Dual echo, PDFF and mDIXON compared to ^{1}H-MRS for fat fraction estimation: only PDFF can accurately measure low fat fractions.

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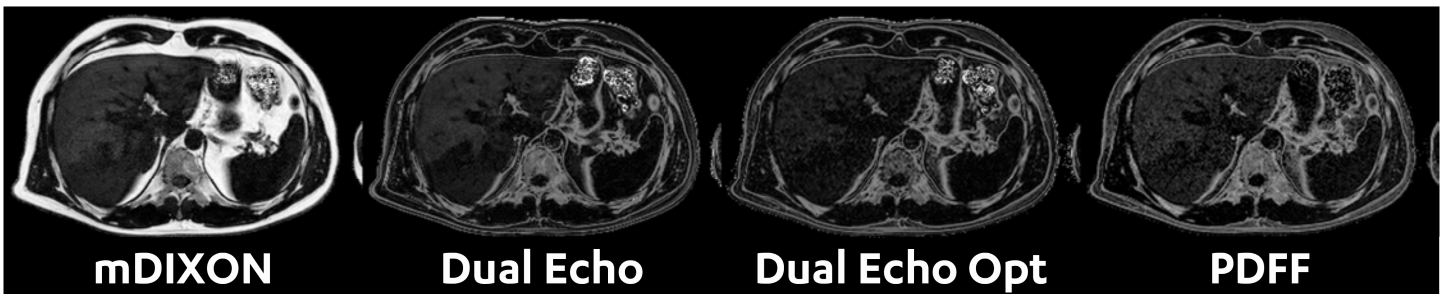
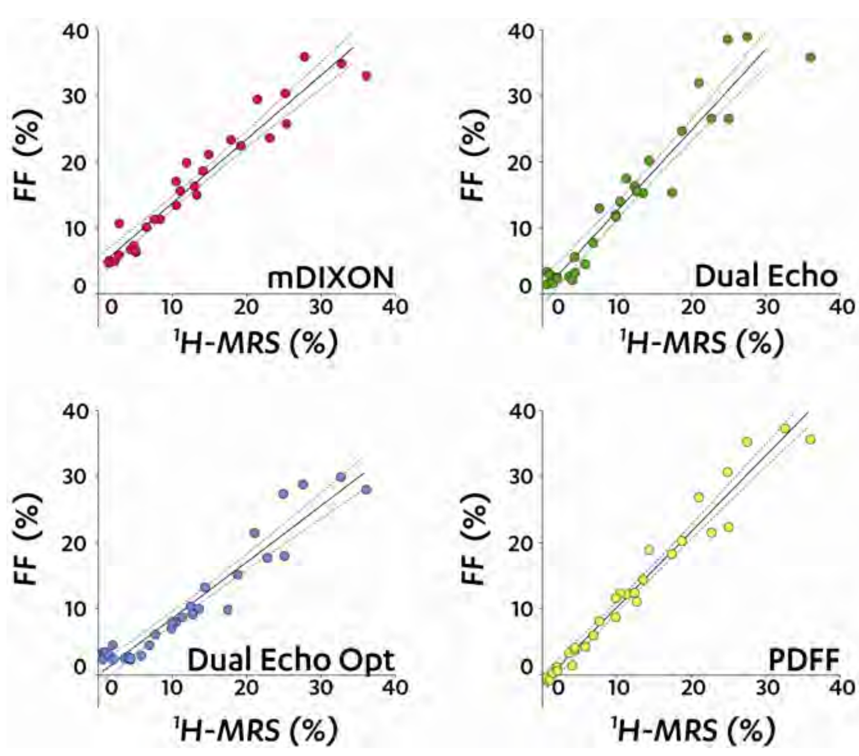
Purpose The increasing prevalence of the metabolic syndrome underscores the necessity for accurate magnetic resonance techniques to measure FF[1,2]. ^{1}H-MR Spectroscopy (^{1}H-MRS) is the reference standard but has limited spatial coverage and is prone to user-dependent bias at low FF[3]. In-out-phase (IP/OP) dual echo gradient echo (GRE) allow 2-point dixon FF map reconstructions that are reported to perform poorly compared to ^{1}H-MRS[2]. Other GRE acquisitions allow true separation of water (W) and fat (F) signal and FF map generation, covering the entire liver, with less user influence at low fat fractions. However, acquisition and reconstruction details still influence final FF results. Hence, not all FF maps are equal. The modified Dixon scheme (mDIXON) with flexible TEs generates W+F images at high spatial resolution with whole-liver coverage in a single breath hold[3,4], using a multi-echo acquisition[4]. In addition, its relatively high flip angle (FA) and short TR induce T_1-weighting, providing an explanation to earlier reports of bias in mDIXON FF[5-7]. To solidify this hypothesis, we compared standard mDIXON, dual echo and proton density fat fraction (PDFF) methods with ^{1}H-MRS as the final reference standard.

Material & Methods Data of 30 subjects (21M/9F) included in a board approved study were used. Examinations were performed at 3.0T (Ingenia, Philips Healthcare, Best, The Netherlands). ^{1}H-MRS was performed with single voxel (20×20×20 mm^3) STEAM with TR/TE1/ΔTE of 3500/10/5ms and 5 echoes after 1 dummy acquisition[8]; dual echo 2D GRE with the vendor's protocol (FA/TR/TE1/TE2 of 55°/182/1.15/2.3ms) and an optimised variant with FA/TR of 10°/150ms, to reduce T_1-weighting; mDIXON with a 3D fast GRE acquisition with FA/TR/TE1/ΔTE of 10°/5.4/2.11/1.0ms and 3 echoes. Voxelwise FF maps were calculated from the W+F images (mDIXON) and from the IP and OP images (dual echo)[2,7]. PDFF maps were reconstructed from 2D six-echo GRE images with FA/TR/TE1/ΔTE of 10°/200/1.15/1.15ms[8]. For comparisons, we automatically located the image voxels inside the ^{1}H-MRS voxel's boundaries. Mean FF map values and ^{1}H-MRS were assessed with linear regression analysis.



Results Median (IQR) age, BMI and ^{1}H-MRS value were 52 (44-57), 27 (25-31) and 10.2 (3.9-19.3). The scatter plots show FF map (*y*-axes) against ^{1}H-MRS values (*x*-axes) in addition to solid linear regression and dashed 95%-CI-of-fit lines.

	Slope (95%-CI)	Intercept
mDIXON	0.97 (0.87-1.07)	4.07 (2.5-5.6)
Dual Echo	1.23 (1.09-1.36)	0.27 (-1.8-2.3)
Dual Echo Opt	0.85 (0.76-0.95)	0.012 (-1.5-1.5)
PDFF	1.15 (1.06-1.23)	-1.3 (-2.6-0.05)



Discussion and Conclusion The regression line between mDIXON and ^{1}H-MRS had a significantly non-zero intercept, though in this cohort was the only method with a slope of 1 within its 95%-CI. The non-zero intercept is probably due to T1-bias. Dual Echo plots show deviation of linearity in the 0-5% ^{1}H-MRS FF range. However, PDFF had near 0 intercept, near 1 slope, smallest 95%-CI of the linear regression fit and is therefore preferable. Standard mDIXON should not be used for quantitative FF mapping.

References: 1. Loomba ea. Nat Rev Gastroenterol Hepatol **10** (2013) 686-690. **2.** Reeder ea. J Magn Reson Imaging **34** (2011). 729-749. **3.** Runge ea. Acad Radiol **21** (2014) 1446-1452. **4**. Hernando ea. Magn Reson Med 67 (2012) 638-644. **5.** Livingstone ea. Magn Reson Mater Phy **27** (2014) 397-405. **6.** Runge ea. ISMRM 2014: 2134. **7.** Liu ea. Magn Reson Med **58** (2007) 354-364. **8.** Yokoo ea. Radiology **258** (2011) 749-759.