Comparison of Hepatic Fat Measurements using Dual-Echo mDIXON Imaging and ^{1}H MRS with Fat Phantom Validation

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Introduction:

In vivo fat assessment by MR techniques of the liver has been widely applied in medicine for non-alcoholic fatty liver disease, and type 2 diabetes. To date ^{1}H MR-Spectroscopy (MRS) is considered as the gold standard for liver fat measurements due to its accuracy. However, in- and out-of-phase DIXON [1] imaging techniques are increasingly being used for liver fat quantification. Recently a flexible Dual-Echo DIXON technique (mDIXON) has been introduced [2], which can provide a higher signal-to-noise by employing very short echo times. The goal of this study was to compare the accuracy of ^{1}H MRS to a Dual-Echo mDIXON sequence on a set of fat phantoms, and to determine the feasibility of Dual-Echo mDIXON imaging to accurately quantify hepatic fat content *in vivo*.

Materials and methods:

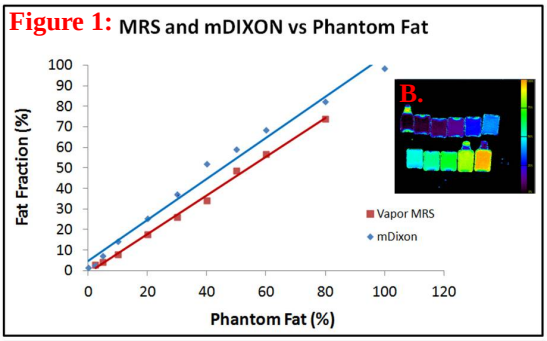
All measurements were conducted on a whole body 3.0 T Achieva MRI (Philips Healthcare, The Netherlands), using a 16 channel XL torso phased-array receiver coil. 16 healthy subjects (age: 54±11 yr, BMI: 26.2±2.9 kg/m^2) consented to a research protocol which was approved by the local review board of human studies.

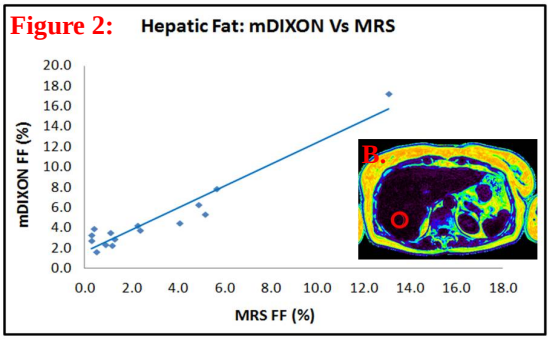
Phantom construction:

Homogeneous emulsions of canola oil, distilled water, agar (2% by weight), and 20 mM sodium dodecyl sulfate [3] were prepared in 100 ml bottles with fat fractions of 2.5, 5, 10, 20, 30, 40, 50, 60, and 80%. The agar and SDS were heated over a hot plate before being mixed with oil using a household homogenizer and allowed to cool.

^{1}H MRS:

MRS was conducted with both non-water-suppressed, and VAPOR (WS) STEAM sequences (Single voxel 30x30x20 mm^3, NSA: 32, TR/TE: 4000/10ms, samples: 2048, BW: 2000 Hz), with respiratory triggering for *in vivo* measurements. MRS data was analyzed via NUTS (Acorn NMR Inc, USA). Fat fraction was expressed as (WS Fat)/(Water+WS Fat) in all cases, with fat expressed as the summation of the water suppressed fat peaks at 1.3 and 0.9 ppm. *In vivo* measurements were also corrected for T2 and percent of total hepatic fat content [4].





mDIXON:

Abdominal (F/IP/OP/W) images were acquired in a 19 sec breathhold (BH) via a 3D T1 fast field gradient echo (FFE) pulse sequence (Flip Angle: 5°, TR/TE$_1$/TE$_2$: 5.0/1.2/2.5 ms, FOV: 375x295x200 mm^3, resolution: 2x2x2 mm). mDIXON fat fraction was also expressed as fat/(water+fat), and obtained pixel by pixel using the PRIDE software package (Philips Healthcare, The Netherlands). Fat fraction was calculated from the average of four (800 mm^3) ROIs placed in different slices within the liver.

Results:

The fat phanom emulsions remained stable after cooling and revealed no air bubbles during imaging (Figure 1B). (Figure 1) VAPOR MRS revealed a strong correlation (slope = 0.94, r = 0.95, P < .0001) and a high sensitivity for fat fractions below 10% (intercept = 0.99%). mDIXON imaging also showed a good correlation (slope = 1.00, r = 0.99, P < .0001); however, with an over estimation of fat fractions (intercept = 4.5%). *In Vivo* results of hepatic fat quantification by mDIXON and ^{1}H MRS correlated well with each other (slope = 1.07, r = 0.96, p < 0.0001, intercept = 1.6%) (Figure 2), and *in vivo* fat fraction maps reconstructed in PRIDE provided an accurate separation of fat and water signals both within the body and adipose tissue (Figure 2B).

Discussion:

The Dual-Echo mDixon sequence provided a high SNR and accurate fat-water separation over the whole abdomen at a high image resolution within a single BH. The high sensitivity and correlation of Dual-Echo mDixon imaging to ^{1}H MRS also shows that mDixon can be used as a clinical tool for fast detection of changes in liver fat due to intervention in patients with diabetes or fatty liver disease. However, the zero offset and residual noise shows that ^{1}H MRS is still superior for exact liver quantification, and that more work must be done to use mDIXON for accurate disease diagnosis and fat fractions below 2%.

References

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