Combination of T1-selective and tissue specific methods for normal tissue signal suppression in MRI

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1. Introduction

A method of simultaneous suppression of signals from several normal tissues to simplify the pattern of tissue contrast. It leads to cut off the unnecessary information and can improve lesion visualization. The method is realized by a combination of inversion-recovery (IR) and the Dixon method. It allows to suppress the signals from the two tissues, one of them has a specific longitudinal relaxation time (T_1) and the other is peculiar chemical shift.

2. Methods

It is preferable to suppress signals from all normal (nonpathological) tissues, giving strong signals especially. To simplify the tissue contrast, IR methods - FLAIR and STIR are used often [1,2]. They are T1-selective methods and aimed to suppress signals from tissues with long and short T_1 respectively. In some cases DIR method is used [3]. It is based on double application of inverting pulses and allows to suppress signals from two tissues with different T_1, for example, cerebrospinal fluid - CSF (2 s) and fat (0.1 s). DIR gives good visualization (3D included) of demyelination zones, tumors and others lesions [4].

IR methods are simple to realize as they are insensitive to B_0-inhomogeneity. Disadvantage of IR methods is unambiguous interpretation of MRI data by hemorrhages and studies with the contrast agents as T_1 for both blood and tissue after contrast agent action are very variable.

In theses cases tissue selective methods are preferable. For example methods based on differentiation of spins due to chemical shift – CSS. Particularly chemical shifts of water and fat differ by 3.5 ppm.

The easiest way to realize the CSS is to use a frequency selective RF pulse [5]. Disadvantage of this method is high sensitivity to B_0-homogeneity. Because of it artifacts on fat CSS image arise. It obstructs the interpretation of MRI data.

Dixon method is more useable for CSS [6]. The method gives phase separation of signals from spins with different chemical shifts. This is achieved by varying an interval between start of the RF pulse and data acquisition. The method is sensitive to B_0-inhomogeneity. But the varying of mentioned interval within p/(qD), (p,q – integers, D – chemical shift difference,) gives additional MR images. Processing with them gives distortionless image [7].

It is useful to simplify the tissue contrast pattern by combined method which allows the suppression of the signal of one tissue with certain T_1 and of another tissue by CSS. It is advisable to use Dixon method for CSS fat suppression. To suppress signal from the tissue with a certain T_1, some IR pulse sequence can be applied - FLAIR, STIR or DIR. This scheme is acceptable as IR is based on preparation of longitudinal magnetization but Dixon method is based on tracking of the transverse ones.

3. Results

We realized three point Dixon method on 0.5 T scanner Tomikon S50 ("Bruker"). The software changes were made to displace the moments of reading of spin-echo signal (0,7,14 ms) to provide (in-, out-, in-) phase orientations of fat and water magnetizations. The homemade software was developed to process phase images [8]. To overcome the problem of "unwrapping phase" [9] we used a modified version of the region-growing method [10].

We received PD- and T2-WI (TR/TE=2.5/0.015 s and 5.0/0.1 s) by modified spin-echo method with fat CSS. Also we add an inverting pulse followed by TI delay to the beginning of the pulse sequence. It gave combination of IR and Dixon method. We used TI=1.3 s for suppression of CSF signal, TI=0.5 s - of fluid in paranasal sinuses. To create images with different variants of normal tissue suppression we also used algebraic operations with images from different scanning modes [11].

We used images with suppression of the signal from normal tissues for research of orbits and dermoid cysts.

4. Conclusion

The offered method of simultaneous signal suppression from normal tissues uses two independent mechanisms of their selection – by T_1 and chemical shift. One of them works at preparation stage of pulse sequence, and another one - at acquisition stage. The method expands possibilities of MR contrast control. Additional possibilities arise at use of algebraic operations with MR-images. It may be useful for better visualization and automatic search of lesion zones.

References

[1] Hajnal J, et al.//J Comp Assist Tomogr,1992,16,841–44.
[2] Fleckenstein JL et al. // Radiology, 1991,179, 499-504.
[3] Redpath T, Smith F // Br J Radiol, 1994, 67, 1258–63.
[4] Pirogov YA, et al. // Proc SPIE, 2002, 4681, 612-16.
[5] Rosen BR // J Comp Assist Tomogr, 1984, 8, 813-18.
[6] Dixon WT // Radiology, 1984, 153 (1), 189-94.
[7] Glover GH, Schneider E // MRM, 1991,18, 371-83.
[8] Volkova KL, et al. //Proc ECR, 2012, C-1583,10,1594.
[9] Szumowski J, et al. // Radiology, 1994, 192(2), 555-61.
[10] Oh C, Hilal SK, Cho ZH // Proc SMRM, 1988, 1042.
[11] Anisimov NV, et al. // Proc ESMRMB, 2005, 435.