3D SONOELASTOGRAPHY FOR PROSTATE TUMOR IMAGING

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ABSTRACT-Sonoelastography is a new imaging technique to detect hard tumors in soft tissue. In sonoelastography imaging low frequency (200-500 Hz) shear waves are propagated through a tissue sample while real time Doppler techniques are used to image the resulting vibration pattern on an ultrasound scanner. A sonoelastography image is therefore a mapping of the relative vibration amplitude of the tissue sample. Hard tumors are visualized as a deficit or local perturbation of the low-frequency vibration pattern in tissue.

A prostate phantom containing an isoechoic tumor was imaged using sonoelastography. The phantom was manufactured so that the phantom material mimicked both the acoustical and elastic properties of human tissue with the tumor having an elasticity 7 times that of the surrounding normal tissue. This value is in the range of reported values for hard tumors in soft tissue. Two-dimensional images of the phantom were obtained and captured using a special research package supplied with the GE scanner.

In 1988 Lerner et. al.[1] proposed a new ultrasound technique for detecting and imaging the relative stiffness of tissues, and proposed the name sonoelasticity. They used an offset-cam plunger to vibrate a sponge containing a 2 cm hard inclusion made of RTV silicone, then used the range gated Doppler function of a Toshiba commercial scanner to produce a low resolution image. Each pixel value in the image corresponded to the peak velocity measured using the range gated Doppler at that position. In 1990 Lerner, Huang and Parker [2] used an acoustic horn to externally apply low frequency (less than 1 kHz) sound waves through a tissue sample while real time Doppler techniques were used to image the resulting vibration pattern on a color flow Doppler ultrasound scanner. Phantoms containing hard tumors were imaged, as was a rabbit liver containing a 2 cm tumor. In 1995 Gao, Alam, Lerner and Parker [3] developed a theory for vibration wave propagation in inhomogeneous elastic tissue, establishing the theoretical basis for sonoelastography. The elasticity equations for an elastic medium of finite extent were formulated and solved for the vibration amplitude with and without the inclusion of a small hard tumor. The results demonstrated that a small hard tumor in an

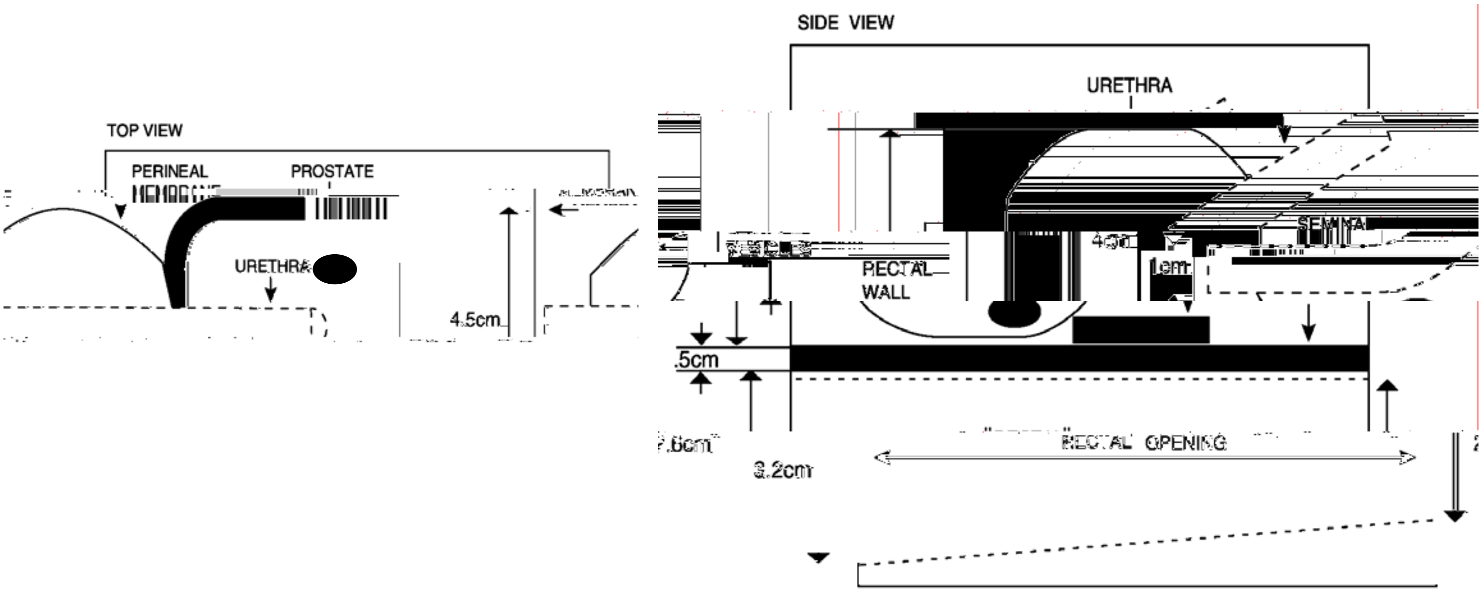
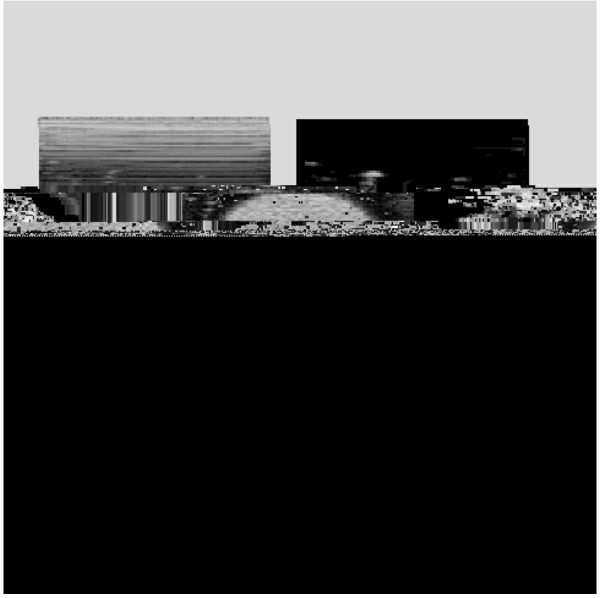


Fig 1. Top view and side view of the tissue mimicking prostate phantom used in the imaging experiments. The prostate has uniform elasticity except for the hard mass shown by the black ellipse.

otherwise homogeneous elastic medium will produce a disturbance in the vibration pattern that would not otherwise be seen if the tumor was not present.

In this paper the application of sonoelastography to the detection of hard tumors in the prostate is explored by means of an ultrasonic test object (phantom) which mimics the acoustic and elastic properties of real tissue. Two dimensional images are presented which show that a known hard lesion, not visible under conventional b-scan imaging, can be seen using sonoelastography. Three dimensional images sh



from the fact that there are Rayleigh scatters distribu

Conclusions

The feasibility of imaging an isoechoic hard region using sonoelastography has been demonstrated using a tissue mimicking phantom containing a tumor where the location and elasticity of the tumor was known. A two dimensional