

Monitoring of Wound Healing Through Structural and Functional Mechanisms Using Photoacoustic Imaging Modality

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Abstract : Traumatic injury is the leading worldwide health problem. Annually, millions of surgical wounds are created for the sake of routine medical care. The healing of these unintended injuries is always monitored based on visual inspection. The maximal restoration of tissue functionality remains a significant concern of clinical care. Although minor injuries heal well with proper care and medical treatment, large injuries negatively influence various factors (vasculature insufficiency, tissue coagulation) and cause poor healing. Demographically, the number of people suffering from severe wounds and impaired healing conditions is burdensome for both human health and the economy. An incomplete understanding of the functional and molecular mechanism of tissue healing often leads to a lack of proper therapies and treatment. Hence, strong and promising medical guidance is necessary for monitoring the tissue regeneration processes. Photoacoustic imaging (PAI), is a non-invasive, hybrid imaging modality that can provide a suitable solution in this regard. Light combined with sound offers structural, functional and molecular information from the higher penetration depth. Therefore, molecular and structural mechanisms of tissue repair will be readily observable in PAI from the superficial layer and in the deep tissue region. Blood vessel formation and its growth is an essential tissue-repairing components. These vessels supply nutrition and oxygen to the cell in the wound region. Angiogenesis (formation of new capillaries from existing blood vessels) contributes to new blood vessel formation during tissue repair. The betterment of tissue healing directly depends on angiogenesis. Other optical microscopy techniques can visualize angiogenesis in micron-scale penetration depth but are unable to provide deep tissue information. PAI overcomes this barrier due to its unique capability. It is ideally suited for deep tissue imaging and provides the rich optical contrast generated by hemoglobin in blood vessels. Hence, an early angiogenesis detection method provided by PAI leads to monitoring the medical treatment of the wound. Along with functional property, mechanical property also plays a key role in tissue regeneration. The wound heals through a dynamic series of physiological events like coagulation, granulation tissue formation, and extracellular matrix (ECM) remodeling. Therefore tissue elasticity changes, can be identified using non-contact photoacoustic elastography (PAE). In a nutshell, angiogenesis and biomechanical properties are both critical parameters for tissue healing and these can be characterized in a single imaging modality (PAI).

Keywords : PAT, wound healing, tissue coagulation, angiogenesis

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