

A method for MR imaging of prostate cancer patients in the radiotherapy treatment position without loss of image quality

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Introduction: Modern radiotherapy treatment planning (RTTP) requires volumetric localisation of tumour and critical structures. 3-dimensional computed tomography (CT) data is the preferred imaging modality in RTTP due to: spatial accuracy; electron density information; the speed of acquisition; the ability to image the patient in the treatment position and the visualisation of bony anatomy. However, magnetic resonance imaging (MRI) provides superior soft tissue contrast over CT and it has been shown that improved prostate and rectal volume delineation from MRI has the potential to improve target coverage and rectal sparing [1]. It is therefore desirable to integrate MR data into the treatment planning process. MR suffers from geometric distortion and gives no electron density information and so most hospitals rely on the CT scans to plan treatment. CT-MR fusion introduces errors as a result of changes in patient positioning from diagnostic and planning scans, potentially giving inaccuracies in the delineation of the target volume. Patient positioning problems can be overcome by taking the MR diagnostic scans in the same position as the radiotherapy treatment. For pelvic tumour patients a flat table is required since image registration with a curved table introduces fusion inaccuracies, as shown in figure 1. Patients are not routinely scanned on a flat table in MR because clinicians do not wish to compromise diagnostic information for positional accuracy. This study investigates a method for maintaining satisfactory diagnostic information in MR while positioning the patient in the CT and radiotherapy treatment positions using a customised flat table, patient immobilisation, a laser positioning system and a suitable imaging coil.

Materials and Methods:

A multi-channel body coil is recognised as the optimum coil for imaging pelvic patients; however, it is incompatible with the flat table. Instead, four imaging coils were tested in a different way from intended using the MagNET [2] phantoms. This allowed RTTP (in combination with a flat table and immobilisation) quality assurance testing. The range of tests included uniformity, linearity and distortion; slice width; resolution, signal to noise ratio and slice position. A contrast test was also performed using a variety of T1 shortened liquids. These tests are an essential part of accurate RTTP workup. The imaging coils used were: the integrated body coil; an 8 and 12-channel body coil; and a 4-channel cardiac coil. Using the integrated body coil the test objects were positioned at isocentre and scanned. For tests with the 8-channel body coil the lower anterior section of the coil was wrapped around the test object and the remainder of the coil was redundant. The 12-channel body coil was tested with the same arrangement. The 4-channel cardiac coil was positioned within a recess in the flat table, without losing the benefits of the flat surface and on top of the phantom. The results of the tests using the MagNET phantoms were compared with published data [3] on the multi-channel body coil. A comparison was also made between the contrast measurements with the four imaging coils and repeated using a multi-channel body coil. Within the MR scanner room is the first UK installation of a Dorado 3 LAP system. This has movable lateral and overhead lasers which project coronal and sagittal lines and a fixed axial laser line. These lasers are accurate to within 1mm and can therefore be used to accurately reproduce the patient's CT position whilst on the MR flat table.

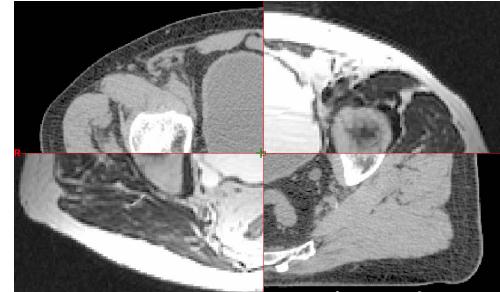


Figure 1. Inaccuracies in MR-CT fusion due to different table set-up even when patient is aligned correctly with laser positioning system.

Results and Discussion: The integrated body coil would offer the least physical restrictions to the patient and reduce set-up time, however, the integrated body coil gave a poor signal to noise result of 31% of the normalised signal to noise (NSNR) of a multi-channel body coil, when averaged over three orthogonal planes. All other tests on the integrated body coil were satisfactory. The NSNR measured on the 8 and 12-channel body coils were 40% and 25% of the results from a multi-channel body coil respectively. This improved to 64% and 38% for the 8 and 12-channel body coil respectively when using the vendor's uniformity correction algorithm. Fractional uniformity measurements, averaged over three orthogonal planes, demonstrated that 53% and 60% of pixels were within 10% of the mean uniformity value for the 8 and 12-channel body coil respectively. All pixel values (100%) are required to be within 10% of the mean uniformity value for acceptable diagnostic information. This can be achieved using the vendor's uniformity correction algorithm, although the NSNR was still inadequate. The remainder of the tests proved satisfactory with these imaging coils. The 4-channel cardiac coil would present few physical restrictions to the patient. The four channel body coil gave a NSNR of 99% of the multi-channel body coil results. This would be acceptable for treatment planning and can be increased to 158% of the multi-channel body coil results using the vendor's uniformity correction algorithm. It was found that 98% of the pixels were within 10% of the mean uniformity value and this rose to 100% after using the uniformity correction algorithm, for the 4-channel cardiac coil. Using the 4-channel cardiac coil integrated within a flat table satisfied the diagnostic and patient positioning requirements for RTTP.

Conclusion: This study has shown that imaging pelvic cancer patients on a flat table can be achieved without loss of the diagnostic image quality required for RTTP using a 4-channel cardiac coil. Inaccuracies encountered when registering MRI datasets with CT due to differences in scanning position are largely eliminated, thereby ensuring accurate image registration and establishing the prospect of MR-based RTTP. A study is now underway to measure changes in tumour target volume as a result of the improved patient positioning.

[1] Debois M et al The contribution of magnetic resonance imaging to the three-dimensional treatment planning of localized prostate cancer *Int. J. Radiat. Oncol. Biol. Phys.* 1999 45: 857–65.

[2] MagNET test object, Purchasing and Supply Agency, National Health Service, Department of Health, UK

[3] National Health Service, Purchasing and Supply Agency, Report 06005 1.5T MRI Systems, Issue 6, London (2006).