Clinical use of an image-guided remote manipulator for endorectal prostate biopsy

M. A. Rea[1,2], Z. Tse[2], V. Morgan[3], S. Giles[3], D. W. McRobbie[1,3], M. Lamperth[2], I. Young[2], and N. deSouza[3]

[1]Radiological Sciences Unit, Imperial College Healthcare NHS Trust, London, United Kingdom, [2]Mechanical Engineering, Imperial College London, London, United Kingdom, [3]MRI, Royal Marsden Hospital, Surrey, London, United Kingdom

Introduction

The current gold standard for the confirmation of suspected prostate cancers is a sextant biopsy guided by transrectal ultrasound (TRUS) [1]. This is in widespread use despite the poor SNR of the modality and the reported low sensitivity [1,2] of the technique due to its lack of targeting ability within the prostate gland. Recent work has shown how MR-guidance can be used for easier targeting leading to improved diagnostic ability and a reduction in repeat procedures [3,4]. Here we report on the clinical use of a MR-compatible electromechanical system for prostate biopsy which employs remote actuation to position and fire the needle, with the patient remaining inside the scanner bore.

Methods

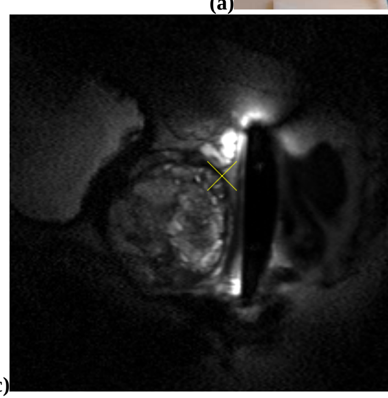
Patients recruited through the prostate clinic at the Royal Marsden Hospital (Surrey, UK) were positioned in the left lateral decubitus position, and the probe was inserted into the rectum. An MR-compatible 3-axis robotic manipulator based upon piezoelectric actuation [5] was used in conjunction with a custom designed endorectal coil / needle guide on a Siemens Avanto 1.5T MR system (Siemens Medical Solutions, Erlangen, Germany). To localise the target, axial and sagittal images of the prostate were taken using a Half-fourier Single-shot Turbo Spin Echo (HASTE) sequence (TR = 1630ms, TE = 241ms, ETL = 256, NEX = 2, $\alpha = 150^o$, N_{PE} = 160, matrix = 320x236), and used to localise a target of the suspected tumour in three dimensions. A Fast Low-Angle Shot (FLASH) pulse sequence (TR = 9.1ms, TE = 4.8ms, $\alpha = 1^o$, slice thickness = 5mm, matrix 128^2) was modified to perform 3D tracking of embedded passive micro-coil fiducials using real-time feedback [6]. This FLASH sequence was run while the probe was aligned by the operator from an in-room touchscreen console. When the target was properly aligned, the needle was fired using a cable driving stage and a pneumatic firing system.

Figure 1. (a) The manipulator and probe are shown during phantom testing. (b) The setup of the robot and the patient on the couch in the left lateral position during clinical trials. (c). HASTE image used to identify the target within the prostate. (d) Orthogonal real-time images in the (left) coronal and (right) sagittal aspects showing an overlaid projection of the current needle location (yellow box) and the position of the intended target (yellow cross).

(a)

(b)

(c)



(d)

Results

The measured accuracy of the needle tip was found to be 2.2(±1.5)mm when deployed inside an anatomically representative phantom. During clinical testing the total time of the procedure from patient positioning to needle firing was less than 15 minutes.

Discussion

This work reports on the clinical use of a new method for image-guided prostate biopsy procedures. The observed needle tip accuracy of 2.2mm in the phantom was caused by bending of the biopsy needle during insertion, and it is expected that this may be reproduced *in-vivo*, tissue deformation may also lead to additional inaccuracy. The procedure time is similar to the current TRUS method. Clinical trials are continuing at this time and should be completed in early 2009.

References

[1] Rabbani F *et al*, Incidence and clinical significance of false-negative sextant prostate biopsies, *J Urol*, 1997; 159(4):1247 – 1250.
[2] D'Amico A *et al*, Transperineal magnetic resonance image guided prostate biopsy, *J Urol*, 2000; 164(2):385-7.
[3] Tsekos NV *et al*, "Magnetic resonance compatible robotic and mechatronics systems for image-guided interventions and rehabilitation: A Review Study," *Annual Review of Biomedical Engineering*, 2007; 9(1):351-387.
[4] Wefer AE *et al*, Sextant localization of prostate cancer: comparison of sextant biopsy, magnetic resonance imaging and magnetic resonance spectroscopic imaging with step section histology, *J Urol*, 2000; 164(2) 400-4.
[5] Elhawary H *et al*, A Modular Approach to MRI Compatible Robotics: Interconnectable One DOF stages," *IEEE Engineering in Medicine and Biology Magazine*, 2008; 27(3):35-41.
[6] Rea M *et al*, System for 3D real-time tracking of MRI-compatible devices by image processing, *IEEE/ASME Transactions on Mechatronics*, 2008; 13(3):379-382.