Resolution Enhanced TOSSI (T-One insensitive Steady State Imaging)

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Introduction: Pure T2 contrast can be generated using steady state acquisitions, a.k.a. TOSSI (T-One insensitive Steady State Imaging), by applying non-uniformly spaced inversion pulses which align the magnetization in states parallel and anti-parallel to B_0 in a way that mitigates T1 relaxation[1-3]. While the method has been demonstrated for neuroimaging, its use in the body imaging has been hampered by low spatial resolution in this single-shot acquisition. A method to simultaneously increase the spatial resolution of body TOSSI images while reducing imaging time and SAR deposition is presented.

Methods: Resolution Enhanced (RE) TOSSI can be thought of as a combined acquisition technique (CAT)[4]. Instead of repeatedly inverting the magnetization for the entire image acquisition as is done in traditional TOSSI, an initial TOSSI imaging block is followed by a TrueFISP acquisition (Figure 1a). Simulations of the magnetization evolution were performed using Matlab (The MathWorks Inc., Natick, MA) using: T1 range 150-2250 msec, T2 range 25-1000 msec, FA = 50, TR = 5 msec, 1 read per antiparallel block (rpd). For actual human imaging, an asymptomatic human volunteer was placed in the bore of a 1.5 T MR scanner (Siemens Espree, Erlangen, Germany). HASTE (TE/TR = 62/1090 msec), traditional TOSSI (TEeff = 85 msec, TR = 5.2 msec, FA = 50, 1 rpd, half Fourier), RE TOSSI images (TEeff = 96 msec, λ = 0.2), TSE (60/3000) and TrueFISP (TR=4msec) were acquired with a 32 cm FOV, 256 matrix and 5 mm slice thickness.

Results: Figure 1b demonstrates the simulated longitudinal magnetization magnitude during conventional TOSSI acquisitions. Species with differing T1 values are grouped according to their respective T2 values (each color represents a different T2 value). Figure 1c demonstrates the magnetization evolution during RE-TOSSI. These simulations show that by eliminating the later inversions, the signal in the outer regions of k-space is increased compared to traditional TOSSI and the point spread functions (PSF) become sharper for short T1-short T2 tissues (figure 1d). Figures 1e-g show human abdominal images acquired using HASTE, traditional TOSSI and RE TOSSI. The salient differences are summarized below.

Sequence	Imaging Time (sec)	SAR (W)	Resolution	Fat Signal
HASTE	1.1	205.4	OK	Bright
TOSSI	1.9	185.0	Worse	Dark
RE TOSSI	0.8	47.8	Better	Dark

Figures 1h and 1i show comparison TrueFISP (bright fat) and TSE images (breathing artifacts).

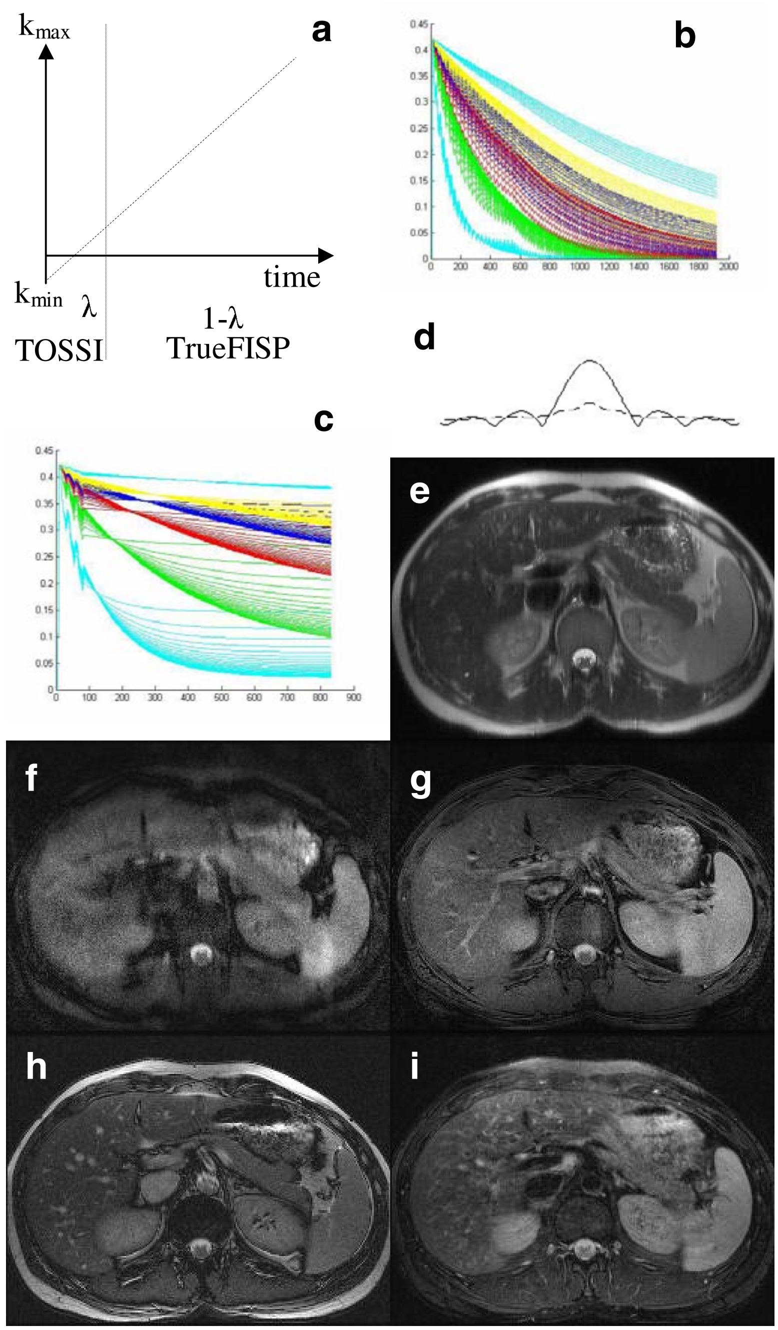

Fig. 1. (a) RE TOSSI combined acquisition technique (CAT). **(b)** Simulated TOSSI and **(c)** RE TOSSI signal decay. **(d)** Point spread functions of RE TOSSI (solid) and traditional TOSSI (dashed) for short T1-short T2 species (150/25 msec). In vivo human abdominal imaging results: **(e)** HASTE, **(f)** traditional TOSSI and **(g)** RE TOSSI, **(h)** TrueFISP and **(i)** T2W TSE.

Conclusions: RE-TOSSI method retains the benefits of pure T2 weighted imaging afforded by TOSSI. Compared to traditional TOSSI there is a significant increase in spatial resolution for short-T1 short-T2 tissues (e.g., abdomen). A 58% savings in imaging time and 74% less RF power can be realized. RE TOSSI produces TSE like contrast with much shorter time. RE TOSSI produces different contrast than TrueFISP. Compared to HASTE, there is also a gain in resolution, a 27% faster imaging rate, a 77% decrease in SAR and the benefit that fat appears dark. Therefore, RE-TOSSI is a promising method for faster, safer, higher resolution, fat suppressed T2W body imaging.

References:

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