Reading nailfold capillaroscopic images in systemic sclerosis: manual and/or automated detection?

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This editorial refers to 'Vision Transformer assisting rheumatologists in screening for capillaroscopy changes in systemic sclerosis: an artificial intelligence model' by Garaiman et al., Rheumatology [in press].

A new artificial intelligence model tested on capillaroscopic images in systemic sclerosis

In the field of nailfold capillaroscopy (NFC) image analysis, Garaiman et al. have realized an interesting investigation to implement and assess the performance and reliability of a vision transformer (ViT)-based deep-learning model, ("off-the-shelf" artificial intelligence solution), in order to identify distinct signs of microangiopathy in already diagnosed patients with systemic sclerosis (SSc) [1]. The Authors conclude that ViT is a modern, well-performing and readily available solution to assess patterns of microangiopathy on NFC images, and the system that may serve as an assistive tool in supporting rheumatologists in generating consistent and high-quality NFC reports, nevertheless, the diagnosis of a scleroderma pattern in any case needs the final observer's evaluation.

Advantages and limitations from the previous systems of automated reading of nailfold capillaroscopic images

As matter of fact, from almost a decade, besides several semi-automated or automated systems have been developed mainly for aiding the detection of altered capillaries (abnormal shapes), useful for the early diagnosis of SSc, during the NFC image analysis also recently fast and reliable visual algorithms exist to reliably discern scleroderma patterns from non-scleroderma patterns, merely on visual inspection. An exceptional reliability of novices versus the golden standard has been attested by this simple, non-expensive and fast algorithm (mean cohen kappa of novices of 0.98 and light kappa of 0.95) after a mere training of 30 minutes [1,2].

However, despite a general usefulness in distinguishing normal from abnormal capillary shapes and their numerosity, some of these systems are excessively time consuming to use.
In addition, as the capillary density (number of capillaries per field) is today regarded as the most important parameter in nailfold microvascular analysis, several different automated approaches have been proposed to quickly assess capillary density, including a fully automated software for measuring the absolute nailfold capillary number in SSc NFC images (per linear millimeter) in a few seconds [3-5]. Surely, from a clinical and research perspective, it seems evident that automated capillary analysis both qualitative and quantitative, can facilitate support large scale prospective studies using well assessed NFC parameters, that act as microvascular morphological biomarkers of SSc-spectrum disorders [6,7].

Conversely, since in SSc the progressive complexity of NFC changes correlates with disease activity and severity, as well the morphological combined changes are predictive for disease worsening, therefore, the adequate assessment of single NFC images is of great importance, but need to be "embedded" and "addressed" in a more complex qualitative and quantitative

process of evaluation that mean their contribution to the assessment of validated progressive NFC patterns [7,8].

On the other hand, the presence of specific NFC abnormalities, need the complex evaluation of an expert reader, for example in order to distinguish the single SSc patterns ("Early", "Active", "Late") within the scleroderma pattern or individuate a scleroderma-like pattern, like in dermatomyositis and some overlap connective tissue diseases [7]. Of note, recently a worldwide study standardised nailfold capillaroscopy in children with rheumatic diseases and in particular was found that the NFC-assessment in juvenile rheumatic and musculoskeletal diseases differed significantly from healthy controls [9].

The performances of the VIT testing on nailfold capillaroscopic images

Certainly, the ViT study was managed very carefully and results were found significant, especially in term of recognition of specific single NFC abnormalities in SSc (ie. Giant capillaries, microhaemorrhages, loss of capillaries) (Fig.1). Less convincing seems the possibility for the ViT to identify and distinguish all the different /single NFC SSc patterns (namely: "Early", "Active" and "Late"), even if the ViT was able to identify the main/generic scleroderma pattern, that was distinguishable from a "non-scleroderma pattern" [2]. In particular, the NFC "images" of the abnormal shapes linked to the microvascular angiogenesis, that mainly characterize the "Late" NFC SSc pattern, were not introduced in the ViT reading system, and therefore made impossible to detect this "Late" pattern by ViT itself. We remind that the "Late" SSc pattern is characterised by no giant capillaries, presence of capillary dilations, < 3 capillaries/mm, no microhemorrhages, BUT intensive presence of angiogenesis [1] (Fig.1).

A limitation of the ViT testing on NFC images, as the Authors also underlined, is that the cohort of SSc patients evaluated could not be enriched with healthy controls or with patients with primary Raynaud's phenomenon for technical reasons, but this might be easily done in a second time. On the other hand, the Authors used NFC images arising from different sources (centers) and they included all images available, irrespective of any image artefacts, but given the good performance on the unfiltered images, the ViT was possibly found an efficient solution to deal even with image artefacts [1,8].

Meanwhile, in the reliability set, the expert rheumatologists involved in this study reached higher average accuracy in reading the NFC images, as well as was reached a better tradeoff between sensitivity and specificity compared to ViT. The Authors reported overall, that the rheumatologists' accuracy was higher than ViT's, (ranging between 80% and 100%), however the accuracy of ViT did not drop under 81%. As matter of fact, Garaiman et al. underline that the final diagnosis of a scleroderma pattern needs the final observer's experience and judgement [1].

In other words, the issue still that the complex final reading and assembly of the NVC images (based on several morphological and/or numerical parameters) in order to define a single scleroderma pattern (namely: “Early”, “Active” or “Late”), even if based on algorythms, cannot be achieved without the final intervention of the expert. Another recent study, mentioned by the Authors and using a convolutional neural network/RetinaNet solution, revealed similar sensibility and specificity in just predicting single parameters of the scleroderma patterns; namely enlarged capillaries, giant capillaries and microhemorrhages, but not specific NFC SSc patterns were detectable (10). New investigations are dealing with the important target to combine in an automated system, both NFC images with local blood flow at the same time and in the same area (morphology and function together), as recently proposed, but limited to normal individuals and requiring a validation in pathological cases [6,7,11].

Conclusion

In conclusion, the ViT it is welcome and seems to represent a further valid system for an early and fast reading of the NFC images/morphological biomarkers in SSc, reaching for the first time the fusion of EULAR validated algorythms for the delineation of the scleroderma pattern from the non-scleroderma pattern and the artificial intelligence. However, similarly to what is advised for other automated and integrated diagnostic systems, always exposed to biological/clinical interindividual complexity and variability, a final human expert intervention in order to confirm the automated reading, to define detailed SSc patterns and to finalize the diagnosis, should be warranted also in this case. Along with this vision, the Authors in their key messages suggest that ViT might easily assist rheumatologists in screening for NFC changes and generating reliable reports.

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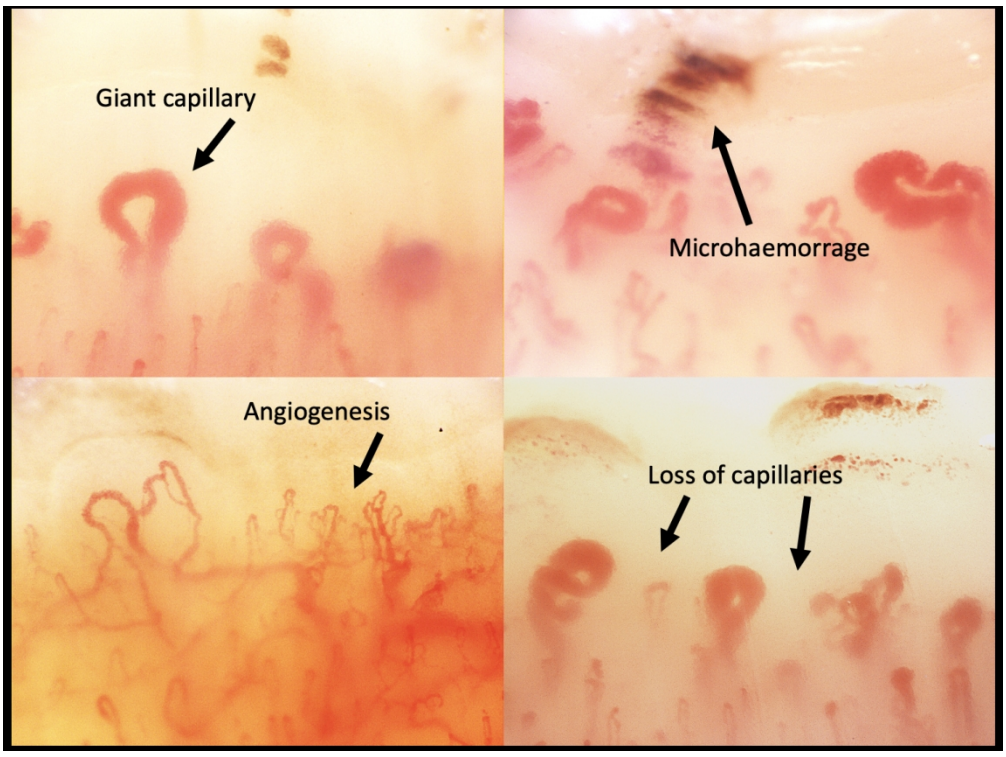
Figure 1. Nailfold capillaroscopy images showing typical microvascular abnormalities. Nailfold capillaroscopy images (NFC magnification 200X) showing typical microvascular abnormalities, namely giant capillaries, microhaemorrhages, angiogenesis and loss of capillaries, that with different combinations, during the progression of systemic sclerosis (SSc), are qualitatively classified as SSc-patterns ("Early", "Active", "Late").



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