Iterative Decomposition of Water and Fat with Echo Asymmetric and Least-Squares Estimation (IDEAL) Compared to T1-weighted Spin Echo in the Evaluation of Vertebral Body Lesions

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Objective: Although Iterative Decomposition of Water and Fat with Echo Asymmetric and Least-Squares Estimation (IDEAL) depicts pathology effectively by suppressing fat, it has not been used to characterize fat content in spinal lesions. Conventionally, T1-weighted spin echo (T1W-SE) has been the preferred sequence for high intensity detection of fat content for any tissue including the spine. Here, we compare the effectiveness of IDEAL fat-selective images to conventional T1W-SE images for depiction of vertebral body lesions with reduced or increased fat content.

Methods: 27 patients referred for spine MRI for a variety of indications underwent 2D FSE imaging with asymmetrically timed 3-point echo detection optimized at 1.5T and 3T. In addition to conventional T1W-SE images, IDEAL images were acquired with an intermediate T2-weighting at 1.5T: TR/TE= 3500/70 ms and a high T2-weighting at 3T: TR/TE= 3500/100 ms.

48 vertebral body lesions were identified. Contrast characteristics of the lesions were obtained by computing signal ratios for each of the lesions compared to background fat in adjacent vertebrae (lesion/background signal ratio) within the fat-selective IDEAL and T1W-SE image slices. A comparison was made of signal intensity in the depot fat posterior to the spine to the cerebrospinal fluid within the thecal sac (fat/water ratio) to assess overall contrast between fat and water.

Two observers compared the T1W-SE and IDEAL fat-selective images for overall image quality, sharpness, presence of motion and lesion depiction.

Results: Lesion/background signal ratios < 1 (i.e. fat-depleted lesions) were observed in 21 of 48 lesions. Lesion/background signal ratios > 1 (i.e. fat-accumulating lesions) were noted for the other 27 lesions. Mean signal ratios for fat-depleted lesions were 0.58 (SD 0.14) on T1W-SE images, and 0.25 (SD 0.23) on IDEAL fat-selective images, suggesting that IDEAL results in significantly higher contrast between lesions and adjacent vertebral bodies than T1W-SE (two-tailed t-test, $p < 0.05$). Similar findings were noted for fat- accumulating lesions with mean signal ratios of 1.47 (0.17) for T1W-SE and 1.83 (0.62) for IDEAL; $p < 0.05$. Fat-selective IDEAL images showed significantly higher fat/water contrast of 75.77 (SD 38.17) than T1W-SE images 15.15 (SD 8.31); $p < 0.001$.

Compared to T1W-SE, both observers reported better lesion depiction in 42 of 48 lesions for the IDEAL fat-selective images.

Conclusions: IDEAL fat images demonstrated significantly higher contrast between lesions and adjacent vertebrae than conventional T1W-SE at 1.5T and 3T, implying higher sensitivity in detecting vertebral body lesions. We are currently expanding the application of IDEAL fat images for characterizing a larger set of vertebral abnormalities; here we report increased conspicuity of lesions with IDEAL compared to T1W-SE images, both subjectively and by objective quantitative validation. It is particularly encouraging that the fat/water ratio, which is a signature of T1W-SE, is much higher for fat-selective IDEAL images. We note that the IDEAL acquisition parameters used here are T2-weighted and the observed contrast is based on the fat/water chemical shift rather than on T1 differences. Therefore, although the contrast ratios may change with different parameters, our results suggest that the advantage of IDEAL fat images over conventional T1W-SE may be agnostic to the timing parameters.