

Ultra Short TE MRI as a quantitative measure of bone density?

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Introduction

Ultra short TE (UTE) MR employs half RF excitations followed by radial filling of k space to reduce TEs to a μ s range. This allows detection of signal from very short T2 tissue that previously returned no signal on conventional MR sequences¹. We have previously optimised UTE MRI of the spine to return signal from short T2 components in sclerotic bone metastases² which are commonly encountered in metastatic carcinoma of the breast and prostate. Our aim was to investigate the relationship between changes in T2* measurements of bone metastases and changes in bone density with treatment as measured by CT Hounsfield units (HU).

Methods

Sagittal UTE MRI lumbar spine and axial UTE MRI pelvis was performed at baseline and 12 weeks following chemotherapy in 6 patients with known sclerotic metastatic bone disease on a Siemens Avanto 1.5T; (TR 500ms; TEs 0.07, 4.7, 9.4ms; FOV 800cm, matrix 512, 2 averages; flip angle 85°; BW 540Hz, fat saturation; 4mm slice thickness). Regions of interest were drawn around lesions and mean T2* calculated with a monoexponential fit of signal decay over the 3 echo times (DiffusionView). As part of the routine staging protocol patients also underwent CT chest, abdomen and pelvis at baseline and 12 weeks after chemotherapy - GE Lightspeed (GE Healthcare Technologies, Waukesha, WI): Omnipaque 300 100mls at 3ml/s portovenous phase using a Smartprep technique, 16 slice, 1.25 mm thick with 5mm reconstructions. Regions of interest were drawn on CT bone windows to correspond with those drawn on MR images and mean HU documented.

Data Analysis: Corresponding pre and post treatment T2* and HU were available on 13 lesions from 6 patients at baseline and following 12 weeks of therapy. The data were tested for normality (Kolmogorov-Smirnov test; SPSS vs15) and percentage change in T2* plotted against percentage change in HU. Pearson correlation coefficient was calculated (SPSS vs15).

Results

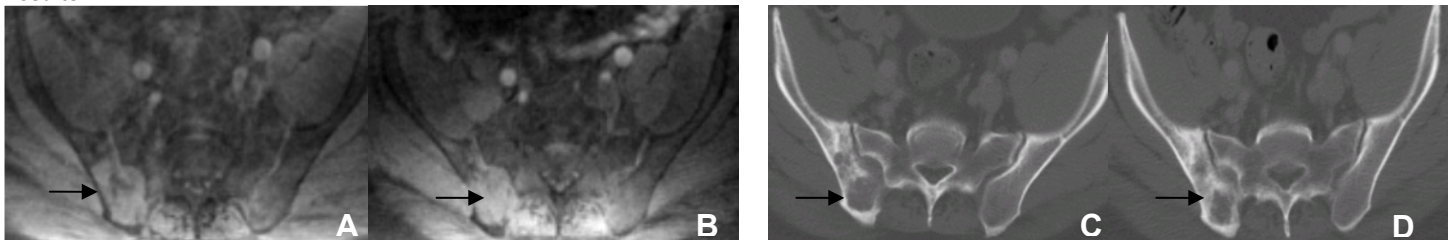


Fig 1. Osteoblastic healing. Axial UTE pelvis (0.07ms) shows high signal returned from short T2 components in bone metastases (A, arrow). After 12 weeks treatment the patients disease had responded (PSA fell from 357 to 31.5 ng/ml) and UTE shows filling in of the metastasis with short T2 sclerotic components and T2* fell from 32 to 21ms (B, arrow). Corresponding axial CT pelvis shows an increase in bone density and HU increased from 443 to 529 (C and D, arrows).

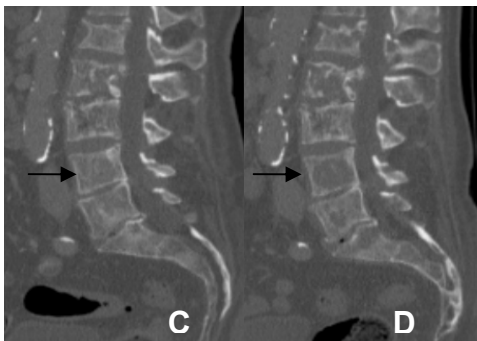


Fig 2. Lytic progression. After 12 weeks treatment the patients disease progressed (PSA rose to 692 from 483 ng/ml) and the T2* of the L4 vertebral body measured with UTE MRI rose from 11.5 to 16.2 ms. Sagittal CT reformat shows a decrease in bone density to 158 from 184HU (C and D arrows).

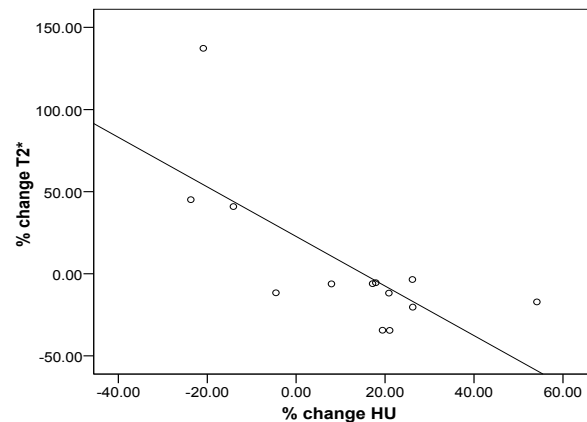


Figure 3. Percentage change T2* vs percentage change in HU. Pearson correlation coefficient of -0.717 was significant ($p < 0.05$).

Discussion

Preliminary data from this ongoing study suggests that there is a significant linear relationship between % change in T2* and HU of bone metastases, hence UTE MRI has potential to quantify changes in the sclerotic components of bone metastases. We plan to confirm this with larger patient numbers. The effects of multiple tissue components within each voxel must also be investigated as this will lead to multiple relaxation rates affecting the accuracy of a single exponential fit and T2* measurement. Judicious choice of TEs and long T2 suppression techniques may further improve the measurement of short T2 components. If the relationship of T2* with HU can be extrapolated to electron density this would allow much sought after radiotherapy planning using MR data and may also be a novel approach to attenuation correction for PET/MR.

References:

1. Robson MD, Bydder GM. NMR Biomed 2006; 19(7): 765-80.
2. Messiou C, Collins DJ, Robson M et al abstract 4004, ISMRM 2009.