**Objective:** Iterative Decomposition of water and fat with Echo Asymmetry and Least squares estimation (IDEAL) is a chemical shift fat-water separation method that uses asymmetric echoes and least square fitting in order to achieve the maximum possible SNR performance (1). Most chemical shift fat-water separation techniques including IDEAL use a single signal model in which fat is modeled as a single resonance peak. Since fat consists of multiple chemically distinct moieties which give rise to at least 6 resonance peaks, these techniques fail to suppress up to 15% of signal arising from fat protons (2). An advantage of IDEAL is that its signal model is easily modulated to include multiple fat peaks, so long as the resonance frequencies and relative amplitudes of these peaks are known a priori (3). The purpose of this study was to evaluate and quantify improvements in the quality of fat suppression for fast spin-echo (FSE) imaging of the knee using more accurate, multi-peak spectral modeling of fat and IDEAL fat-water separation.

**Methods:** T$_1$-weighted FSE sequences (TR/TE=850ms/19.3ms, FOV=14cm, matrix=384x224, slice thickness=3mm, bandwidth=31.25kHz, signal averages=3 for frequency fat-saturation methods and 1 for IDEAL, scan time=4:48 min) and T$_2$-weighted FSE sequences (TR/TE=5000ms/81ms, FOV=14cm, matrix=384x224, slice thickness=3mm, bandwidth=41.67kHz, signal averages=3 for frequency fat-saturation methods and 1 for IDEAL, scan time=3:35 min) with IDEAL fat-water separation and 2 frequency-selected fat-saturation methods (fat-selective saturation and fat-selective partial inversion) were performed at 3.0T in 10 knees of 5 asymptomatic volunteers using a single channel extremity coil. T$_2$-weighted FSE sequences with fat-selective saturation and IDEAL fat-water separation were performed at 3.0T on the knees of 10 patients with acute post-traumatic bone marrow contusions using identical imaging parameters and an 8-channel phased array extremity coil. The IDEAL images were reconstructed using a single-peak method and an investigational version of a self-calibrated multi-peak method that more accurately model the NMR spectrum of fat. SNR was measured in various tissues for the sequences performed on the 5 asymptomatic volunteers. Student t-tests were used to compare SNR values. Two fellowship-trained musculoskeletal radiologists ranked the sequences performed on the 10 patients with acute post-traumatic bone marrow contusions according to the following subjective criteria of image quality: 1) quality of fat-suppression, 2) overall tissue contrast, and 3) conspicuity of bone marrow edema. Exact binominal tests were used to compare the ranks given to each sequence.

**Results:** Multi-peak IDEAL had significantly greater (p<0.05) suppression of signal of subcutaneous fat and bone marrow than fat-selective saturation, fat-selective partial inversion, and single-peak IDEAL for both T$_1$-weighted and T$_2$-weighted FSE sequences (Figures 1 and 2). For T$_1$-weighted FSE sequences, multi-peak IDEAL had between 66% and 84% greater suppression of signal of subcutaneous fat and bone marrow. For T$_2$-weighted FSE sequences, multi-peak IDEAL had between 21% and 81% greater suppression of signal of subcutaneous fat and bone marrow. On subjective analysis, T$_1$-weighted FSE sequence with multi-peak IDEAL was ranked significantly higher (p<0.05) than T2-weighted FSE sequences with fat-selective saturation and single-peak IDEAL for quality of fat-suppression, overall image quality, and conspicuity of bone marrow edema (Figure 3).

**Conclusion:** Multi-peak IDEAL fat-water separation provides improved fat-suppression for both T$_1$-weighted and T$_2$-weighted FSE imaging of the knee when compared to single-peak IDEAL and two widely used frequency-selected fat-saturation methods. The greater suppression of signal within bone marrow and subcutaneous fat may improve the conspicuity of pathologic conditions as demonstrated in our patients with post-traumatic bone marrow contusions.