Repeatability of whole-body T1 mapping using B1 corrected T1 mDIXON imaging

Anna Barnes[1], Catherine Morgan[2], Alan Bainbridge[3], Lorna Smith[4], Scott Rice[5], David Atkinson[6], and Shonit Punwani[5]

[1]Nuclear Medicine, University College Hospital, London, England, United Kingdom, [2]Centre of Medical Imaging and Computing, University College London, london, England, United Kingdom, [3]Medical Physics, University College Hospital, London, England, United Kingdom, [4]Radiology, University College Hospital, London, England, United Kingdom, [5]Radiology, University College Hospital, london, England, United Kingdom, [6]Centre of Medical Imaging, University College London, london, England, United Kingdom

Introduction: Assessing the response to new cancer agents is increasingly challenging for conventional imaging methods that rely upon evaluation of size changes as a marker of response [1]. Alternative methods of assessing drug efficacy are necessary. T1 relaxation time is known to differ between tumour and benign tissue; moreover changes in T1 relaxation time have been observed in cancers during therapy [2]. Yet, obtaining reliable whole-body T1 maps within a time-frame acceptable to patients has to date not been reported. Here we describe the development of a reproducible 3.0T B1 corrected multi-flip angle mDIXON technique to generate whole-body T1 maps within a 15 minute scan time, because the mDixon combines multiple echoes it is expected to have SNR benefits over a single gradient echo.

Methods: Acquisition Imaging was carried out on a Philips 3T Ingenia (R4) (Philips Medical Systems, Best, The Netherlands) 9 subjects were imaged using multi-flip angle mDIXON sequences to cover the whole body. Each subject was imaged twice in a single session and then again a week later. B1 maps were collected for each FoV.

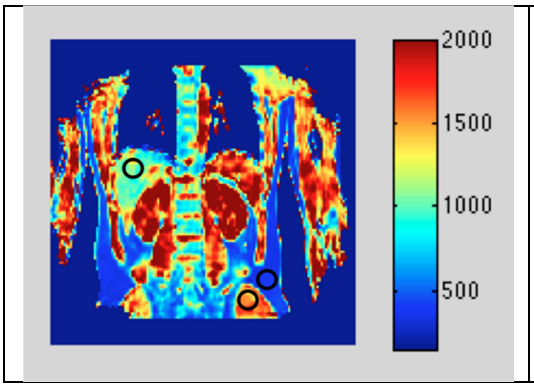
Review Images were exported from the scanner in DICOM format and T1 maps were calculated from B1 corrected in-phase images using a linear algorithm [3] in matlab (v7.13 for MacOSX) from all 8 flip angles initially and then various combinations of angle pairs. ROIs were drawn in a range of tissue types: liver, muscle, and subcutaneous fat, for each of the T1 maps calculated from all 8 flip angles and then for each of the T1 maps calculated from flip angle pairs.

Evaluation The mean and standard deviation of each ROI per tissue type was plotted within session and between session, across subjects to assess repeatability using co-efficient of variation (CoV) as a metric.

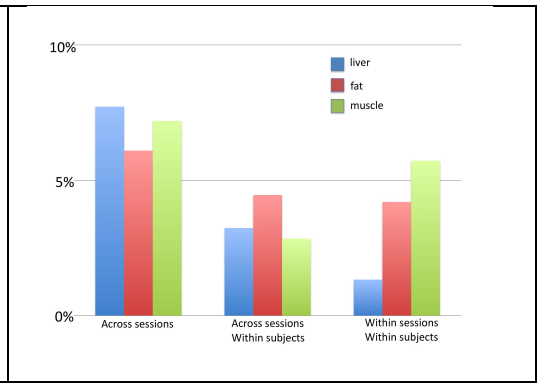
MR parameters

mDIXON: voxel size 6.4x2.65x5mm
TR= 4ms, TE = 1.15/2.3ms
Matrix size 192x192x120, breath holds for head and neck FoV and thorax/abdo FoV, Flip angles: 2.5, 5, 7.5,10,12.5,15,17.5,20

B1 map: voxel size 6x6x6mm
TR=20ms, TE= 2.8ms, Matrix size 68x79x100, no breath holds. Flip angle=60.



T1 map calculated from all 8 flip angles for a single subject showing the position of the ROIs (black circles).



Column graph of mean CoV of T1 values calculated from all 8FA.

Results: The mean T1 value calculated from all 8 flip angles, across all subjects for each tissue type: T1fat= 375.1ms, T1liver= 1061ms, T1muscle= 1608.4ms. CoV showed that there was good reproducibility using the 8 flip angle mDIXON sequence to calculate T1 maps across these tissue types, within subjects and between sessions as shown in graph 1. (mean CoV within subject for sessions on different days: liver = 4.47%, fat = 3.26%, muscle = 2.87%). The mean CoV within subject across sessions on different days was calculated for each of the flip angle pairs for each tissue type, and used as a metric to establish the optimum flip angle pair. The flip angle pair for the overall lowest CoV across tissue types was 2.5° and 20° (liver=4.81%, fat=3.78%, muscle=2.45%). However, the flip angle pair with the lowest CoV for liver was 2.5° and 10° (3.57%), the lowest CoV for fat was 2.5° and 17.5° (3.69%) and the lowest CoV for muscle was 2.5° and 20° (2.45%) but all CoV was under 5% for all flip angle pairs. Acquisition time for 2 flip angle pairs for total body mDIXON sequence is 15 mins.

Discussion: We have shown that a B1 corrected dual flip angle mDIXON acquisition can be used to produce reproducible whole-body T1 maps within a 15 minute acquisition. Reported changes in T1 values indicating pathology are of the order of -20% [2] much larger than the variability measured here. The technique will have utility in rapid assessment of response of cancers to novel therapies.

References

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