Monitoring Microwave Ablation Treatments for Liver Tumors Using Ultrasound Elastography

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Abstract: Liver cancer is the sixth most common and the third leading cause of cancer related deaths world-wide. New cases and mortality in the U.S. have doubled during the past two decades, increasing at a rate of 3.4% per year from 2007 to 2011. Existing treatment methods for liver cancer include partial hepatectomy, embolization with chemotherapy, liver transplant, and percutaneous ablation. Percutaneous ablation is increasingly being adopted as an effective treatment method for liver cancer by thermally necrosis of cancerous tissue, with the advantage of promising treatment outcomes, and minimally invasive procedures.

Previously percutaneous ablation was performed using radiofrequency ablation (RFA), which uses a local circuit loop to generate a thermal dose. To improve the heating rate and volume treated with RFA, microwave ablation (MWA) was introduced which heated local tissue by agitating water molecules using microwave energy. The key factor to yield a promising treatment outcome with MWA is to effectively monitor the ablation margin of the treated region. The guidance imaging modality for MWA, namely ultrasound B-mode imaging is not sufficient to delineate the ablated region after the MWA procedure. Thus, computed tomography (CT) is adopted as the current gold standard to determine the ablation margin by comparing the pre and post treatment images. However, CT scans prolong the treatment time and expose the patients to ionizing radiation. In this dissertation, an ultrasound elastography technique, which

is referred to as electrode displacement elastography (EDE), is applied for monitoring clinical MWA procedures. By comparison with B-mode imaging and commercial acoustic radiation force impulse imaging (ARFI), EDE is potentially an alternative imaging modality to provide effective real time feedback of the ablated margin, which might improve treatment outcomes with MWA.

In addition, our previously introduced three-dimensional (3D) reconstruction algorithm, Sheaf of Ultrasound Planes Reconstruction (SOUPR) was applied for a phantom study to depict the ablation inclusion as a 3D volume instead of a single 2D ultrasound plane. An image fusion technique is also developed to register EDE and CT to determine the ablation margin on EDE with comparison to the current gold standard.