# Optimizing 3D FSE FS Sequences of the Knee at 3 T for Clinical Use, Automated Segmentation, Quantitative Analysis of Articular Cartilage and Templating for T2 Maps: Creating a Single MR Data Set for Morphological and Quantitative Functions

Joshua Michael Farber[1], Jose tamez-Pena[2], saara Totterman[3], Hubert LeJay[4], Edward Schreyer[3], and Karl Baum[3]
[1]*Radiology, Qmetrics/Rad Ass of N KY, Cincinnati, Ohio, United States,* [2]*Mathematics and Statistics, Tec de Monterrey, Monterrey, NL, Mexico,* [3]*Imaging, Qmetrics, Rochester, NY, United States,* [4]*MRI - Global, GE, Milwaukee, Wisconsin, United States*

**OBJECTIVE**: To: 1) Develop and present the imaging parameters of a single, multifunctional 3D FSE FS sequence for the knee that is robust and accurate in a conventional clinical setting for the evaluation of internal derangement, and which can be segmented as well, automatically, for quantitative analysis of the articular cartilage (AC); 2) To demonstrate the automated transformation of the segmentations into 3D AC thickness maps, and the fusion of these AC segmentations with T2 Map data to create 3D renderings of the T2 Map data.

**Methods**: At 3 T (Optima 750W, GE, Milwaukee) a 3D FSE sequence (CUBE) was optimized first for clinical use, for evaluation of the ligaments, AC, marrow, muscles and tendons, and other structures about the knee. A 16 channel medium sized flex coil was used. The FOV = 16 cm, with an in-plane resolution of 384 x 384 or 416 x 416. The slice thickness varied from 0.6 mm – 0.9 mm. The TR ~ 2300, and the TE ~ 20. A fat sat in the low 80 % (Classic), was used. The ETL varied from 30-45, and the acceleration factors varied from 1.5 to 2.0. Total scan time per knee was < 4 minutes. Two dedicated MSK radiologists, each with over 15 years of experience, evaluated the images for clinical utility. The data sets from images deemed best for clinical use were then sent to a dedicated work station for segmentation (Qmetrics, Rochester, NY); the platform has been validated (1). Once approved, these segmentations were automatically 3D rendered into AC thickness maps, which subsequently were fused with T2 Maps to create 3D T2 Maps.

**Results**: With appropriate parameters, a 3D FSE FS sequence can produce robust images for accurate clinical use, and can provide the data substrate for unsupervised segmentation and 3D AC thickness map rendering. These 3D renderings can serve as a template to create 3D T2 Map renderings (Figure 1).

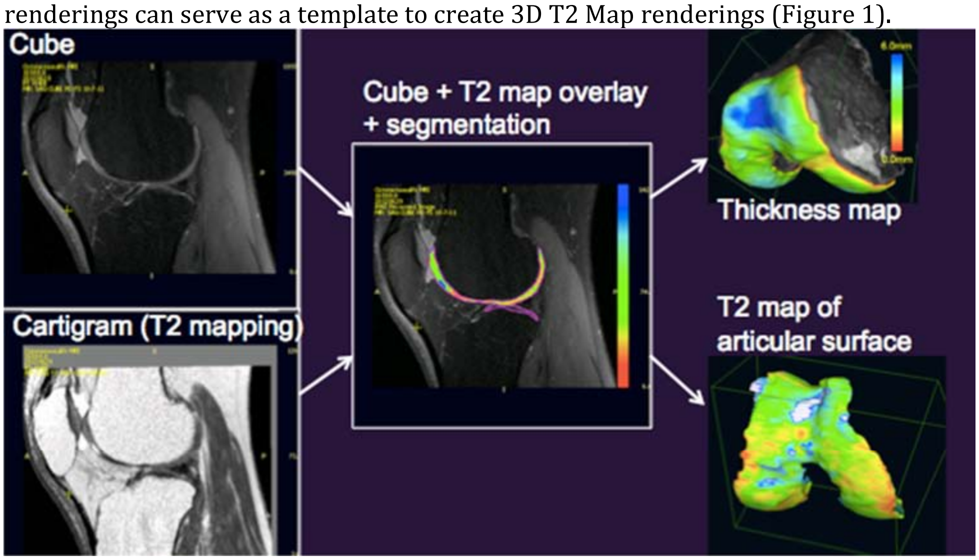


**Figure 1**: Top left 3D FSE data set is useful for clinical imaging, and can be segmented automatically (middle image), from which AC thickness maps can be rendered (top right image). A T2 Map (bottom left image) can be fused with the 3D FSE data set (middle image), and a 3D T2 Map can be rendered from the fused data. (Figure is courtesy of Hubert LeJay, GE Healthcrae)

**Conclusion**: Current soft ware, gradients and coil technology allow the acquisition of single MR data sets that can be used for traditional clinical purposes, and can be used as well for segmentation and quantitative analysis. That single sequences can serve these multiple functions allows morphological and quantitative data to be collected during routine exams with reasonable scan times. The ability to collect these rich MR data sets routinely on all patients facilitates longitudinal observations and the development of MRI biomarkers, which improves ultimately patient care and resource utilization.

**References**: 1) Unsupervised Segmentation and Quantification of Anatomical Knee Features: Data From the Osteoarthritis Initiative. Tamez-Pena, J, et al. IEEE Transactions on Biomedical Engineering; April 2012; Vol 59; No 4; pp 1177-1186. 2) MR Imaging and T2 Mapping of Femoral Cartilage. Goodwin, D, et al, AJR; 2001; 177; pp 665-669. 3) Magnetic Resonance 3D FSE Technique in the Knee: Bridging Clinical and Research Imaging. Farber, JM, et al. ICRS Newsletter, Special Focus: Imaging 2012; Vol 15;pp23-24.