ITERATIVE DECOMPOSITION OF WATER AND FAT WITH ECHO ASYMMETRY AND LEAST-SQUARES ESTIMATION (IDEAL) IMAGING OF THE CERVICAL SPINE: CLINICAL EFFICIENCY COMPARED WITH CONVENTIONAL MR

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Synopsis:
T2-weighted (T2W) iterative decomposition of water and fat with echo asymmetry and least-squares estimation (IDEAL) – fast spin echo (FSE) imaging can provide good uniformity of fat suppression, but the clinical efficiency is not evaluated. The purpose of this work was to evaluate the clinical efficiency of T2W IDEAL FSE imaging of the cervical spine, compared with conventional fat-saturated T2W FSE, including quantitative measurements of SNR and SNR efficiency and qualitative scoring of diagnostic image quality and fat suppression.

Introduction:
For a better diagnosis in cervical spine disease, reliable and homogeneous fat suppression on T2W images is important and necessary because high intensity of fat on T2W images may obscure some lesions. IDEAL –FSE is used clinically for a better fat suppression. IDEAL-FSE is a kind of chemical shift-based water-fat separation methods by exploiting differences in the resonant frequency of water and fat. In this method, three images with small relative shifts in the echo time (TE) are obtained with an iterative algorithm and a least-squares pseudoinverse operation and thus the local inhomogeneities in the magnetic field can be measured directly. Therefore, IDEAL-FSE can correct the chemical shift artifact in the readout direction and obtain a better imaging quality in fat suppression. These TE shifts can achieve the best possible SNR performance of the water-fat decomposition when the first and third echoes are acquired $2\pi/3$ before and $2\pi/3$ after the center echo, respectively. Compared with conventional fat-saturation sequences, IDEA-FSE can provide higher SNRs. However, one prominent drawback to the IDEAL method is the additional increase in scanning time, required by the multipoint data acquisition, and it may limit the widespread use.

Materials and Methods:
Institutional review board approval and informed consents were obtained. We recruited 100 patients undergoing routine MR imaging of the cervical spine. No patient was excluded from the study on the basis of any factor, including age, weight, severity of neurologic deficit, history of prior spine surgery, or quality of the MR examination. All patients received conventional MR imaging, consisted of a sagittal frequency-selective fat-suppressed T2W FSE sequence, an axial MERGE T2W sequence, a sagittal SE T1-weighted (T1W) sequence, and a axial SE T1W sequence. After the non-enhanced conventional MR sequenced, a sagittal T2W IDEAL FSE sequence was performed and water images was auto-calculated by the manufacturer-supplied console. The qualitative and quantitative evaluations of frequency-selective fat-suppressed T2W imaging and the T2W IDEAL water imaging were performed after decoding of the personal and sequence data.

RESULTS:
Totally, 100 patients (49 female and 51 male) were enrolled in this study. 16 patients (9 female and 7 male) had metallic internal fixation. All of the quantitative data, including signal-to-noise ratios (SNR), contrast-to-noise ratios (CNR), SNR efficiency (SNReff) and CNR efficiency (CNReff) in the IDEAL group showed significantly higher than that in the FS TSE group (all p<0.001) (Fig. 1). Figure 2 showed the qualitative data. In the qualitative evaluation, the IDEAL sequence showed better fat suppression (Fig. 3) and lesser metallic artifact (Fig. 4) than the FSE FS T2W sequence. However, the FSE FS T2W sequence was better than the IDEAL sequence in the overall quality, motion artifact (Fig. 5) and CSF homogeneity (Fig. 6).

Discussion:
In this present study, we evaluated the clinical efficiency of T2W IDEAL sequence in the routine cervical spine MR examination. The IDEAL sequence showed higher SNR, CNR, SNR efficiency and CNR efficiency than the FSE FS T2W sequence. As the expectation, the IDEAL sequence showed excellent fat suppression and improved the metallic artifacts. However, a longer scan time made the motion artifacts more severe in the IDEAL sequence than in the FSE FS T2W sequence and resulted in a worse overall quality and a lesser homogeneity of CSF.

Conclusion:
The results of our study have shown that T2W IDEAL-FSE imaging provides high-SNR images with excellent fat suppression and less metallic artifact for clinical evaluation of the cervical spine. However, a long scan time and relatively significant motion artifacts make that T2W IDEAL-FSE imaging is considered as an additional sequence only in patients with poor fat suppression or severe metallic artifacts under conventional fat suppressed FSE T2W imaging.

References:
1. Reeder SB, Pineda AR, Wen Z, Shimakawa A, Yu H, Brittain JH, Gold GE, Beaulieu CH, Pelc NJ (2005) Iterative decomposition of water and fat with echo asymmetry and least-squares estimation (IDEAL): application with fast spin-echo imaging. Magn Reson Med 54:636-644.
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3. Gerdes CM, Kijowski R, Reeder SB (2007) IDEAL imaging of the musculoskeletal system: robust water fat separation for uniform fat suppression, marrow evaluation, and cartilage imaging. AJR Am J Roentgenol 189:W284-291

Figure 1: Quantitative evaluation between IDEAL sequence and FSE FS T2W sequence.
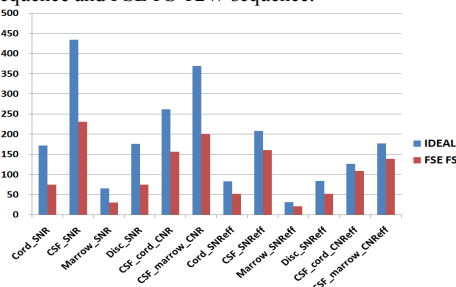

Figure 2: Qualitative evaluation between IDEAL sequence and FSE FS T2W sequence.
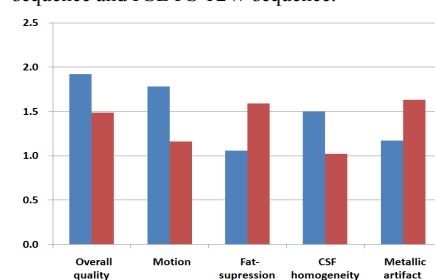

Figure 3: Comparison of the motion effect on (a) IDEAL sequence and (b) FSE FS T2W sequence.
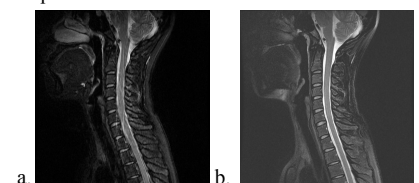

Figure 4: Comparison of the metallic artifacts on (a) IDEAL sequence and (b) FSE FS T2W sequence.
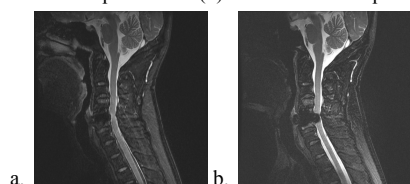

Figure 5: Comparison of the fat-supression effect on (a) IDEAL sequence and (b) FSE FS T2W sequence.
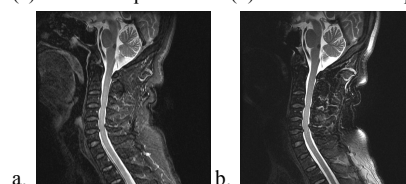

Figure 6: Comparison of the CSF homogeneity on (a) IDEAL sequence and (b) FSE FS T2W sequence.