Sound speed and attenuation mapping of collagen in skin tissue due to light damage

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Age related changes have a deleterious impact on the function and structure of human organs such as skin. Collagen plays a crucial role providing elastic and mechanical strength to human skin and as the main building block of the human body, it is important to be able to characterize collagens properties and ageing state with a minimally invasive method.

Mechanical properties of living tissues and cells like elasticity, viscosity and density directly associate with cell function. One efficient method for evaluation living tissue's mechanical properties is based on Scanning acoustic microscopy (SAM) which allows non-invasive qualitative and quantitative evaluation of tissue stiffness without significant tissue preparation or damage.

A new quantitative high-resolution imaging approach using SAM is proposed to micro map tissue elasticity in skin.

Porcine skin models were used to evaluate the extent of dermal collagen degradation post radiation using an Intense Pulse Light (IPL). Biopsies from back-neck folds of a 4-week-old, 25 kg white pig were irradiated at increasing radiation doses of 40 J/cm^2 once, thrice and ten times (λ= 584 nm). Samples were then cryo-sectioned at a thickness of 10 μm.

Ex-vivo biopsies were assessed with scanning acoustic microscope (Honda AMS-50SI equipped with 320MHz focused transducer), polarized light microscopy and atomic force microscopy (AFM). Customized software was developed for micro-mapping the sound speed and attenuation on the SAM images.

Both polarized light, AFM and qualitative SAM images indicated that collagen fibres degrade depth wise into the reticular dermis. At maximum irradiation, loss of banding and gelatinisation was observed. As seen in Fig. 1. sound attenuation decreases with higher exposure. Damaged collagen demonstrated much lower sound speed and attenuation compared to healthy controls. Sound speed decreases at much faster rates than the attenuation.

The ability of ultrasound to visualize and quantitatively measure biological processes in the tissue beckons the method to a molecular level diagnostic device. A combination of both sound speed and attenuation along with tissue and cells morphology significantly contribute to diagnostic imaging and can be a valid biomarker assessment of collagen alignment and health which leads to ageing and inflammatory processes.

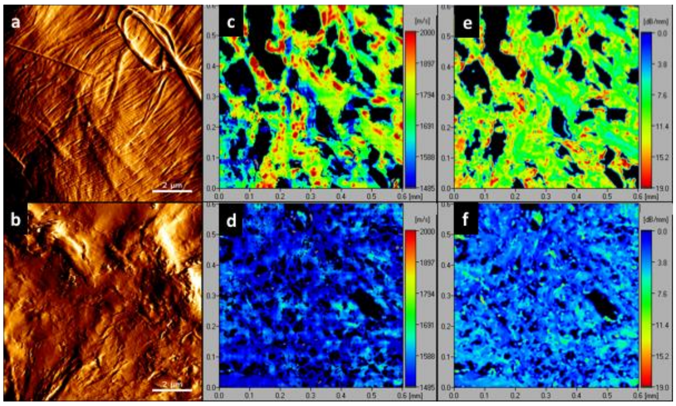

Fig. 1. AFM and SAM images of 40 J/cm^2 IPL irradiation of porcine papillary dermis. (a) and (b) AFM images of control and 40 J/cm^{2}x10 dose. Loss of banding and gelatinization in (b) is observed. (c),(d) and (e),(f) SAM attenuation and sound speed images respectively where (c) and (e) are of a control and (d)(f) are of 40 J/cm^{2}x10 dose. Clear decreasing differences in measurements of sound speed and attenuation are evident.