

A method for MR imaging of head and neck 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) offers superior soft tissue contrast over CT and can be used to discriminate tumour extension in most (>80%) brain tumour patients [1]. It is therefore desirable to integrate MR data into the RTTP process. MR suffers from geometric distortion and lack of electron density information, so many hospitals fuse MRI and CT data. The fusion process introduces errors as a result of changes in patient positioning, potentially giving inaccuracies in the delineation of the target volume. Patient positioning problems can be overcome by imaging MR diagnostic scans in the same position as the radiotherapy treatment. For head and neck cancers this requires immobilisation, by way of a thermoplastic head and neck mask and a head rest to tilt the head in the sagittal plane. Patients are not routinely positioned in this way 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 RTTP position using a customised flat table and a suitable imaging coil.

Materials and Methods:

The multi-channel head coil is recognised as the optimum coil for imaging head and neck cancer patients; however, it is incompatible with the thermoplastic face mask. Instead, four other imaging coils were tested 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. A thermoplastic head rest was affixed to the flat table using a customised base-plate and the MagNET phantoms were tested in turn within the face mask. These tests are an essential part of accurate RT planning 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 head and neck thermoplastic face mask 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 also wrapped around the thermoplastic face mask. The results of the tests using the MagNET phantoms were compared with published data [3] on the multi-channel head coil. A comparison was also made between the contrast measurements with the four imaging coils and repeated using a multi-channel head coil.



Figure 1. 4-channel cardiac coil wrapped around thermoplastic face mask containing test object.

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 19% of the normalised signal to noise (NSNR) of a multi-channel head coil, when averaged over three orthogonal planes. The contrast was 88% of the same test on the multi-channel head coil. All other tests on the integrated body coil were satisfactory. The NSNR measured on the 8 and 12-channel body coils were 24% and 15% of the results from a multi-channel head coil respectively. This improved to 39% and 23% 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 presents little physical restrictions to the patient. The four channel body coil gave a NSNR of 61% of the multi-channel head coil results. This is considerable improvement over the other imaging coils and can be increased to 96% 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 this arrangement the 4-channel cardiac coil satisfied the diagnostic and patient positioning requirements for RTTP.

Conclusion: This study has shown that imaging head and neck cancer patients with immobilisation and a head rest can be achieved, without loss of diagnostic image quality, using a 4-channel cardiac coil. The standards of image quality and immobilisation required for RTTP are therefore both satisfied. Inaccuracies encountered when registering MRI datasets with CT due to differences in scanning position are largely eliminated, thereby ensuring accurate image registration. A study is now underway to compare tumour target volumes with and without the improved patient immobilisation and associated change in inclination of the head.

[1] Krempien RC, Schubert K, Zierhut D, et al. Open low-field magnetic resonance imaging in radiation therapy treatment planning. *Int J, Radiat Oncol Biol Phys* 2002;53: 1350-1360.

[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).