Fast T2 weighted imaging by PSIF at 0.2T for interventional MRI

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Introduction Tumors and thermal induced lesions are best visualized in T2 weighted (T2W) images (1). Fast T2W images are very useful in interventional thermotherapeutic procedures for device guidance and post ablation lesion assessment. While FISP and True-FISP provide good temporal resolution during the device guidance stage, they are T1/T2 weighted and do not always give sufficient contrast for tumor or lesion visualization. PSIF has been known to give good T2W images (2) but PSIF techniques today are notorious for their low SNR even at high field. In this study we report our redesign and re-evaluation of PSIF for interventional use at 0.2T.

Materials and Methods The PSIF Sequence Three modifications were made on the original PSIF: 1) balancing the readout gradient. 2) asymmetric sampling (up to 62.5%) towards the end of TR cycle. 3) adding a gradient spoiler to destroy the FID. The sequence gives less motion artifact, improved signal and reduced susceptibility compared to the PSIF first proposed (2). Fig. 1 shows the modified PSIF implemented on a 0.2T MR scanner (Open, Siemens, Erlangen, Germany). 2D sequential imaging was used.

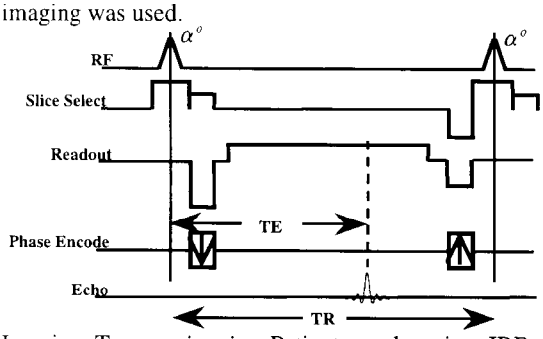


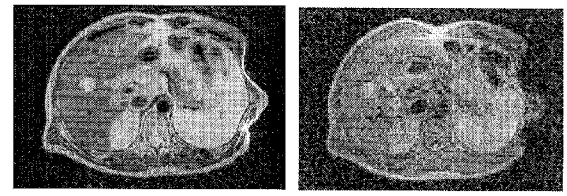
Fig.1 The modified PSIF sequence

Imaging Tumors *in vivo* Patients undergoing IRB investigation protocols (n=3) were scanned using diagnostic imaging protocols (turbo spin echo, or TSE) to locate previously confirmed tumors. PSIF images were acquired at the same anatomical positions where tumors were found. In two cases, In two cases, FISP and true-FISP images were also acquired for contrast comparison.

PSIF for device guidance PSIF images were used to guide device insertion in RF interstitial thermal ablation (RF-ITA) of patients (n=7, IRB approved). After the probe was located inside the tumor, ablation procedures followed similar protocols previously reported (3). The tissue/vessel conspicuity in the images was qualitatively compared to those from our earlier experiences (3).

Lesion contrast in vivo in PSIF images IRB approved porcine experiments were used to evaluate the potential of PSIF in depicting thermal-induced lesions. The pigs (n=2) were anesthetized. Thermal lesions were induced by a RF probe put into the brain via a bore drilled through the skull. Imaging was done after probe removal. TSE (ETL=17) and PSIF were used to image the lesions using comparable imaging parameters.

Results All tumors showed up very well in PSIF images. Fig.2 shows one such case (tumor to tissue CNR for TSE, FISP, true-FISP and PSIF were 38.7, -0.98, 0.49 and 7.9 respectively). FISP and true-FISP did not detect the tumors reliably in these cases. In all RF-ITA procedures using PSIF for device guidance, the RF probe was accurately located in the tumors. Fig.3 shows a typical PSIF image showing tumor/tissue/device conspicuity in MR images during one of the procedures. Fig. 4 shows RF induced lesions in PSIF images (7 sec/image, CNR = -2.9) which compare favorably with T2W TSE images (5 images/min, CNR = -3.0) in terms of contrast. Echo asymmetry in PSIF helps reduces susceptibility artifact (Fig.4b).



(a) (b)

Fig.2. Tumors in (a) TSE images (ETL=7) (TR/TE/FA =5172ms/102ms/90°; NSA=5; FOV=300mm x 400mm; SL=8mm; 168 x 256 matrix; time=10 min) (b) PSIF (62.5% asymmetry) (TR/TE/FA=18.2ms/10.3ms/80°; NSA=2; FOV=(400mmx400mm: SL=6mm: 128^2 matrix: time=4.7s)

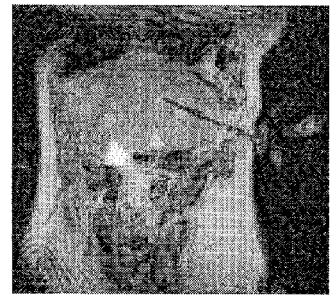
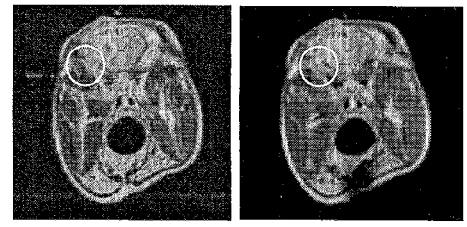


Fig 3. Using PSIF to guide RF probe insertion in a RF-ITA procedure. Images were taken during breath hold. The tumors, RF probe and liver tissues were well depicted. (TR/TE/FA= 19.4ms/9.5ms/35°; NSA =3; FOV= $(350mm)^2$; 128^2 matrix; SL= 6mm; scan time= 7.5s).



(a) (b)

Figure 4. RF-induced lesion in TSE and PSIF with RF probe removed. The lesion was in the left frontal lobe of the porcine brain. (a) TSE image (ETL = 17, TR/TE = 2000ms/105ms; NSA = 3; SL = 6mm; FOV = 199mm x 265mm; 170 x 256 matrix; scan time = 1min 3 s (5 slice. (b) PSIF image (62.5% asymmetry, TR/TE/FA = 17.8ms/10.3ms /80°; NSA = 3; SL = 6mm; FOV = 265mm x 265mm; matrix = 128^2; scan time = 6.9 s/slice.

Discussion The strong T2 weighting and short scan time of PSIF images compare favorably with those from T2W TSE sequences despite the slightly reduced spatial resolution. The much improved T2 contrast from PSIF justifies the small decrease in temporal resolution compared to FISP/true-FISP. These characteristics of PSIF greatly facilitate MR device guidance in terms of speed and targeting. It was found that T2 contrast of PSIF at 0.2T is much better for effective echo time (=TR+TE) > 28ms. Careful sequence design and improvements in MR systems over the years make PSIF feasible even at 0.2T.

Conclusion The modified PSIF provided clinically useful T2W images in 5-7 seconds. The sequence can often demarcate tumors not shown in more rapid FISP / True-FISP images in the device guidance stage of interventional procedures. Initial results suggested PSIF may also be able to image thermal lesions, making it a useful addition to the existing arsenal of pulse sequences for interventional MRI.

References 1) Boaz TL et al. JMRI 8:64, 1998. 2) Gyngell ML. MRI 6:415, 1988. 3) Lewin JS et al. JMRI 8:40, 1998.