A NOVEL NEEDLE DRIVER FOR TUMOR DETECTION AND BIOPSY IN MAGNETIC RESONANCE ELASTOGRAPHY

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Introduction:

Needle biopsy is a medical test to identify the biological nature of a lump or mass, or other abnormal condition in the body. Magnetic Resonance Elastography (MRE) is a technique for assessing the viscoelastic properties of tissue. MRE technique can quantitatively depict the elastic properties of tissues in vivo and reveal high shear elasticity in known tumors[1,2]. An obvious potential role for MRE in imaging is to serve as a method for improving the diagnostic specificity of contrast-enhanced MRI.

We invented a drum driven needle-guided biopsy device for tumor detection and biopsy in MRE. The device is constructed and arranged for utilization within an MRI machine. It generates shear waves which are necessary to perform highly sensitive and specific MRE analyses without generation of artifacts. The assembly is non-metallic except for the needle and its outer sleeve. Tests of this device have been carried out in a gel phantom in Mayo Clinic and in human subjects at Jockey Club MRI Centre, University of Hong Kong. The overall objective of this study is to demonstrate the ability of the device to reduce unnecessary biopsies and interventions, by virtue of its increased sensitivity and specificity in detection and biopsy of invasive cancer.

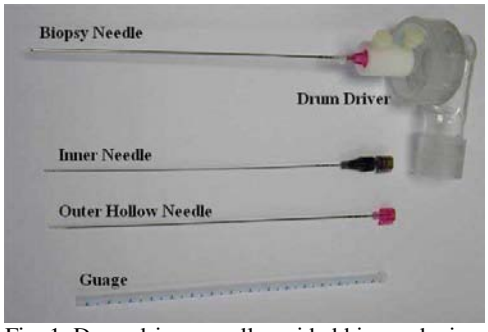

Fig. 1. Drum driven needle-guided biopsy device.

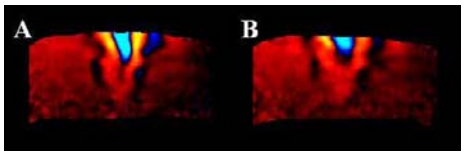

Fig. 2. (A) plane waves induced by the needle driver in human. (B) spherical waves induced by the surface driver in human.

Materials and methods:

The drum driven needle-guided biopsy assembly was made by purely plastic material (Fig. 1). The MRI compatible biopsy needles have several sizes, so the needles can be changed accordingly. 14% Bgel Phantom was made with 1000 mL distilled water, 140 g Bgel powder and 70 mL iodine solution. The MRE study was performed on a 1.5 Tesla scanner (Signa Horizon Echo Speed with version 11 software; General Electric Medical Systems, Milwaukee, WI, USA). MRE uses Gradient Echo sequence with the typical data acquisition parameters of TR = 100 ms, TE = minimum full, flip angle = 30°, acquisition matrix = 256 x 64, FOV = 24 cm, slice thickness = 5 cm, frequency direction = S/I. The frequency of mechanical excitation was 90 Hz with 6 V; 150 Hz with 30 V and 300 Hz with 30 V. Coronal images were obtained to estimate the stiffness of the Bgel phantoms to verify and compare the accuracy of MRE results using the drum driven needle-guided biopsy device. MREview was used for the data analyze

Results:

Drum driven needle-guided biopsy device with a MRI compatible biopsy needle was shown in figure 1. Figure 2 showed the drum needle driver generated the plane waves rather than the spherical waves generated by the surface driver in human. Figure 3 showed the wave length was decreased with the increasing frequency and volume in Bgel phantom. The result is a higher accuracy of measurement. The technique can be employed for needle-guided biopsy in patients with breast, liver, kidney and prostate tumors.

Discussion:

MRE surface drivers have previously been used for the detection of breast, liver, kidney and prostate tumors via generation of spherical waves. Currently, MRE surface drivers have certain limitations. Since they use relatively low frequency, the wavelength is relatively long. The long wavelength makes it difficult to detect small lesions. The needle driver utilizes a much higher frequency, therefore the wave length induced is much shorter than that induced by the surface driver. Additionally, since the needle deeply penetrates the tissue, lesions which are deeply located, or are smaller in size, are able to be detected. By combining surface and needle drivers, it is possible to generate both spherical and plane waves at the same time. The combined driver can further improve the shear waves and increase the sensitivity and specificity for the detection of tumors, while again reducing unnecessary biopsies. Simultaneously, it is possible to use the needle to perform biopsies immediately after finding the lesion, thus eliminating an additional invasive step. The further study should be carried out in patients with breast, liver, kidney or prostate tumors

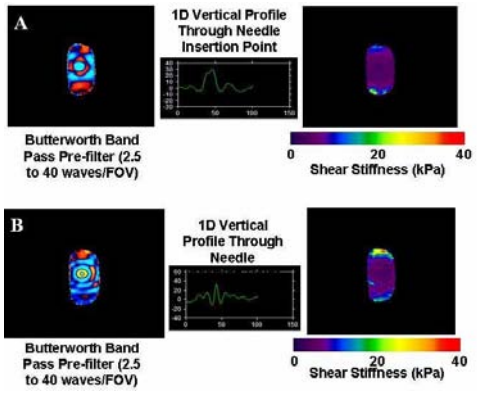

Fig. 3. (A) plane wave induced by drum needle driver with 90 Hz and 6V. (B) plane wave induced by drum needle driver with 300 Hz and 30 V.

Conclusion:

The designed devices are at the forefront of technology in breast, liver, kidney and prostate cancer diagnostics. Given the very high resolution provided by MRE images, the MRE needle-guided biopsy technique can detect small cancers because MRE generates high-amplitude, artifact-free motion throughout a breast to enable visualization of tumors of less than one hundred microns, a very small tumor. The end result of this technology will be the saving of additional lives, along with a reduction in the number of un-wanted biopsy procedures.

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References:

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