Clinical evaluation of elliptical centric fat suppressed time resolved imaging in liver tumor characterization

M. Saranathan[1], R. Venkatesan[2], V. Ramanan[2], A. Padmanabha[3], R. Vadapalli[3]

[1]Dept. of Electrical Engineering, Indian Institute of Science, Bangalore, Karnataka, India, [2]GE Healthcare, Bangalore, Karnataka, India, [3]Asiri Surgical Hospital, Colombo, Sri Lanka

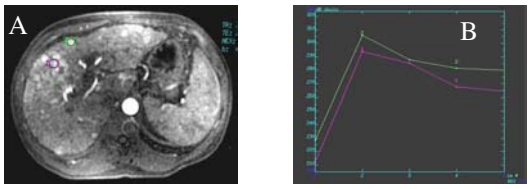
Introduction: Clinical evaluation of a fat suppressed elliptic centric TRICKS (FSTRICKS) pulse sequence for high spatio-temporal resolution dynamic imaging and characterization of liver tumors was the primary purpose of this study. A secondary objective was to assess its potential in providing a pre-surgical planning roadmap in the clinical management of hepatic tumors and lesions. FSTRICKS' role in adequately characterizing and differentiating malignant and benign liver tumors such as HCC (singular tumor or multi-centric nodules with cirrhotic livers), metastatic lesions, focal nodular hyperplasia (FNH), hemangiomas and cystic lesions were studied. MRI study results were correlated with clinical histopathology on all patients studied.

Theory: An optimal, variable-rate fat-selective IR prep based elliptic centric fatsat scheme was initially reported in [1]. Its use in combination with TRICKS, a pulse sequence thus far used only for MRA, in multiphasic dynamic abdominal imaging was demonstrated in [2]. This FSTRICKS sequence was optimized for imaging contrast dynamics of malignant and benign lesions of the liver, with the aim of obviating the need for specific timing of the contrast bolus. By using a 4-region split of elliptic centric (ky,kz) space, the time required for each reconstructed phase was reduced by a factor of 4 and parallel imaging enabled another factor of 2 reduction (3.5s/phase). Each 4-region set was acquired in a short 14s breath-hold and 4 such breath-holds were needed to reconstruct a total of 10 phases. This ensured that the early arterial phase is covered in phases 2-3, the late arterial phase in phases 4-5, the early portal venous phase in phases 6-7, the later portal and hepatic venous phases in phases 8-9, and late equilibrium phase in phase 10.

Methods: 30 subjects (aged 11 to 68 years, male-to-female ratio of 3:1) with suspected liver lesions were recruited for this study, and imaged after prior informed consent on a GE 1.5T Excite system (GE Healthcare, WI, USA) using an 8-channel phased array coil. Following a localizer scan, axial and coronal 2dfiesta images were acquired to locate cystic and other suspected lesions. In/out-of-phase dual echo fgre acquisitions for detecting fatty infiltrations were then acquired. Dynamic data acquisition was started 5s following a 10-15cc injection of Gd-DTPA contrast agent using the 3D FSTRICKS sequence . The sequence parameters were as follows: 15deg flip; +/-62.5 kHz bandwidth; TR/TE=3.9ms/1.4ms; 44 4.8 mm thick slices ; 34cmx 31cm FOV; 256x192 matrix; 0.75 NEX, ASSET factor 2. Lesions were categorized by their temporal behavior from arterial phase to late equilibrium phase. Multiphasic MIPs were generated for arterial phase enhancing lesions to determine the segmental localization of the tumor. Tissue samples were surgically biopsied from each subject, and histopathological data were obtained for correlation with imaging results.

Results: The reconstructed phase 1 was found to be always a pre-arterial phase (appearance of contrast in heart), and the true arterial phase (indicated by hepatic arterial enhancement, non-opacity of hepatic veins and the classical "nutmeg" appearance of the spleen) was never missed on any patient (n=30). HCC's were seen to enhance and also reach peak enhancement in the early arterial phase, and wash out early (Fig 1). It was also possible to reconstruct MIPs of the early arterial phase images to demonstrate the vasculature feeding the tumor, thereby allowing determination of the segmental localization of the tumor, a critical input to the hepatic surgeon in determining which section of the liver to resect. Metastasized lesions, on the other hand, were seen to enhance late and reach a plateau only in late venous phase, whereas cysts remain non-enhancing throughout (Fig 2). FNH lesions were seen to demonstrate the characteristic early enhancement with a star pattern in the center with reducing lesion conspicuity in later phases, associated with increasing liver parenchymal enhancement. Hemangiomas were seen to demonstrate the characteristic irregular early rim enhancement which progressed inward as the lesion is visualized through the multiple phases (Fig 3). Sensitivity and specificity were calculated to be 95% and 90% respectively (n=30).

Conclusion: An FSTRICKS based liver imaging technique with high spatial and temporal resolution has been developed. Initial results from a clinical study show that this technique provides adequate temporal and spatial resolution to allow differentiation of commonly occurring malignant and benign tumors in the liver with high sensitivity and specificity, as correlated with clinical pathological findings. Results are also encouraging for this technique to guide pre-surgical planning because of its strong role in determining the topology and morphology of the tumors as well as the vascularity / segmental localization of the tumors. A larger clinical trial is in underway to assess this and the predictive power of the sequence, following encouraging initial results. Automated functional characterization (of tumor perfusion) via time-course analysis of contrast enhancement will require spatial registration of phases acquired across different breath-holding periods, and this will be an area of active research in the future.



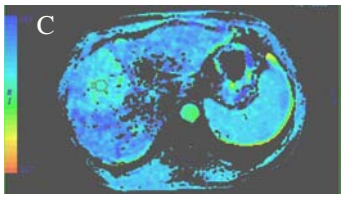


Fig 1. Multiphasic data from a patient with HCC. (A), (B) Signal behavior in ROI's showing fast wash-in and wash-out of contrast in HCC, highlighted by a short mean time to enhance in the same location, as shown in (C).

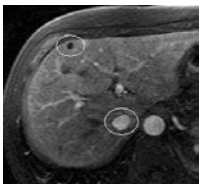
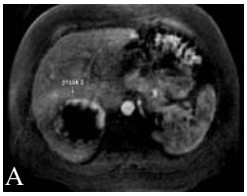


Figure 2. Late enhancing metastatic lesion (indicated by the lower circle) in the 10th phase in a patient with primary lung cancer. Compare with the cystic lesion (indicated by the upper circle), which does not enhance at all.



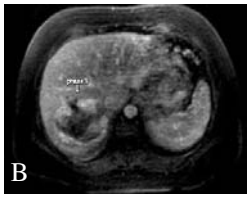


Fig 3. Multiphasic images from a hemangioma patient. (A) True arterial phase shows only a discontinuous rim enhancing lesion; (B) By late venous phase, the lesion stays enhanced, exhibiting delayed washout.

References:

[1] Saranathan, et al. Proc ISMRM 2005; **2206.** [2] Saranathan, et al. Proc ISMRM 2005; **2721.**