

## MR Elastography of the Kidneys: Preliminary Results

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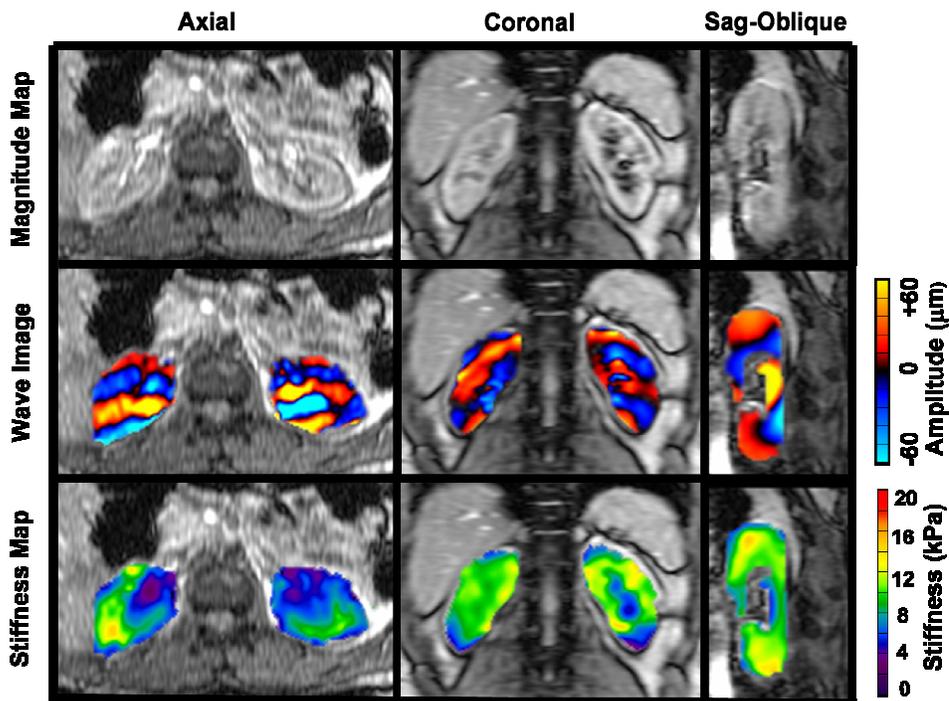
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**Introduction:** While existing imaging technologies have been very successful in the non-invasive assessment of many focal diseases of the kidneys, they have been somewhat less helpful for evaluating diffuse (medical) renal disease such as glomerulonephritis, and renal biopsy remains the diagnostic tool of choice in many situations. Studies in animal models have shown that some diffuse renal diseases cause substantial changes in renal parenchymal stiffness, as assessed by MR Elastography [1]. The goal of this work was to develop and test in volunteers a practical technique for applying MRE to assess the kidneys in humans and to establish preliminary normal shear stiffness values.

**Materials and Methods:** After initial experimentation, a candidate protocol for applying MR Elastography to quantitatively evaluate the shear stiffness of the kidneys was tested in a series of five healthy volunteers with no history of renal disease. The studies were conducted on a 1.5T whole body clinical scanner, using the body coil. All volunteers were imaged in the supine position and MRE was performed with a 25-cm cylindrical, 1.5cm thick passive acoustic driver placed posterior against the posterior abdominal wall. The driver was placed at the level of the kidneys between the 12th ribs and the iliac crest, centered on the spine. Continuous vibrations at 90Hz which were transmitted from an active driver device to the passive driver via a flexible vinyl tube, generating propagating shear waves in the kidneys and surrounding tissues.

Imaging was performed with a modified phase-contrast, gradient-echo MRE sequence to obtain "wave images" in axial and coronal planes and sensitized for motion in all three orthogonal directions. MRE was also obtained in sagittal oblique direction through the right kidney. Three MRE slices were obtained through the kidneys in each acquisition. The total acquisition time was split into 4 periods of suspended respiration of 16 seconds to obtain wave images at 4 phase offsets. In order to obtain a consistent position of the kidneys for each phase offset, subjects were asked to hold their breath at the end of expiration. In two volunteers a single slice MRE through the kidneys and sensitized in one direction and four phase offsets were obtained in one single breath hold of 25 seconds. The elastograms were generated using a local frequency estimation (LFE) algorithm [2]. Mean shear stiffness of the kidneys was calculated using a manually specified region of interest covering as much of the kidney parenchyma in the cross-sectional image and excluding the renal hilum.

**Results:** The MRE studies were successful in all the volunteers. The large, posteriorly-located passive acoustic driver provided excellent shear wave illumination throughout the kidneys, in all cases. Wave motion was observed in all three encoding directions. The shear stiffness of renal parenchyma over the five volunteers' studies was  $7.3 \pm 1.7$  kPa. In contrast, the shear stiffness of retroperitoneal fat, paraspinal muscle, and liver parenchyma were  $1.9 \pm 0.3$ kPa,  $4.5 \pm 0.6$ kPa, and  $2.4 \pm 0.4$  kPa respectively in the axial plane. No significant difference was observed in the shear stiffness of right and left kidneys. Although the shear stiffness of tissues in the renal sinus was systematically lower than that of parenchyma, no difference between cortex and medulla was apparent in the elastograms.



**Discussion and Conclusion:** The results indicate that it is feasible to quantitatively image the shear stiffness of both kidneys with an MR Elastography technique employing a large, posteriorly located passive acoustic driver. Wave images and corresponding elastograms were readily acquired in axial, coronal, and sagittal planes. These results provide a basis and motivation for investigating the potential to use MRE as a diagnostic tool for characterizing renal parenchyma in diffuse and focal diseases of the kidneys.

**Figure 1** MR Elastography of the kidneys in a normal volunteer. Top row shows magnitude images in axial, coronal and right sagittal oblique planes. Middle row shows wave illumination and bottom row, the corresponding stiffness maps. Note good illumination of both kidneys in axial and coronal planes. The coronal images show the largest cross-section of the kidneys studied.

**References:** 1. Shah NS et al. *Mag Reson Med* 2004; 52:56-64. 2. A. Manduca, *Med Image Anal* 2001, 5(4): 237-254.