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Noninvasive Temperature Estimation Using Diagnostic Ultrasound: In Vivo Results

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In this paper, we present temperature imaging data obtained before and after HIFU-induced lesions in implanted tumors in the hind limb of nude mice in vivo. The RF data was acquired using a 9 MHz 192-element linear probe on a diagnostic scanner at 90 frames per second. Approximately 2 seconds of frame data was collected before, during and after sub-therapeutic exposures of 0.2 second duration. The frame rates were sufficiently high to capture the effects of local tissue deformation due to breathing and pulsation near blood vessel. Using a physics-based spatial-temporal filtering of tissue displacement, we were able to produce accurate spatial-temporal maps of the temperature change with fine spatial and temporal resolution. These results are in good agreement with directly measured temperatures using fine temperature sensors near the HIFU focal spot. The results show that robust temperature estimation in the presence of tissue motion/deformation is feasible. Applications of this method in measuring the local thermal properties of tissue will be addressed. In particular, tissue absorption can be estimated and it appears to increase by a factor of 2 - 4 after lesion formation.