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Objective foot ulcer documentation using 3-D shape analysis: a feasibility study

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Introduction

In treating the condition of a diabetic foot with ulcerations need for objective documentation of wound site and wound size is obvious.

There is to our present knowledge no objective method available to document the exact localization of an ulceration with accuracy beyond anatomical description and photographic documentation. In measuring ulcer size, i.e. diameter, area, depth and volume stereoscopic measurement is widely accepted as a most reliable and precise technique [1]. However, it demands for highly skilled computer assisted evaluation making it time consuming and impractical for routine use in clinical practice.

It was the aim of the present study to explore the potential of an automatized evaluation of 3-D measurements of ulcerations of the foot. This should include following steps:

• 3-D data capture of the ulceration and the foot.

• automatized 3-D evaluation of the 3-D data for detection of the wound edges:

• localization of the wound with respect to anatomical landmarks of the foot

3-D measurement of the foot and establishing a reference system based on anatomical landmarks has been described elsewhere [2].

Here the second step is of special interest. Shape analysis based on differential geometriy is used to detect wound edges.

Methods

In a patient with foot ulceration in total 10 3-D scans of the foot have been performed in regular intervals spanning 30 days. Scanning was done with a FastSCAN laser scanner providing after smoothing about 40 points/cm^2 with a statistical error of 0.02 mm. One special localization of the wand relative to the transmitter was recorded, to use it for the calculation of a virtual image of the calculated wound edge to be overlaid to the true photo of the wound taken from that position [3].

Calculation of the edges is based on analysis of the sum ('mean curvature') and difference ('rim curvature') of the principal curvatures. This allows to calculate a geometric line modelling the wound edge, which can be compared directly with the photographically documented wound edge.

Results

Fig. 1 shows an example of a comparison between a wound photo and the curvature map revealing the wound edges.

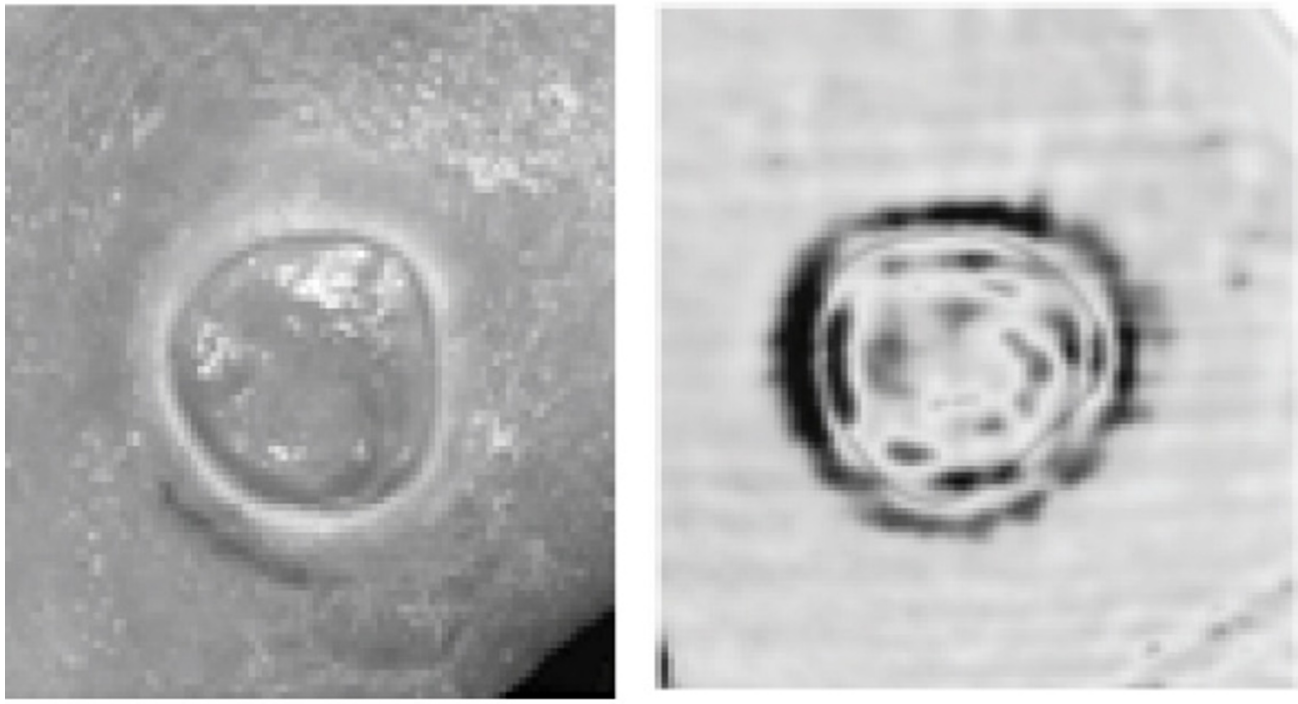

Figure 1
left: wound photo; right: curvature map (difference of principal curvatures) with an automatically generated closed line to model the wound edge.

Evaluation of 3-D measurement in sequence shows the applicability of this concept for a quantitative documentation of wound size, area and volume.

Conclusion

Use of curvature analysis appears to be a valuable tool in the automatic assessment of wounds. It probably works best together with other techniques, e.g. evaluating the texture.

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