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Assessment of tissue viscoelasticity using acoustically interrogated laser-induced microbubble

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Lasers are used in many biomedical and clinical applications, ranging from diagnosis to therapy. In eye microsurgery, for example, a pulsed laser beam produces a localized surgical effect through the formation of a cavitation microbubble as a result of tissue photodisruption occurring in the focal zone. However, to insure successful pre-surgical planning, surgical procedure, and postoperative stages of pathology treatment, the mechanical properties of the tissue must be analyzed before selective laser intervention. Since microbubbles are already produced during laser surgery, we have developed an integrated approach utilizing these laser-induced microbubbles as reporters of tissue viscoelasticity. Specifically, we have derived a general model of gas bubble dynamics in viscoelastic media to describe both translation and oscillations of the microbubble exposed to the acoustic radiation force. Furthermore, an ultrasound method based on temporal measurement of passive acoustic emission from cavity during laser-tissue interaction and simultaneous active pulse-echo ultrasound probing of the cavitation bubble was developed to detect and characterize the laser-induced microbubbles. The results of our theoretical, numerical, and experimental studies demonstrate that measurements of gas bubble behavior exposed to acoustic radiation force can be used to assess the mechanical properties of the surrounding tissue.