Image guidance of focused ultrasound therapy is important for targeting the therapy, ensuring treatment and safety, and for assessing the therapy. This presentation will describe recent advances in these areas of the MR guidance of focused ultrasound.

Accurate focusing of the ultrasound beam to the target tissue can be done with a low temperature rise “test shot.” Alternatively, imaging the acoustic radiation force allows visualization of the focal spot without a temperature rise. MR imaging of the acoustic radiation force displacement (MR-ARFI) relies on the application of the ultrasound during a portion of a series of gradient lobes. In areas where the tissue is displaced, the water spins experience a different magnetic field and accumulate phase, which is not fully refocused at the time of signal measurement. The visualization of the focal spot can thus be achieved without a temperature rise.

In addition to straightforward visualization of the focal spot, MR-ARFI can provide a means for image feedback when correcting phase aberrations from the skull. An iterative method allows modification of transducer phases while maximizing the displacement at the focus. A non-iterative method requires the MR-ARFI measurements to be made, followed by a matrix inversion.

For tissue ablation, MR thermometry can be used to accurately monitor tissue temperature. MR thermometry can be very sensitive to motion, including motion of the treated tissue or even motion of tissue in the vicinity of the treated tissue (such as due to respiration). Temperature imaging methods must be robust to these types of motions and solutions include multibaseline, referenceless, and hybrid multibaseline/referenceless approaches. Another important task for MR guidance is in beam steering in moving organs, such as the liver and kidneys. This can be done based on imaging alone or on a combination of imaging and respiratory phase monitoring, such as can be done with the bellows.

Lastly, there are a number of methods under investigation for the visualization of ablated tissue. MR-ARFI is a potential candidate. The acoustic radiation force displacement depends both on the ultrasound intensity and on the displacement of the tissue, which in the latter case ARFI relies on tissue displacement by the ultrasound beam, which is related to the tissue stiffness. Evaluating the change in tissue stiffness provides the spatial extent of the thermal ablation. Other evaluative imaging methods includes contrast enhanced MRI, which visualizes disruption of perfusion, and diffusion-weighted MRI, which demonstrates a 36% decrease in ADC in the ablated tissue.

Learning Objectives
1. Understand the basis for acoustic radiation force imaging and its applications
2. Understand the current research in the image guidance of focused ultrasound