Tracking digital ulcers in systemic sclerosis – a feasibility study assessing lesion area in patient-recorded smartphone photographs

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Key message: Patient-recorded photographs of digital ulcers are feasible, and photographic measurements may help monitor healing.

Author contribution statement:

GD responsible for study design, data collection, data analysis, and editing and approval of manuscript.

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All authors declare no conflicts of interest.

Sir,

Systemic sclerosis (SSc)-related digital ulcers (DU) are painful, and disabling[1-3], and digital ulcer burden is often the primary outcome measure in clinical trials of SSc-related digital vasculopathy[4]. This is despite several studies showing a lack of agreement between rheumatologists as to what constitutes a DU[5-8].

Objective outcome measures of SSc-related DUs for tracking change over time are therefore urgently required for clinical practice and research studies. The application of digital planimetry to clinical DU photographs has shown the possibility of fine-grained measurement of DU characteristics (area)[9]. Our aims were to: (1) demonstrate the feasibility of patients with SSc-related DUs/digital lesions photographing their lesions using smartphone cameras, and (2) use digital planimetry-style software analysis on images collected from patients to measure and track lesion area as a marker of healing or progression.

Patients with SSc-related digital lesions (judged to be ulcers by an experienced clinician) were asked to photograph their lesion(s) daily, using their own smartphone, for a maximum of 35 days. All patients gave written, informed consent. All patients were taking vasodilators, and 1 was on immunosuppressant therapy (methotrexate). The patients received normal clinical wound care throughout the study period, after which images were collected in-person, and stored securely for further analysis (see Figure 1 for examples).

Time and date stamps were extracted for each patient image sequence to accurately describe chronology. Images were loaded into custom digital planimetry software[9] and initially calibrated using a fixed-size object (often the finger width) to allow comparison between images in the sequence. For each image, the lesion area was measured by fitting an elliptical shape to the outline of the lesion by a single observer (Figure 1). Using the calibration information, areas from each image were finally normalised to the area measured in the first image in the sequence.

Image sequences were collected from four patients describing a total of seven lesions (one patient with three lesions, one patient with two lesions, two patients with one lesion). The median (range) sequence duration was 29 (13-35) days, and for number of images recorded/day 0.63 (0.31-1.00). The relative area time course for each lesion is shown in Figure 2. On average, lesion areas had, by study's end, reduced to 56% of the area measured on day 1, with six out of seven lesions reducing in size over the time course.

This pilot study confirms that it is feasible for patients to monitor their own lesions over an extended period (weeks) by taking photographs with their smartphone camera. Photographs were taken on approximately 2 out of every 3 days during the study period, suggesting patients were highly engaged in the process. Collected photographs were of analysable quality.

This study therefore suggests a potential new tool for monitoring of lesion status/healing, both in the clinical setting, and as an outcome measure in clinical trials of SSc-related digital vasculopathy. Further work involving larger numbers of patients is now required to validate measurements produced, and to improve data collection by integrating imaging into a smartphone application.

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References

1. Amanzi L, Braschi F, Fiori G, et al. Digital ulcers in scleroderma: staging, characteristics and sub-setting through observation of 1614 digital lesions. *Rheumatology (Oxford)* 2010;49(7):1374-82.
2. Matucci-Cerinic M, Krieg T, Guillevin L, et al. Elucidating the burden of recurrent and chronic digital ulcers in systemic sclerosis: long-term results from the DUO Registry. *Ann Rheum Dis* 2016;75(10):1770-6.
3. Hughes M, Herrick AL. Digital ulcers in systemic sclerosis. *Rheumatology (Oxford)* 2017;56(1):14-25.
4. Galluccio F, Allanore Y, Czirjak L, et al. Points to consider for skin ulcers in systemic sclerosis. *Rheumatology* 2017;56(suppl_5):v67-v71.
5. Herrick AL, Roberts C, Tracey A, et al. Lack of agreement between rheumatologists in defining digital ulceration in systemic sclerosis. *Arthritis Rheum* 2009;60(3):878–82.
6. Baron M, Chung L, Gyger G, et al. Consensus opinion of a North American Working Group regarding the classification of digital ulcers in systemic sclerosis. *Clin Rheumatol* 2014;33(2):207–14.
7. Hughes M, Roberts C, Tracey A, et al. Does the clinical context improve the reliability of rheumatologists grading digital ulcers in systemic sclerosis? *Arthrit Care Res* 2016;68(9):1340-5.
8. Suliman YA, Bruni C, Johnson SR, et al. Defining skin ulcers in systemic sclerosis: systematic literature review and proposed World Scleroderma Foundation (WSF) definition. *J Scleroderma Relat Disord* 2017;2(2):115-120.
9. Simpson V, Hughes M, Wilkinson J, et al. Quantifying digital ulcers in systemic sclerosis: Reliability of digital planimetry in measuring lesion size. *Arthrit Care Res* 2017;Jun2:doi: 10.1002/acr.23300. [Epub ahead of print].

Figure legends

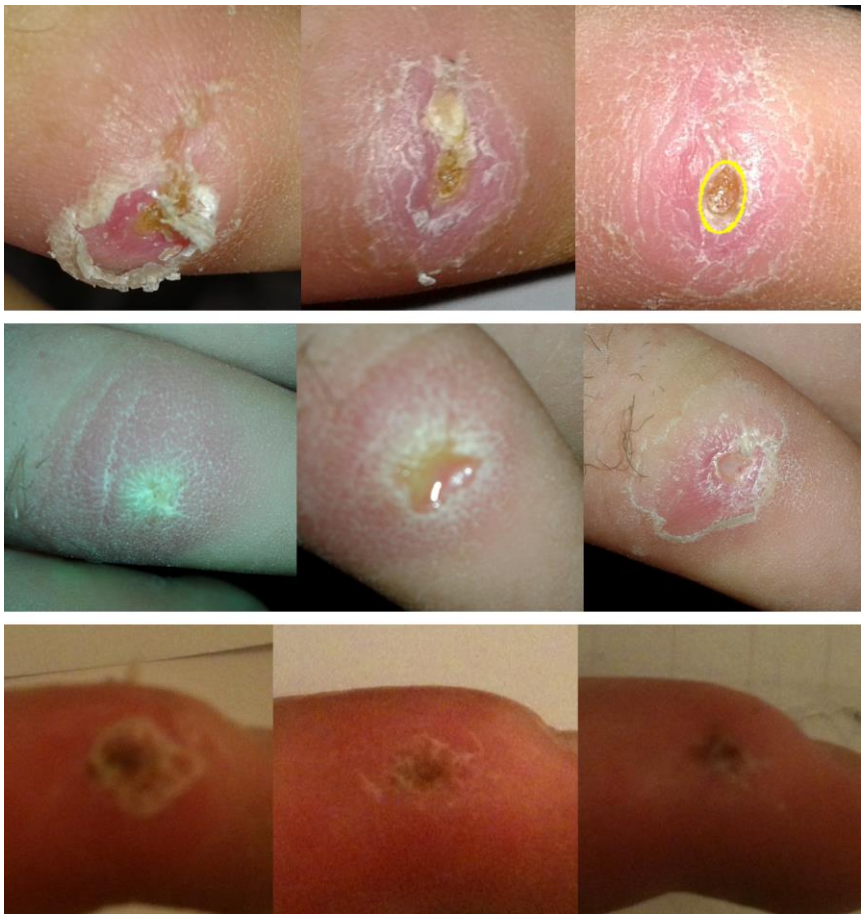

Figure 1. Selected examples of DU/lesion images taken from 3 sequences. Sequences demonstrate the varying quality of images captured by patients (particularly the bottom sequence where there are focus issues), although all were acceptable for further quantitative analysis. Top (L to R): days 1, 24, and 35; Middle (L to R): days 1, 4, and 12; Bottom (L to R): days 2, 7 and 18. Lesions are represented by sequences 4, 5 and 6 in Figure 2 (top to bottom respectively). Top right image includes example of fitted ellipse shape (yellow outline) from software analysis.

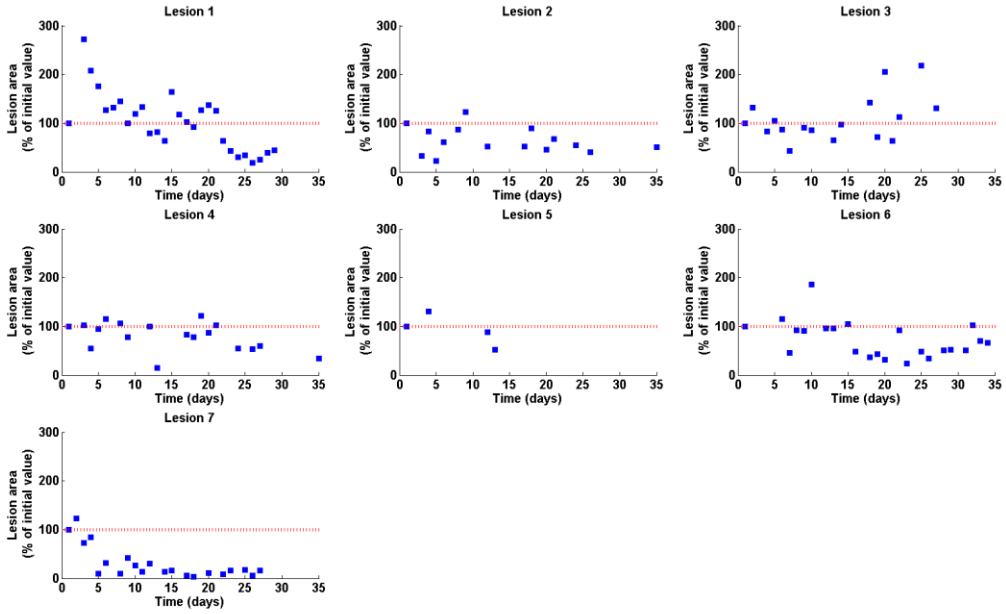

Figure 2. Relative area time course plots for each of 7 digital lesions. Dashed red lines indicate 100% area, relative to the area measured on day 1. Lesion areas all reduced except for lesion 3 (top right).