Fat quantification in back muscles with low lipid content: A comparison of SVS, CSI and Dixon measurements

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PURPOSE

Both imaging and spectroscopy methods are available for fat/water quantification. "Dixon" MR Imaging methods calculate separate fat and water images based on the acquisition of in-phase and out-of-phase signals. On the other hand, spectroscopic methods such as single voxel spectroscopy (SVS) and chemical shift imaging (CSI) allow for fat-water quantification by direct spectral analysis. While imaging methods benefit from much higher spatial resolution, spectroscopy methods may separate fat and water signals more reliably and can take more easily into account the complexity of lipid spectra with different lipid resonances. Several studies have already assessed the comparison of Dixon with spectroscopic sequences in different organs such as in the liver[1]. A recent study on a specific back muscle (*bilateral lumbar multifidus*) [2] showed a high correlation between SVS and Dixon lipid determination, but the fat fractions ranged from low to very high percentages. However, a reliable fat contribution determination is clinically important also in a low fat range [3]. The aim of this study was therefore to compare fat quantification determined by Dixon MRI, SVS and CSI in a back muscle *(psoas major)* in healthy subjects for small amounts of lipids only.

METHODS

Volunteers: Back muscles (*psoas major*) of 16 healthy volunteers (4 female, 12 male, age = 33±5y, BMI=24.6±3.7 kg/m^2) were examined on a 3T MR-scanner (Trio, Siemens, Erlangen, Germany). **MR-Method:** A standard two-point DIXON sequence was used for coronal and transversal fat-water imaging, with the following parameters: Dixon coronal (TR = 18ms, TE = 2.45/3.68 ms, FOV = 330×330mm^2, Voxel Size = 0.8×0.8×1 mm^3); Dixon transversal (TR = 7ms, TE = 2.45/3.68 ms, FOV 247×360mm^2, Voxel Size = 0.8×0.8×1mm^3). SVS was acquired with 2 averages (TR = 2020ms, TE = 30ms) without water-suppression, with a size between 15×15×15 mm^3 and 20×20×20 mm^3 depending on the size of the muscle. The SVS voxel was always carefully placed in a region with low muscle fat content, based on the Dixon lipid images. PRESS CSI (32×32 matrix, circular encoding) was acquired with one acquisition (TR = 1060ms, TE = 35ms). Each CSI voxel had a nominal size of 15×4×4 mm^3. Saturation bands were placed around the excited volume to minimize contamination from surrounding fat. **Result analysis:** Spectral processing of the SVS and CSI data included weak spectral and (for CSI) spatial apodization, phase-correction and fitting of the water and four lipid resonances, including the methylene protons $(CH_2)n$ at 1.3-1.6 ppm from extramyocellular lipids and also fitting the intramyocellular lipids at 1.27ppm. Here, we report only on the fitting results for the methylene peak for comparisons with the Dixon images. For CSI processing 12 voxels were averaged at the position of SVS location to allow for a comparison of the results. The spectroscopy results were corrected for T1 using literature values ($T1_{H2O}$=1400ms, $T1_{Lip}$=370ms) because of different TR used for SVS and CSI. For the Dixon results, an ROI approximating the SVS size and position (Fig.1) was analysed using an in house developed program for DICOM image segmentation, iSix (Image Segmentation in OsiriX) [4]. Results from each method (SVS, CSI and Dixon) were statistically compared.

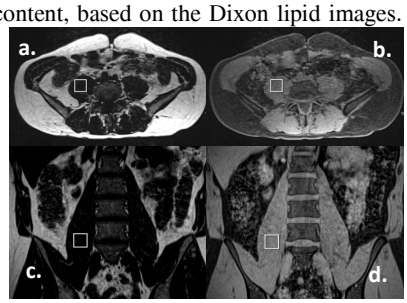

Figure 1: Dixon Images a. Transverse Fat, b. Transverse Water, c. Coronal Fat, d. Coronal Water. Voxel placed in the *Soas Major* Muscle.

RESULTS

Spectroscopic results showed low fat content in the selected part of the muscle. A strong correlation was obtained for SVS and CSI results (Fig. 2, R^2 = 0.8, p<0.0001), with a fat range between 1% and 8%. The data were very close to the identity line (slope close to 1) and the offset was small (0.3). On the other hand, transverse and coronal Dixon results from ROIs placed at the same position as the spectroscopy voxels did not correlate significantly with any of the two spectroscopic methods used Dixon quantification yielded always significantly higher results than SVS and CSI. However, this comparison does not account for required corrections, e.g. for T1. Dixon results are in the same range for coronal and transverse images from the same volume, however, transverse and coronal Dixon results were not significantly correlated.

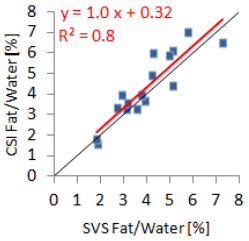

Figure 2: CSI- SVS correlation from back muscle fat quantification

DISCUSSION

This fat quantification study in a back muscle *(psoas major)* in healthy subjects with a high correlation between the spectroscopy methods suggests that SVS and CSI are able to reliably detect small amounts of lipid within the muscle, while the Dixon measurements failed to detect lipid variations in this small range and tended to overestimate the low fat content. The higher fat content in Dixon images and the lack of correlation is most likely due to residual respiratory motion artefacts, which were visually more prominent in transverse than in coronal images. Overestimation of fat contents by Dixon methods compared to spectroscopy methods has also been described before for the liver, particularly for liver fat fractions below 10% [1]. Therefore, for back muscle imaging, it might be beneficial to reduce this movement by respiration triggering, with the drawback of increasing considerably the acquisition time. It has already been reported that low fat ranges are more dependent on "Rician" noise related errors in magnitude images [5] and is confirmed here for our low fat content back muscle measurements. As coronal Dixon images showed fewer artefacts, coronal orientation might be preferred for investigating muscles of the back. Our results show that both SVS and CSI are more precise in the case of a low range of fat content. A clear limitation of our study was that we applied a standard two-point Dixon method, while more advanced fat/water imaging methods are available. However, it is unlikely that these advanced methods would considerably reduce the respiration motion related artefacts, which are likely the main cause for the variability.

CONCLUSION

Back muscle low fat content quantification can reliably be quantified by spectroscopy MR techniques (SVS and CSI), while noise and artefacts limit the preciseness of Dixon MRI for low fat quantification.

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REFERENCES

1. Kim H. et al., Magn Reson Med, 2008; 59: 521. 2. Fischer et al., Radiology, 2013; 266: 555. 3. Fischman et al., J Neurol, 2012; 259:1648, 4. Valenzuela et al., "iSix (Image Segmentation in OsiriX)". ESMRMB Ann. Meeting 30: 697(2013) 5. Liu C.Y. et al. Magn. Reson. Med, 2007; 58: 354.