Distortion correction of body diffusion weighted images using three point-Dixon method

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Introduction: Significant distortion can often be observed in body diffusion weighted images (DWI) using single shot EPI. Distortion is caused by external magnetic field (B0) inhomogeneity. The degree of distortion is proportional to B0. When a precise B0 map is obtained, distortion can be corrected using the B0 map. In this study, we demonstrate that a B0 map obtained using three point-Dixon method is useful to correct for distortion. Clinical images corrected using this method are also shown.
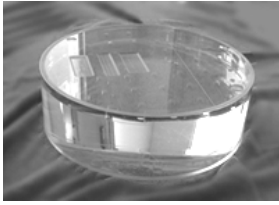

Fig.1. Phantom (diameter 380mm)

Method: A flow chart of our proposed method is shown in Fig.2. In this method, we applied five low pass filters to a B0 map. Only pass bands of these five low pass filters were varied. Distortion correction was done using these five B0 maps. A final corrected image was selected from these five corrected images. We calculated correlation coefficients between each corrected image and the combined water and fat image. A corrected image that produced the highest correlation coefficient was chosen as the final image. We performed both phantom and volunteer scanning to test our proposed method. In phantom study, we scanned a column phantom filled with water (Fig.1) using eight channel phased array coils. The size of the phantom was 380mm x 380mm x 100mm. Details of scanning parameters were: FOV 400mm, slice thickness/gap 4/0mm, #slices 100, NEX 2~10, SENSE acceleration factor 2, image matrix size 256 x 256. We used three types of pulse sequences in this experiment. Parameters of these sequences are as follows. Sequence 1: single shot EPI TR/TE 7000/60msec; Sequence 2: three echo- GRE (Dixon methods) #phase encoding (PE) steps 32, TR/TE 2500/3.2x3msec; Sequence 3: three echo- GRE (Dixon methods) #PE steps 128, TR/TE 2500/3.2x3msec. We created water and fat images, a B0 map and the combined water and fat image using the sequences 2 and 3. We performed distortion correction for 100 axial images. Two types of B0 maps were created using sequences 2 and 3. They differed in resolutions. Correction was done based on each B0 map. A sagittal multiplanar reformatted image was created using both of these corrected images. We made comparison on preciseness of the correction between these B0 maps. In in-vivo study, we scanned asymptomatic volunteers. DWI of pelvis and spinal cords of the vol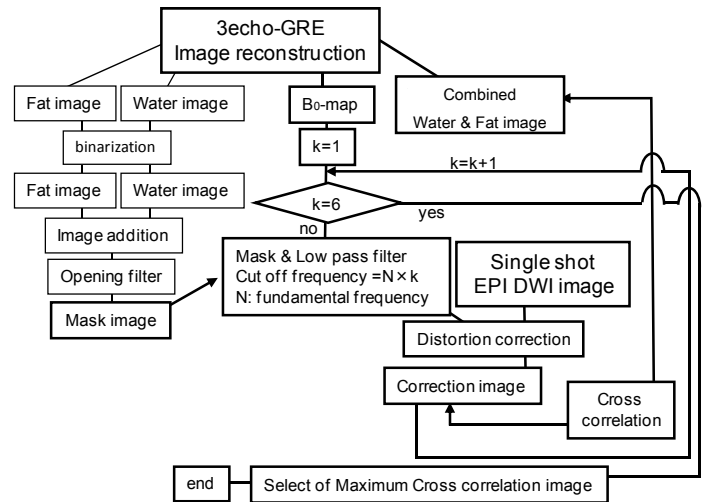unteers were scanned using eight channel phased array coils. b-value was set to 800s/mm². We used the same pulse sequences as Sequences 2 and 3 described above in this experiment.

Fig.2. A flow chart of distortion correction

Results: In phantom study, there was no significant difference between the images corrected using the B0 map with 32 PEs and those corrected using the B0 map with 128 PEs. （Fig3） The correlation coefficients of both corrected images were increased by 0.01 or greater from those of the uncorrected images. In in-vivo study, significant improvements of distortion correction were observed in both spinal cord and pelvis images.(Fig4)

Discussion: In three point-Dixon method, good distortion correction is achieved using the sequence with 32 PEs. In this method, although prescan is required, it requires about a minute and a B0 map obtained from the prescan can be applied to 50 images. This method is quite useful in practice since a B0 map created using this method enables good distortion correction.
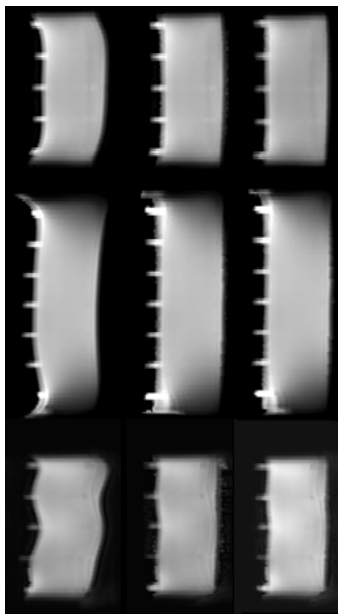
Fig.3. Sagittal MPR images （ reconstructed from axial images）

a,b,c: Images 170mm shifted from the center to the left
d,e,f: Images at the center
g,h,i: Images 170mm shifted from the center to the right
a,d,g: Images before distortion correction
b,e,h: Images corrected using B0 maps created using Sequence2
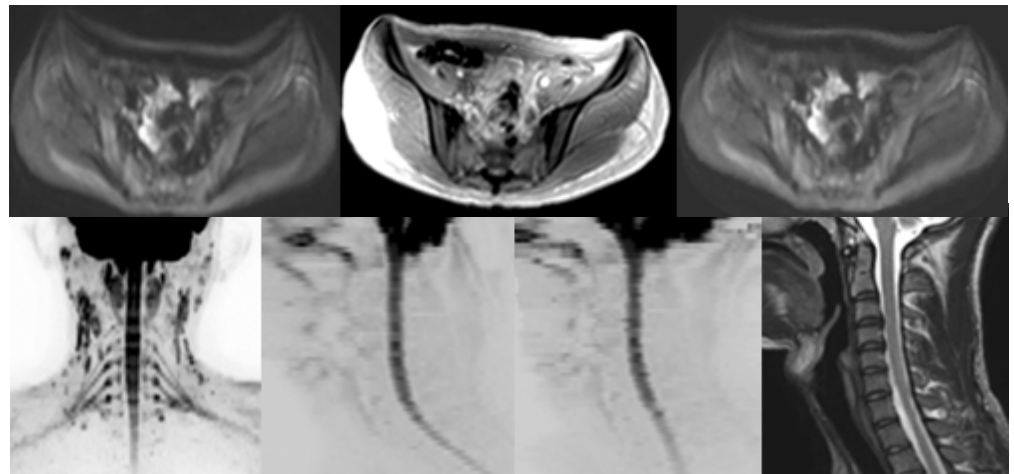c,f,l: Images corrected using B0 maps created using Sequence3

Fig.4.In-vivo images

a : Pelvis DWI before distortion correction   b : Combined water and fat images   c : Pelvis DWI after distortion correction
d : MR neurography   e : Sagittal MPR image without correction   f : Sagittal MPR image with correction   g : TSE conventional image