Near-infrared Optical Imaging and Wound Segmentation in Lower Extremity Ulcers

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Abstract

Near-infrared (NIR) optical imaging can reveal tissue oxygenation of the wound, complementing the visual inspection of the surface granulation. Herein, graph cuts algorithm is applied to segment NIR images of the wound from its peripheries.

Background

Lower extremity ulcers are the most common complications which have affected millions of people over past few years.

• Wound healing process involves a complex series of stages.
• Stages - Bleeding, Inflammatory, Proliferative, & Remodeling
• Healing wounds: Undergo all stages.
• Non-Healing wounds: Usually halt at inflammatory phase.

To date, clinicians employ visual inspection of wounds. However, there is no objective assessment clinically available.

Introduction

• There is a need for an objective imaging tool for assessing wound healing.
• Over the past years, a near-infrared optical scanner (NIROS) has been developed for non-contact sub-surface imaging of wounds.
• Preliminary in-vivo investigations demonstrated the differences in optical contrast of a healing from a non-healing wound.
• There is a need to demarcate wound area across which optical contrast is observed (in terms of oxy- & deoxy-hemoglobin concentration levels).
• To automatically segment the internal wound regions in NIR images, an NIR wound segmentation system consisting of image preprocessing, automatic segmentation and performance evaluation has been developed.

Near-infrared Optical Scanner (NIROS)

Instrumentation

• Diffuse reflectance imaging using NIR
• Non-contact surface imaging: 35 cm³
• Source : 830nm LED (<50mW)
• Detector: NIR CMOS sensor
• CW imaging
• Size : 5.7 x 7 x 15 cm³
• Weight <1 lb.
• Operation: USB powered
• Automation of data acquisition and processing on MATLAB GUI

Subject recruitment

• IRB approved study.
• Subjects were recruited from 2 local clinics in Miami: Podiatry Care Partners Inc.
• Wigley Foot and Ankle LLC.
• A total of 9 healing/non-healing lower extremity ulcers (6 healing wounds & 3 non-healing wounds)
• Diabetic patients between the ages of 41-78 years

NIROS – Past Work

Raw NIR image

Optical Contrasts

Venous Leg ulcer

Diabetic foot ulcer

A positive optical contrast

Venous Leg ulcer

Sensitivity 92.4 %

Specificity 97.9 %

A negative optical contrast

Non-healing wound

Diabetic foot ulcer

Healing wound

Calibration ratio

Background noise removal

Raw NIR image

Segmentation of Raw NIR image

Segmentation of NIR image after removal

Reflected light from homogenous white sheet

Gaussian model of reflected light

Noise from reflected light

Non-healing bilateral venous leg ulcer

Calibration ratio

Background noise removal

Background Noise Removal

Non-healing wound

Sample data - Co-registration study

Sample data - Venous leg ulcer

Healing

Venous Leg ulcer

Region with changes in blood flow from wound to normal tissue is larger than visual wound size itself.

- Potentially greater area below the wound has blood flow differences.

Co-registration of the segmented NIR images onto the white light images.

Modify NIROS for Hemodynamic imaging of wound.

To monitor healing rate over weekly imaging in terms of oxy & deoxy hemoglobin concentration

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