Non-invasive monitoring of skin restoration by line-field confocal optical coherence tomography in an experimentally induced superficial wound model

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INTRODUCTION & OBJECTIVES

Line-field confocal optical coherence tomography (LC-OCT) is a recently introduced non-invasive in vivo method for visualizing skin components and structures with a formerly not achievable resolution of approx. 1 µm reaching into the skin to a depth up to approx. 500 µm (1). LC-OCT allows digital imaging of the epidermis and superficial dermal skin layers. It was our aim to evaluate LC-OCT for an objective and quantitative evaluation of the wound healing process with a special focus on a structural restoration process of the epidermis.

MATERIALS & METHODS

Superficial wounds were induced in healthy volunteers by suction blisters with consecutive removal of the blister roof directly after procedure, first described by Kiistala and Mustakallio in 1967(2) modified by us in 2016 (3). Directly after wound induction a transparent film dressing was placed over the open wound for 5 days to prevent bacterial contamination. Wound healing was then documented by LC-OCT in defined intervals for up to day 35.

RESULTS

Directly after removal of the blister roof the sharp demarcation of the wound area and the intact skin is clearly detectable.

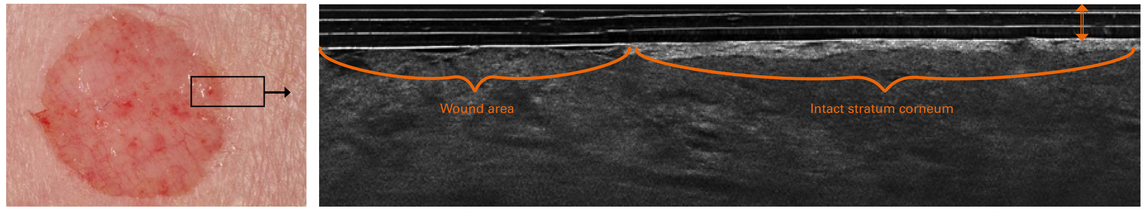

Fig 1: Day 1 directly after wound induction, clinical (left) and LC-OCT (right) imaging of the open wound and the the adjacent intact skin (the rectangle shows the approximate image section of the LC-OCT imaging, the ↕ indicates the transparent film dressing).

On day 7, following superficial wound induction by suction blister, a thin wound membrane was seen on LC-OCT images, combined with epidermal edema and clearly enlarged epidermal cells ( ).

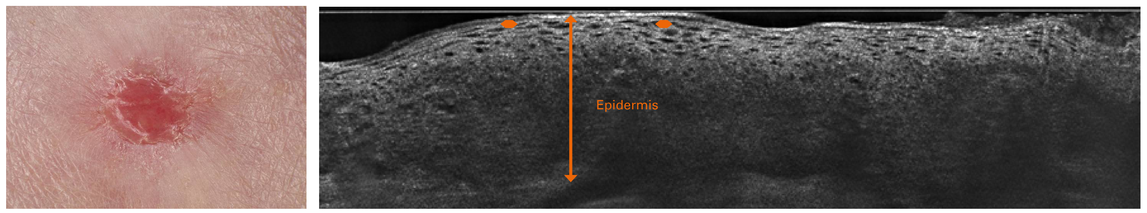

Fig 2: Day 7 after wound induction (left clinical image and right LC-OCT imaging of a section of the wound area).

On day 14, all layers of the epidermis are rebuilt in full thickness except the stratum corneum. Epidermal swelling is less pronounced. Enlarged blood vessels are seen (▲), and keratinization can be seen on the skin surface.

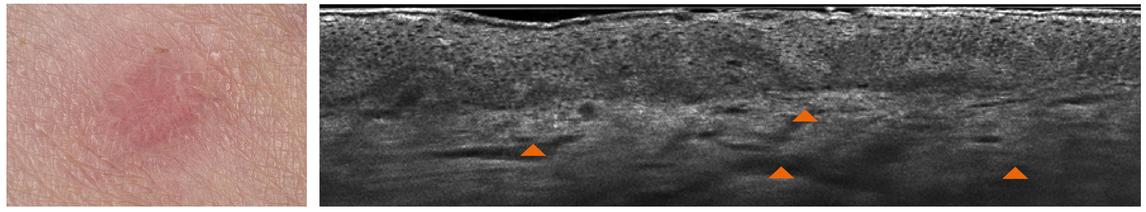

Fig 3: Day 14 after wound induction (left clinical image and right LC-OCT image of a section of the original open wound area).

Complete wound healing was achieved on day 28 with a complete restoration of the stratum corneum. However, blood vessels are still enlarged (▲), also clinically visible by a slight reddening of the skin. The surface of the wound is remarkably uneven(LC-OCT imaging).

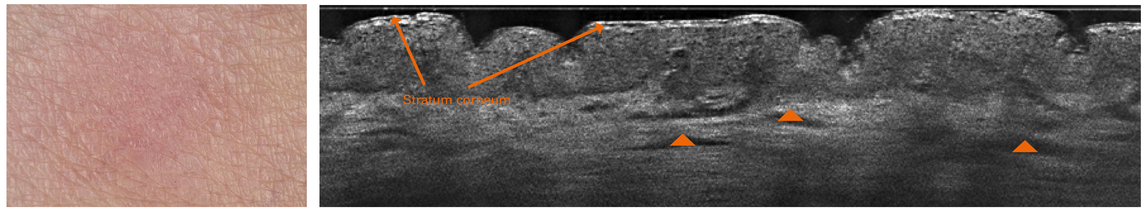

Fig 4: Day 28 after wound induction (left clinical image and right LC-OCT imaging of a section of the original open wound).

Enlarged blood vessels, increased blood-flow of the upper dermal plexus was fading after day 28 and had mainly ceased on day 35.

CONCLUSION

Our results demonstrate that epidermal structures and their modifications in the wound healing process can be visualized in detail by the noninvasive optical technique of LC-OCT. LC-OCT further provides objective parameters for wound closure with visualization of wound healing processes which are not accessible for clinical methods or devices that lack single cell resolution as the conventional OCT. Skin barrier restoration can be objectively monitored by LC-OCT by measuring epidermal thickness, assessing the composition of cells and fibrin structures, as well as the vasodilation of blood vessels and thus providing a better understanding of the different stages of wound healing. LC-OCT represents an excellent and objective noninvasive method in real time, offering a wide range of potential applications in clinical trials.

REFERENCES

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CONFLICT OF INTEREST: None for this presentation