MHEALTH TOOL FOR SELF-ASSESSMENT OF DIGITAL ULCERS
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Introduction
Digital ulcers (DU) are visible manifestation of vascular diseases in systemic sclerosis (SSC) that often appear on fingertips and bony area [Botzoritis et al., 2011]. DU are associated with exceptional pain, which influences the hand function of patients and their quality of life [Hughes et al., 2017]. DUs are slow to heal and often associated with bone infection [Botzoriset et al., 2011]. Periodic wound measurement and documentation are important to monitor wound progression and healing [Wang et al., 2017]. Current DU assessment is hospital based, which limits patients living far away from visiting the hospital regularly, and there are few standardization to take high quality DU images. Our aim was to develop a mobile health (mHealth) tool to enable SSC patients to take standardized and high-quality pictures of their DU at home with the goal of enabling remote DU assessment.

Methods
To assist SSC patients in imaging their own DU with a mobile phone with high repeatability, we developed a custom imaging app and a smartphone holder. The app featured a login, picture taking with automated colour correction to standardize colours, and secure upload to a data base.

The top plate of the smartphone holder is to hold a mobile phone to take finger pictures from the top. The bottom plate where the finger is placed features two rulers to guide finger alignment and a custom colour checker (Figure 1).

Figure 1. The developed smartphone holder

Results
We applied our developed mHealth tool to take finger pictures on dorsal, lateral, palmar and fingertip under the normal ambient light condition (Figure 2). The ruler and colour checker assisted to align the fingers, and the hole on the bottom plate allowed to insert the fingertips. The smartphone holder was stable and able to take repetitive finger pictures. The fingers and colour checker were clearly recognizable for colour correction and post processing. However, there were shadows appeared on the images (Figure 2c, 2d) which may influence the image quality.

Figure 2. Finger images taken on the developed smartphone holder from one subject. a) dorsal, b) lateral, c) palmar, and d) fingertip image.

Discussion
We developed a tool to acquire finger pictures in a standardized way for patient self-assessment of high quality DU images. Placing the fingers underneath the camera is repeatable. However, the analysis of the images showed that the use of ambient lighting may compromise the picture quality. Shadows and over/under-exposed regions may not benefit from the colour correction and negatively affect the overall image analysis. We consider integrating an additional light source that can illuminate the finger and the colour checker homogeneously with diffuse light. To produce the smartphone holder in a large scale, we consider laser cutting as more cost effective.

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References
Hughes et al., Rheumatology, 56(1), 14–25, 2017
Wang et al., PLoS ONE, 12(8), 2017