Comparison of IDEAL, MultiPeak IDEAL and Fat-Saturated FSE for Imaging of Osteoarthritis (OA) Knee Patients: Initial Clinical Experience

J. Zhao[1,2], R. Bolbos[1], A. Shimakawa[3], H. Yu[3], X. Li[1], S. Majumdar[1], and T. Link[1]

[1]Radiology Department, University of California San Francisco, San Francisco, California, United States, [2]Radiology Department, The Third Hospital of Hebei Medical University, Shijiazhuang, Hebei, China, People's Republic of, [3]GE Healthcare – ASL West, Menlo Park, California, United States

INTRODUCTION

Iterative Decomposition of Water and Fat with Echo Asymmetry and Least-Squares Estimation (IDEAL) is a promising MRI technique for robust fat and water separation (1). It was found with higher fluid/cartilage contrast-to-noise ratio efficiency and fat-suppression quality than FSE imaging in ankle. The goal of this study is to assess image quality, fat suppression and fat-water separation of single-peak IDEAL (1) and multiple-peak IDEAL (3) imaging to fat saturated fast spin-echo (FSE) imaging in knee osteoarthritis (OA) patients.

METHODS

Twenty patients (12 male, 8 female, mean age 40.8 ± 12.5 years) with clinically diagnosed knee OA underwent MRI at 3T (Signa, GE Medical Systems). The MRI protocol included sagittal fat-saturated FSE images (TR/TE = 4300/51ms, matrix = 512×256, slice thickness 2mm with gap of 0.5mm), sagittal IDEAL images based on FSE sequence acquired with an investigational version of IDEAL (2) (using the same parameters as FSE imaging). The acquired IDEAL data were processed with two reconstruction approaches: 1) the original IDEAL algorithm that models fat as single resonant frequency (termed as single-peak IDEAL or SP IDEAL) and 2) an improved IDEAL algorithm with multi-frequency modeling of fat signals (3) (termed as multi-peak IDEAL or MP IDEAL). IDEAL water-only images from these two methods and conventional fat-saturated FSE imaging were analyzed in this study. Image quality was scored by a musculoskeletal radiologist using a 4-point scale: 1, poor; 2, fair; 3, good; 4 excellent. The signal intensity (SI) of cartilage, fluid, bone marrow, bone marrow edema like lesion (BMEL) was measured in the same location of all these three sequences. Cartilage SNR efficiency and fluid SNR efficiency were calculated, as well as fluid/cartilage contrast-to-noise ratio (CNR) and BMEL/bone marrow CNR. A paired t-test was used to compare the cartilage SNR efficiency, fluid SNR efficiency, fluid/cartilage CNR and BMEL/bone marrow CNR, respectively. Signed rank test was used to compare the score of image quality between SP IDEAL, MP IDEAL and FSE.

RESULTS

IDEAL water-only images show a more uniform fat suppression compared to fat-saturated FSE, especially in MP IDEAL images. In addition, metal-artifacts caused by interventions were significantly reduced with IDEAL images (Figure 1). Image quality scores were found significantly improved in MP IDEAL (3.6 ± 0.5), when compared with SP IDEAL (3.1 ± 0.2) and FSE imaging (3.2 ± 0.5). Cartilage and fluid SNR efficiency were found similar between SP IDEAL, MP IDEAL and FSE sequences (11.7 ± 2.7 and 31.6 ± 6.4 for SP IDEAL; 12.3 ± 3.0 and 33.1 ± 6.9 for MP IDEAL; 15.8 ± 3.3 and 29.7 ± 6.7 for FSE, p>0.05). However, fluid/cartilage CNR efficiency was found significantly higher for SP IDEAL (42.0 ± 11.1) and MP IDEAL (43.9 ± 11.9) compared to FSE imaging (30.3 ± 12.1, p=0.0025 for SP IDEAL, p=0.0005 for MP IDEAL). No significant difference of fluid/cartilage CNR was found between SP IDEAL and MP IDEAL.
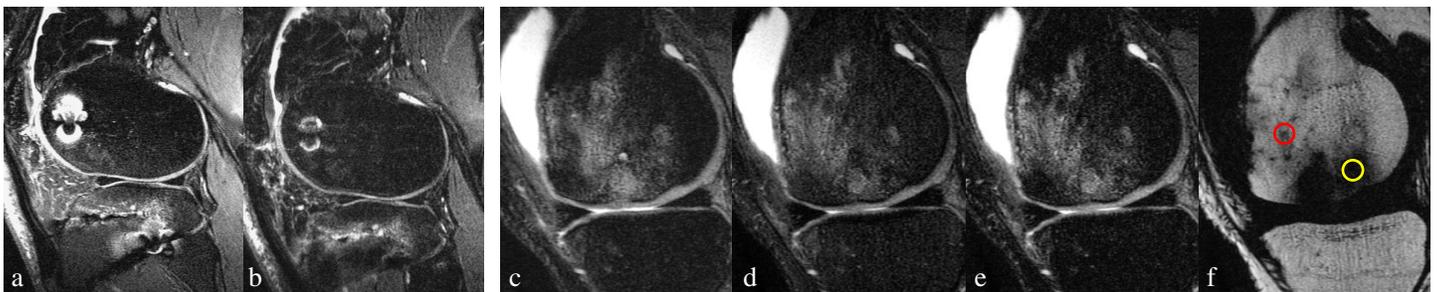

Figure 1. IDEAL water-only images showed significantly improved fat suppression and decreased metal artifacts compared to FSE images. (a) FSE images showed significant metal artifacts in an OA patients with interventions. (b) MP-IDEAL water-only images showed significant reduction of metal artifact and better fat suppression in bone marrow. (c)-(f): FSE, SP-IDEAL water images, MP-IDEAL water images and MP-IDEAL fat images for an OA patient with large BMEL. ROI red within BMEL had significant fat contents while ROI yellow with BMEL had little fat contents.

DISCUSSION

The IDEAL sequence can provide excellent contrast between cartilage and fluid. Image quality (in particular fat suppression) was improved significantly with uniformed fat suppression and less metal artifacts with IDEAL images compared to conventional fat-suppressed FSE images, especially in MP IDEAL images. In this study, the BMEL/bone marrow CNR were found to be similar for SP IDEAL (11.0 ± 4.6), MP IDEAL (12.7 ± 6.8) and FSE imaging (10.9 ± 5.3, p>0.05), although by visualization, MP IDEAL provided a better BMEL CNR than SP IDEAL and FSE imaging (Figure 2). This can be partially explained by that the BMEL also contains fat contents (Figure 1f) and therefore the signal intensity in BMEL was also lower with a good fat suppression (in MP IDEAL), which resulted in a similar BMEL CNR between MP BMEL, SP BMEL and FSE. Interestingly, we have observed that some BMELs had significant fat contents but some BMELs showed very little fat content (ROI red and ROI yellow in Figure 1f respectively for example). The latter may be a pre-stage of cysts or have a high risk of developing into cyst. IDEAL images provide us valuable information that may potentially help with further understanding BMELs in OA.

REFERENCES

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