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Optical Coherence Tomography in Differentiation of Acute and Non-Healing Wounds

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Abstract : Application of optical technology in medicine and biology has a long track-record. In this endeavor, OCT is able to attract both engineers and biologists to work together in the field of photonics for establishing a striking non-invasive imaging technology. In contrast to other in vivo imaging modalities like Raman imaging, confocal imaging, two-photon microscopy etc. which can perform in vivo imaging upto 100-200 micron depth due to limitation in numerical aperture or scattering, however, OCT can achieve high-resolution imaging upto few millimeters of tissue structures depending on their refractive index in different anatomical location. This tomographic system depends on interference of two light waves in an interferometer to produce a depth profile of specimen. In wound healing, frequent collection of biopsies for follow-up of repair process could be avoided by such imaging technique. Real time skin OCT (the optical biopsy) has efficacy in deeper and faster illumination of cutaneou tissue to acquire high resolution cross sectional images of their internal micro-structure. Swept Source-OCT (SS-OCT), a novel imaging technique, can generate high-speed depth profile (~ 2 mm) of wound at a sweeping rate of laser with micron level resolution and optimum coherent length of 5-6 mm. Normally multi-layered skin tissue depicts different optical properties along with variation in thickness, refractive index and composition (i.e. keratine layer, water, fat etc.) according to their anatomical location. For instance, stratum corneum, the upper-most and relatively dehydrated layer of epidermis reflects more light and produces more lucid and a sharp demarcation line with rest of the hydrated epidermal region. During wound healing or regeneration, optical properties of cutaneous tissue continuously altered with maturation of wound bed. More mature and less hydrated tissue component reflects more light and becomes visible as a brighter area in comparison to immature region which content higher amount water or fat that depicts as a darker area in OCT image. Non-healing wound possess prolonged inflammation and inhibits nascent proliferative stage. Accumulation of necrotic tissues also prevents the repair of non-healing wounds. Due to high resolution and potentiality to reflect the compositional aspects of tissues in terms of their optical properties, this tomographic method may facilitate in differentiating non-healing and acute wounds in addition to clinical observations. Non-invasive OCT offers better insight regarding specific biological status of tissue in health and pathological conditions, OCT images could be associated with histo-pathological ‘gold standard’. This correlated SS-OCT and microscopic evaluation of the wound edges can provide information regarding progressive healing and maturation of the epithelial components. In the context of searching analogy between two different imaging modalities, their relative performances in imaging of healing bed were estimated for probing an alternative approach. Present study validated utility of SS-OCT in revealing micro-anatomic structure in the healing bed with newer information. Exploring precise correspondence of OCT images features with histo-chemical findings related to epithelial integrity of the regenerated tissue could have great implication. It could establish the ‘optical biopsy’ as a potent non-invasive diagnostic tool for cutaneous pathology.

Keywords : histo-pathology, non invasive imaging, OCT, wound healing
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