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**TEMPERATURE MONITORING USING ULTRASOUND AND PHOTOACOUSTIC
IMAGING DURING LASER THERAPY**

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Laser thermal therapy is based on the principle of converting light energy to heat leading to tumor necrosis. During therapy, a near-infrared continuous wave laser is coupled with targeted photoabsorbers to cause localized temperature increase. However, the successful outcome of therapy depends on tracking this temperature rise both spatially and temporally, not only to ensure tumor destruction but also to protect the surrounding healthy tissue. We investigate the potential of using ultrasound and photoacoustic imaging to monitor therapy. Since, temperature rise leads to apparent time shifts in ultrasound echoes and increase in photoacoustic signal amplitude, thermal imaging can be accomplished by measuring the differential motion of speckle and photoacoustic signal amplitude.

Simultaneous ultrasound and photoacoustic imaging was performed using an array-based ultrasound imaging system and a tunable pulsed laser. Laser therapy was carried out on ex-vivo animal tissue injected with gold nanoparticles acting as photoabsorbers. To estimate temperature, apparent time shifts between successive ultrasound frames were calculated using a cross-correlation based motion tracking algorithm. In addition, the change in photoacoustic signal intensity was also tracked to evaluate temperature change. Signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) were used to analyze the quality of ultrasound and photoacoustic thermal images.

Prior to commencing laser therapy, photoacoustic imaging identified the spatial location of injected photoabsorbers in tissue. A localized temperature increase of over 8°C was obtained during the therapeutic procedure. The temperature estimates obtained by both ultrasound-based and photoacoustic-based thermal imaging techniques were spatially and temporally co-registered. A maximum temperature difference between the ultrasound and photoacoustic temperature measurements was less than 0.5°C. The CNR of temperature estimates in both imaging techniques rose with temperature. However, photoacoustic imaging has a higher SNR compared to ultrasound.

Overall, the results indicate that ultrasound and photoacoustic imaging techniques are capable of accurate and noninvasive temperature measurement during laser therapy.