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Susceptibility and chemical Shift in MRI.

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Introduction:
Geometrical distortion in Magnetic Resonance Images can be classified in two main categories[1]: non-linear gradient fields and static and patient induced field heterogeneity. The first kind is machine dependent and can be corrected by calibration or post processing [2]. The second kind will be the one discussed in this paper. It can be important near the skull. Since some registration technique use these landmarks, field heterogeneity must be corrected for accurate registration.

Material and Methods
The static (Machine dependent) field heterogeneity can be reduced by regularly shimming the magnet[3]. Patient induced field heterogeneity arises because of the difference in chemical shift between water and fat contained in biological tissues and also wherever a sharp variation in the magnetic susceptibility exists i.e. near the surface of the skin or near the tissue-air interface. The effect is a local displacement of the structures on the image compared to their real physical position that must be estimated and corrected. Several methods have been described to image fat and water individuality using selective saturation pulse or Dixon method. Three points Dixon technique [4] uses 3 images to estimate fat and water images and static field heterogeneity. We propose a method to estimate and correct the effects of the field heterogeneity with only 2 acquisitions of the same object. The method is based on two acquisitions with time echoes TE1 and TE2 such as:

$$\Delta\omega\, TE1 = \Delta\omega\, TE2 + (2k+1)\Pi,$$

where $\Delta\omega$ is the chemical shift between water and fat (220Hz at 1,5Tesla). It can be shown that the module of the sum of these images is proportional to the quantity of water. The module of the difference of these images is proportional to the quantity of fat. The phase of the sum is an image of the field variations used to compute the displacements associated to water and fat components. An efficient phase unwrapping algorithm enables to correct the phase jumps that occur in phase images during the reconstruction process.

Results
Two gradient echo images have been acquired at time echo TE1 = 9,09ms (fat and water in phase) and at TE2 = 11,37ms (fat and water out of phase). Shifts are presented in figure 1b and corrected image is presented in figure 1c. The corrected image has a better SNR and chemical shift is clearly reduced: the fat (white signal near the skull), which was inside the LCR in figure 10a is replaced in figure 10c. Echo planar images have also been processed by this method.

References
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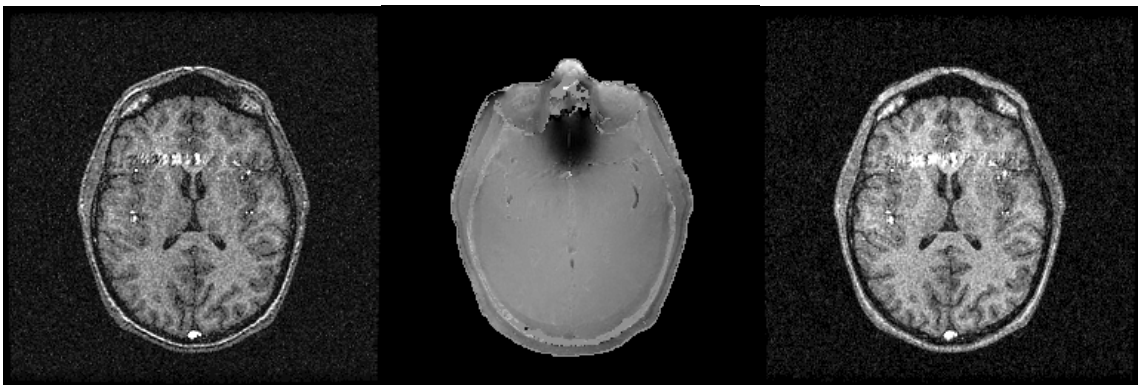

Figure 1 : from left to right : a/ initial image, b/ displacements, c/ corrected image