

Purpose: To explore the potential of photoacoustic tomography (PAT), as an emerging optical imaging technology, for early diagnosis of inflammatory joint disorders and accurate monitoring of disease progression and response to therapy.

Methods: Pulsed laser light in the near-infrared (NIR) region was directed toward a joint with resultant ultrasonic signals recorded and used to reconstruct images that present the optical properties in subsurface joint tissues. The feasibility of this bench-top joint imaging system in delineating soft articular tissue structures in a noninvasive manner was validated first on rat models and then on human peripheral joints harvested from fresh cadavers. Based on the study on a commonly used adjuvant induced arthritis rat model, the capability of PAT to differentiate arthritic joints from the normal was also examined.

Results: With sufficient imaging depth in the NIR region, PAT can realize tomographic imaging of a human or a small-animal joint as a whole organ noninvasively. Based on the optical contrast, various intra- and extra-articular tissues, including skin, fat, muscle, blood vessels, periosteum and bone, were presented successfully in images with satisfactory spatial resolution that was primarily limited by the bandwidth of detected photoacoustic signals rather than by optical diffusion as occurs in traditional optical imaging. In comparison with the images from the normal joints, significant differences were found in the images from the inflammatory joints, including enlarged periosteum diameter and enhanced intra-articular optical absorption.

Conclusions: By presenting additional optical contrast and tissue functional information such as blood volume and blood oxygen saturation, PAI is a natural and promising complement to conventional ultrasound technologies for musculoskeletal imaging. PAT, with its intrinsic advantages, may provide a unique opportunity to enable early diagnosis of inflammatory joint disorders, e.g. rheumatoid arthritis, and to monitor therapeutic outcomes with improved sensitivity and accuracy.