

T2/PD Weighted Water and Fat Separation on Low-field Scanner

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Introduction For low-field scanners, there was a long demand for a fat suppression technique which provides a reliable contrast as hi-field Chemical Shift Selective (CHESS) imaging, and feasible as Short-Tau Inversion Recovery (STIR). Spectral water/fat separation technique, or named Dixon technique, is a preferred option for the requirement. It is known that Dixon technique can provide promising T1 weighted images on low-field systems with SE or GRE based sequences [1]. However, for T2 weighted or PD weighted application, TSE based Dixon is suffering from artifacts such as blurring, ghosting and shading [2]. In this abstract, origin of these artifacts is first analyzed. And then a low-field optimized TSE Dixon sequence scheme is proposed. With reduction of artifacts, fat suppressed PD/T2 weighted images are therefore achieved on low-field scanner.

Methods For low-field TSE sequence, eddy currents and concomitant fields are the major sources to artifacts like blurring, ghosting and shading. There are several approaches to reduce the impact from those system imperfection factors for conventional TSE [3] [4]. Nonetheless, the image quality is dramatically downgraded when Dixon is applied, for its readout gradients become an additional source of the artifacts. In Dixon acquisition, multiple echoes are usually acquired in one echo spacing to reach a minimized scan time. One commonly used scheme is to acquire different echoes with same gradient polarity, namely "mono-polar" mode. A fly-back gradient is required in this case. For most clinical protocols, the fly-back gradient is high in amplitude since the interval between echo centers is fixed. (Shown in Fig.1) On low-field scanner, high gradient amplitude usually brings serious eddy current and concomitant field problems. Artifacts like blurring, ghosting and shading thus arise for all echoes, especially when long echo train applied. Another common scheme is to alternate the polarity of readout gradient for each echo, referred as "bipolar" mode. Although fly-back gradient is not required, this scheme has its own drawbacks: phase inconsistencies, unpaired geometric distortion, different receiver gain for each echo and opposite chemical shifts direction etc. Those factors would finally degrade image quality. [2][5]

Artifacts induced by eddy current and concomitant field can be alleviated either by employing run-time modification in sequence or by using offline correction in image reconstruction [3][4]. For Dixon acquisition, the echo-shift is fixed (e.g. 9.8ms on 0.35T scanner), which leave little room for sequence modification. In this abstract, a new sequence scheme is presented based on mono-polar 2 point acquisition, with "asymmetric readouts" employed. Rear part of the first acquisition is cut according to predefined asymmetric factor, so is the front part of the second echo. Lower fly-back amplitude can be achieved as for the decreased momentum requirement and the increased time interval. Concomitant field is therefore reduced with the lowered gradient. Amplitude of the fly-back gradient is defined same as the acquisition gradient. Gradient slopes between two echo centers are also modified to make full use of the interval, which further removes the eddy current. (Fig. 2) In data processing, besides normal TSE phase correction procedures, each acquired line is applied a Margosian partial Fourier algorithm. For Dixon reconstruction, regional growing is used for phase processing, followed by a 2 point water-fat separation. As references, a 2 point mono-polar TSE Dixon is first tested, by applying the readout block shown in fig 1 to a low-field optimized TSE sequence. Bipolar TSE Dixon is also tested. A 3D linear phase correction was made to remove the 1st order error brought by eddy current.

Results A T2 weighted phantom imaging and a volunteer test were performed on a 0.35T permanent magnet MR scanner (MAGNETOM C!, SIEMENS Mindit Magnetic Resonance Ltd, Shenzhen). For phantom test, Following parameters are used. TR/TE = 3000/106ms, echo train length = 8, readout bandwidth = 130Hz/pixel, image matrix = 256*256, FoV = 270*270mm, image position: transversal, off-centered by 14cm in slice direction. In the asymmetric mono-polar case, 25% of the readout echo is discarded. A volunteer test is also made between mono-polar Dixon, proposed asymmetric mono-polar Dixon and STIR. Parameters are taken from phantom test, with resolution = 213* 256 at 270*270mm. For STIR, TI/TE/TR = 110/64/4620ms, readout bandwidth = 70Hz/pixel, echo train length = 7. Scan time are 4m58s (TSE Dixon) and 4m38s (STIR) respectively. (Fig 2)

Conclusion and Discussion In phantom test, conventional mono-polar image shows a severe shading problem. Bi-polar gives an improved one. But shading and ghosting can still be observed at right side, where further away from iso-center. Asymmetric mono-polar shows the best image quality. A lost in sharpness can be observed due to partial Fourier. For volunteer test, images in asymmetric mono-polar Dixon and STIR have similar image quality. However, STIR has a manipulation on longitude magnetism, which affects the image contrast.

This abstract presents an optimized TSE Dixon acquisition scheme for low field scanner. The proposed solution provides clinical accepted image quality for PD/T2 weighted images, with robust water/fat separation result. Comparing with commonly used STIR, the method is free of contrast manipulation on T2 image, and enables the possibility for a reliable fat suppressed PD weighted imaging on low-field scanner.

Reference:

[1]Bredella MA AJR 2001; 177:1371-1375 [2] Zhang W, JMIR 6:909-917(1996) [3] Zhou XH etc al. MRM 40:582-591(1998)[4] P. Jehenson JMR. 90:264-278 (1990) [5] Yu HZ, etc al. JMIR 31:1264-1271(2010)

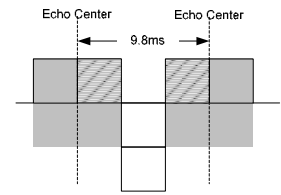


Fig 1 In mono-polar scheme, the amplitude of the fly-back gradient is strong

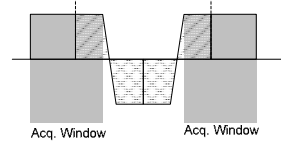


Fig 2 A proposed mono-polar scheme. eddy current is reduced by amplitude de-rating and slope smoothing.

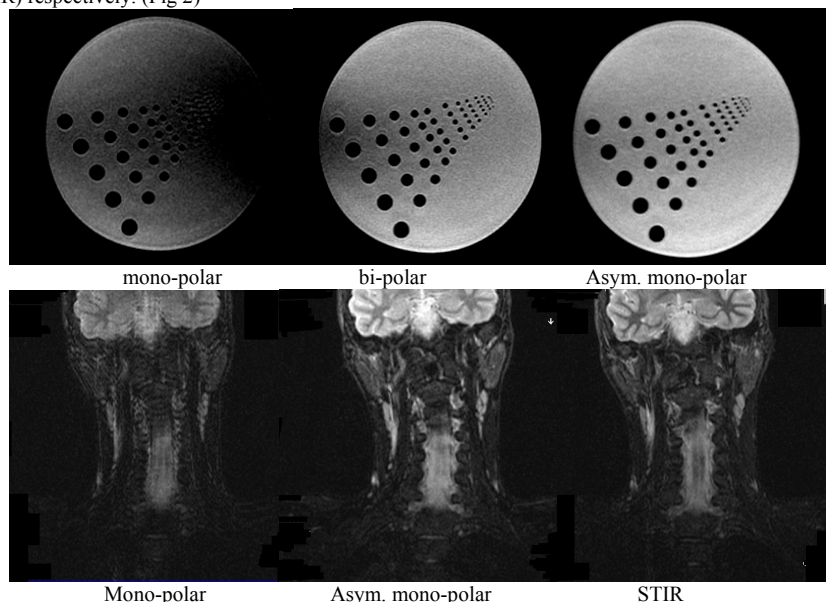


Fig 3 Phantom and volunteer Exams. Only water images are presented, and are rotated to make phase encoding align up-downward. Image windowing are also adjusted as the same.