Accuracy of HISTO-based Liver Fat Quantification at Different Field Strengths

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Target Audience: Radiologists.

Purpose: The accurate fat fraction quantification in liver has several important clinical applications. Nowadays, there is a worldwide increase in diffuse liver diseases, such as the non-alcoholic fatty liver disease, that can be diagnosed and monitored by liver biopsy, an invasive procedure involving some risks and sampling errors. Other non-invasive methods for liver fat quantification are ultrasonography (US), computed tomography (CT) and magnetic resonance (MR) techniques. US and CT have shown a good sensitivity but a lack of accuracy [1]. In recent years there have been several improvements to the MR imaging and spectroscopy techniques, leading to an excellent accuracy in iron and fat quantification [2]. The clinically applicable MR spectroscopy method "High-Speed T2-corrected Multi-echo" acquisition (HISTO) [3,4] has achieved consistent measures of fat and iron content at 1.5T in phantoms, and has shown strong correlation with biopsy data in patients [5]. The purpose of this study is to quantify the fat content in the liver and the relaxivity of water and fat at 3T with the HISTO technique in subjects with a very low fat fraction in the liver (<15%). The results were validated by comparison to measurements of the same subjects at 1.5T.

Methods: The HISTO sequence [3,4] was acquired with the following parameters: TE set={12, 24, 36, 48, 72}ms, TR=3000ms, voxel=3x3x3cm^3, 1024 points, 1200 Hz bandwidth and 1 signal average per echo. The voxel was placed in a homogenous region of the liver, avoiding vessels and tissue boundaries. The acquisition duration was 15 seconds. The measurement was preceded by a 30 second standard shimming. For every spectrum, simple linear baseline correction and low-pass sliding window filtering were applied. The peaks and the area under the peaks for water and fat were determined and integrated for each measured echo. An exponential T_2 decay fit was calculated from the five water and fat integrals, leading to an estimation of the R_2 and M_0 (the equilibrium magnetization) for water and lipid signals, individually. The quality of the fit was assessed using the R-squared measure of goodness of fit. Subsequently, T_2-corrected lipid content was calculated as:

$$\text{fat \%} = [M_0\text{lipid}/(M_0\text{lipid} + M_0\text{water})] \times 100$$

HISTO liver measurement was performed on seven healthy subjects on 1.5T and 3T scanners (MAGNETOM Aera and MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany), and the voxel positioning was kept as consistent as possible across the different measurements. The spectra that were accepted as reliable were those where the peaks of water had a good quality (i.e. symmetry of the water peak, single peak of water, the full width of water peak at half its maximum height $FWHM_{water}$ < 39 Hz at 1.5T and $FWHM_{water}$ <65 Hz at 3T). The exponential fit of the five echoes was acceptable only for an R-square > 0.96 for the water fit. The R_2 values for a total of 12 voxels were thus obtained at 1.5T and 3T. A linear fit was performed to verify the accuracy of fat content calculated from each magnetic field.

Results and Discussion: In Table 1, the values obtained from seven healthy subjects for the R_2 of water, R_2 of fat and fat % are given. We found good correspondence of fat % obtained at 1.5T and 3T (Fig 1: slope of 1.21 with an R-square=0.97) for subjects with very low fat fraction in the liver (< 15%). In [3] , HISTO has demonstrated an apparent sensitivity to measure low lipid content (subject with 4.8% of fat measured in the liver) at 1.5T with a standard deviation <10% for the same subject on the same scanner. We obtained an average difference of 18% between the lipid content calculated at 1.5T and 3T in subjects with very low fat content (from 1.80% to 13.79% of fat) and different 1.5T and 3T scanners. Taking into account that higher lipid content is easier to detect and quantify, we hypothesise that the accuracy of the fat assessment would increase in the case of fatty-liver patients.

In summary, we measured the liver R_2 values with the HISTO technique at 3T and 1.5T for water and fat, and assessed the T2-corrected lipid content validating its accuracy in subjects with a very low liver fat fraction. Further investigations should focus on a higher number of subjects and different liver pathologies with higher iron concentration and fat content.

	R2 water 1.5T (s^{-1})	R2 water 3T (s^{-1})	R2 fat 1.5T (s^{-1})	R2 fat 3T (s^{-1})	Fat % 1.5T	Fat % 3T
average	27,86	40,42	23,34	32,08	3,89	3,72
stdev	2,14	4,31	5,03	7,87	2,49	1,62
(min-max)	24,01 - 31,76	33,48 - 47,97	15,93 - 33,97	24,40 - 48,74	1,93 - 10,89	1,80 - 13,79

Table 1: R_2 of water, R_2 of fat and fat percentage obtained with HISTO at 1.5T and 3T from 7 healthy subjects.

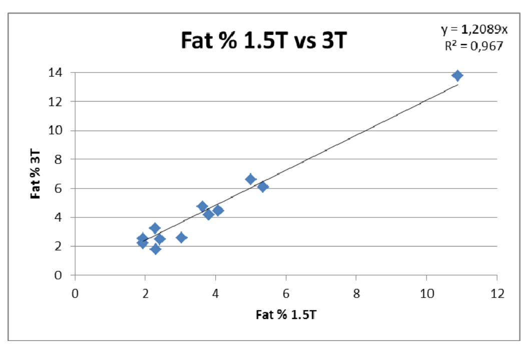

Fig. 1: Linear fit of liver fat % at 1.5T vs 3T.

References:
1. Bohte AE, van Werven JR, Bipat S, Stoker J. Eur Radiol. 2011; 21:87-97.
2. Sharma P, Altbach M, Galons JP, Kalb B, Martin D. Diagn Interv Radiol 2013; DOI 10.5152/dir.2013.13124.
3. Pineda N, Sharma P, Xu Q, Hu X, Vos M, Martin D. Radiology 2009; 252(2): 568-576.
4. Sharma P, Martin D, Pineda N, Xu Q, Vos M, Anania F, Hu X. JMRI 2009; 29:629-635.
5. Sharma P, Kitajima1 HD, Zhong X, Kalb B, Farris AB, Vos MB, Martin DR. Proc. Intl. Soc. Mag. Reson. Med. 19. 2011.