16(5):619–28.
[6] Maricq HR. Wide-field capillary microscopy. Technique and rating scale for abnormalities seen in scleroderma and related disorders. Arthritis Rheum 1981;24(9):1159–65.
[7] Maricq HR. Comparison of quantitative and semiquantitative estimates of nailfold capillary abnormalities in scleroderma spectrum disorders. Microvasc Res 1986;32(2):271–6.
[8] Cutolo M, Sulli A, Pizzorni C, Accardo S. Nailfold videocapillaroscopy assessment of microvascular damage in systemic sclerosis. J Rheumatol 2000;27(1):155–60.
[9] Lonzetti LS, Joyal F, Raynauld JP, Roussin A, Goulet JR, Rich E, et al. Updating the American College of Rheumatology preliminary classification criteria for systemic sclerosis: addition of severe nailfold capillaroscopy abnormalities markedly increases the sensitivity for limited scleroderma. Arthritis Rheum 2001;44(3):735–6.
[10] Barnett AJ, Miller MH, Littlejohn GO. A survival study of patients with scleroderma diagnosed over 30 years (1953-1983): the value of a simple cutaneous classification in the early stages of the disease. J Rheumatol 1988;15(2):276–83.
[11] Smith V, Pizzorni C, De Keyser F, Decuman S, Van Praet JT, Deschepper E, et al. Reliability of the qualitative and semiquantitative nailfold videocapillaroscopy assessment in a systemic sclerosis cohort: a two-centre study. Ann Rheum Dis 2010;69(6):1092–6.
[12] Gutierrez M, Bertolazzi C, Tardella M, Becciolini A, M DIC, Dottori M, et al. Interreader reliability in assessment of nailfold capillary abnormalities by beginners: pilot study of an intensive videocapillaroscopy training program. J Rheumatol 2012;39(6):1248–55.
[13] Boulon C, Devos S, Mangin M, Decamps-Le Chevoir J, Senet P, Lazareth I, et al. Reproducibility of capillaroscopic classifications of systemic sclerosis: results from the SCLEROCAP study. Rheumatology (Oxford) 2017;56(10):1713–20.
[14] Light RJ. Measures of response agreement for qualitative data - some generalizations and alternatives. Psychol Bull 1971;76(5):365.
[15] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33(1):159–74.
[16] Cutolo M, Melsens K, Herrick AL, Foeldvari I, Deschepper E, De Keyser F, et al. Reliability of simple capillaroscopic definitions in describing capillary morphology in rheumatic diseases. Rheumatology (Oxford) 2018;57(4):757–9.
[17] Cutolo M, Smith V. Nailfold capillaroscopy and other methods to assess the microvasculopathy in systemic sclerosis. Third EULAR on-line course on systemic sclerosis. Third2013. p. 129–38. internet. September 2013-June 2014.
[18] Smith V, Beeckman S, Herrick AL, Decuman S, Deschepper E, De Keyser F, et al. An EULAR study group pilot study on reliability of simple capillaroscopic definitions to describe capillary morphology in rheumatic diseases. Rheumatology (Oxford) 2016;55(5):883–90.
[19] Ingegnoli F, Gualtierotti R, Lubatti C, Zahalkova L, Meani L, Boracchi P, et al. Feasibility of different capillaroscopic measures for identifying nailfold microvascular alterations. Seminars Arthritis Rheum 2009;38(4):289–95.
[20] Hudson M, Masetto A, Steele R, Arthurs E, Baron M. Canadian scleroderma research G. reliability of widefield capillary microscopy to measure nailfold capillary density in systemic sclerosis. Clin Exp Rheumatol 2010;28(5):S36–41. Suppl 62.
[21] Hofstee HM, Serne EH, Roberts C, Hesselstrand R, Scheja A, Moore TL, et al. A multicentre study on the reliability of qualitative and quantitative nail-fold videocapillaroscopy assessment. Rheumatology (Oxford) 2012;51(4):749–55.
[22] Sekiyama JY, Camargo CZ, Eduardo L, Andrade C, Kayser C. Reliability of widefield nailfold capillaroscopy and video capillaroscopy in the assessment of patients with Raynaud's phenomenon. Arthritis Care Res 2013;65(11):1853–61.
[23] Dinsdale G, Moore T, O'Leary N, Berks M, Roberts C, Manning J, et al. Quantitative outcome measures for systemic sclerosis-related microangiopathy - reliability of image acquisition in Nailfold Capillaroscopy. Microvasc Res 2017;113:56–9.
[24] Dinsdale G, Moore T, O'Leary N, Tresadern P, Berks M, Roberts C, et al. Intra-and inter-observer reliability of nailfold videocapillaroscopy - a possible outcome measure for systemic sclerosis-related microangiopathy. Microvasc Res 2017;112:1–6.
[25] Murray AK, Moore TL, Manning JB, Taylor C, Griffiths CE, Herrick AL. Noninvasive imaging techniques in the assessment of scleroderma spectrum disorders. Arthritis Rheum 2009;61(8):1103–11.
[26] Maricq HR, Harper FE, Khan MM, Tan EM, LeRoy EC. Microvascular abnormalities as possible predictors of disease subsets in Raynaud phenomenon and early connective tissue disease. Clin Exp Rheumatol 1983;1(3):195–205.