PHOTOACOUSTIC IMAGING AS A POTENTIAL TOOL FOR CLINICAL EVALUATION OF INFLAMMATORY ARTHRITIS

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Key Words: Photoacoustic imaging, inflammation, arthritis, biomarker, diagnosis.

Presenting highly sensitive and clinically relevant functional information from soft tissues in and around the joint with spatial resolution comparable to ultrasound (US) imaging, photoacoustic (PA) imaging may shed new light on early diagnosis and treatment evaluation of human inflammatory arthritis. In this study on severe arthritis patients and healthy control subjects, we explored the potential contribution of PA imaging to rheumatology clinic. The feasibility of a point-of-care device built on a LED based PA imaging system for evaluating human finger joints was also studied.

By performing imaging at a single laser wavelength, the spatially distributed hemoglobin content reflecting the hyperemia in synovial tissue in the finger joints of arthritis patients were imaged. By performing imaging at two laser wavelengths, the spatially distributed hemoglobin oxygenation reflecting the hypoxia in the finger joints of arthritis patients were also imaged. The measurements from the arthritis patients and the healthy controls were statistically analyzed by using two-tailed student t-tests.

The statistical analyses of the imaging results demonstrated significant differences in quantified hemoglobin content and in quantified hemoglobin oxygenation between the arthritis joints and the normal joints. PA imaging is capable of identifying inflammation in human peripheral joints based on the detection of increased hyperemia and increased hypoxia in affected synovium. These two physiological biomarkers of synovitis reflecting the increased metabolic demand and the relatively inadequate oxygen delivery can both be non-invasively evaluated. The results from the LED-based PA imaging system demonstrated satisfactory sensitivity and depth for evaluating the physiological biomarkers in human joints affected by arthritis.
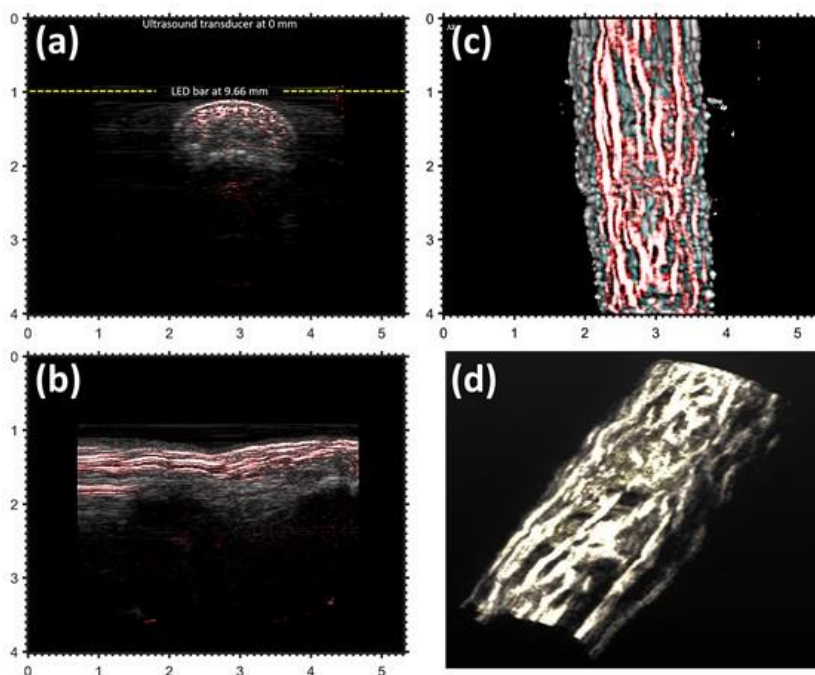
Fig. 1. 3D photoacoustic (PA) and ultrasound (US) dual imaging of a human finger joint. The PA image (in pseudo-color) acquired using a LED-based imaging system is super-imposed on the B-scan US image (in gray-scale) acquired from the same joint. (a)-(c) Display of the imaging result along the axial, the coronal, and the sagittal planes, respectively. (d) 3D rendering of the PA image demonstrating the spatially distributed vasculature in the finger digit.