A Design of Head Holder for Calculation of Susceptibility through Multiple Orientation Sampling (COSMOS)

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Introduction:

Quantitative susceptibility imaging of brain is reconstructed by the different local magnetic fields induced by susceptibility of different brain tissues. It is a promising approach to explore various pathological conditions such as neurodegenerative processes associated with iron deposition/aggregation and contrast agent accumulation. [1] In addition, it can be applied in quantifying deoxygenated venous blood in fMRI [2]. The ill-posed problem is struggled in inversion from field to susceptibility source. To calculate the susceptibility by multiple-orientation samplings (COSMOS) may overcome the problem by conditioning data acquisition, and has been validated as a robust and accurate approach [3]. For clinical application, the challenging problem is to rotate the subject's head with different angles and fixed the head with the angles through the MR scan. In this study, we design a head holder which can rotate a fixed and small degree of the subject's head from the vertical axis Y of the magnet, and hold the position of head during the MR scan.
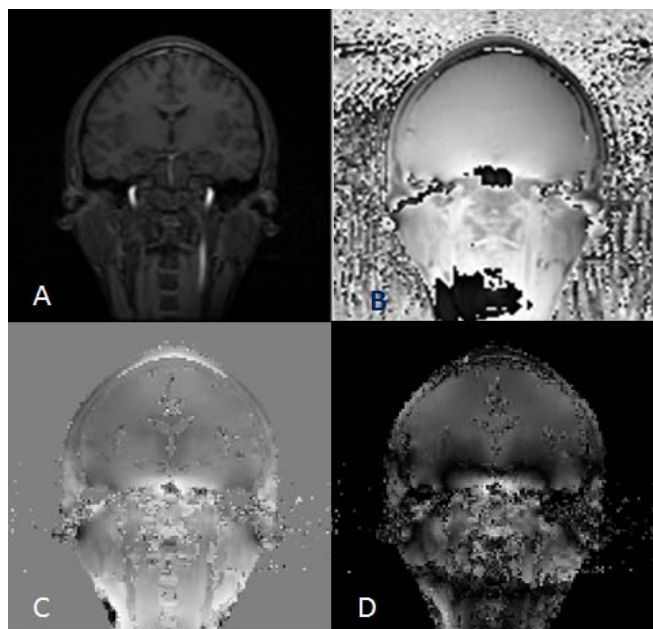
Materials and Methods:

Head holder: To avoid the magnetic effect, the head holder was made by acrylic. The contour of head holder was fitted on the upper surface of head coil; it can be tightly fixed on the head coil and easily taken off. The head holder is composed by two major parts, a plane and a teeth tray. The teeth tray is as an axle vertically through the plane and it can only rotate along the Y axis of magnet. The function of teeth tray is to control the degrees of head rotation and fix the subject's hard palate (Fig.1)

Phantom study: All MR examinations were performed using a 3T MR system (GE Signa). A rectangular jelly phantom was used to test the head holder. The phantom holded by the head holder is scanned by 3D FSPGR sequence with five different degrees of rotation (-20°,-10°, 0°, 10°, 20°). The rotation and translation parameters of the 3D MR imaging with different degrees 0° were calculated using mutual information registration, the result is to verify the accuracy of head holder.

Human brain study: A 3D fast gradient echo with 5 TEs in one TR was applied in one health volunteer (TR: 14 ms TE: 1.57, 4.26, 6.96, 9.66, 12.35 ms, FA: 25). 128 coronal slices were acquired with FOV: 256x256 mm, matrix size: 128x128, and the voxel size was an isotropic resolution (2x2x2 mm). The head of the subject was rotated to different angles (-20° to +20° in the right-left direction) by the head holder. Normalized mutual information registration was conducted to register the brain images from the three different angles. Field maps were reconstructed by fitting the phase evolution with multi-TEs. A high pass filter was applied to remove the background field. A mask by the threshold from first echo magnitude image was applied to separate the brain region. Filtered field maps were then processed for a susceptibility reconstruction χ [3].

Results:

The rotated degrees on the head holder are linearly correlated with the mutual information registration in the phantom test (Figure 2). The mean error degree of Y axis

Figure 1. The home-made head holder is allowed rotation along Y axis.. The teeth tray is set at the bottom, and fixed with teeth by dental alginate impression material.
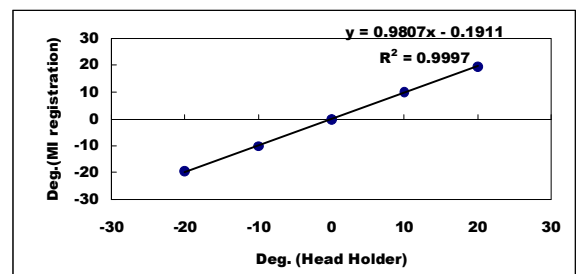

Figure 2. The linear relationship of rotated degree in Y axis between head holder scale and mutual information registration in phantom test.

between head holder scale and mutual information registration is about 0.19°, and the mean degree for other two degrees is 0.13° in X axis and is 0.72° in Z axis. Figure 3 shows the result of a normal subject.

Discussion:

The pivot of head holder is the teeth tray which helps to fixed with subject's palate by dental alginate impression material. The head holder is designed to fix and fit on the head coil. The device helps to head to rotate along the Y axis of the magnet. Our results show that the head of subject can be rotated to an exact degree by the head holder. The slope of linear curve fitting is 0.98 and the offset is -0.19°. The error degree is 0.13° in X axis, but 0.72° in Z axis. To improve the inaccuracy in Z axis, we add a

sponge support at the bottom of subject's head for eliminating the rotation in Z axis. This head holder for COSMOS might offer great help in clinical MR scan. It facilitates the head rotating to a desirable degree and fixing it through the whole MR scan .

References:

1. Haacke et al., MRI, 23: 1-25.
2. Ogawa et al., MRM: 29: 205-210.
3. Liu et al., ISMRM 2008: 643.

Figure 3. The calculated images from 3D multi-echo gradient images of one normal subject. (A) Magnitude image (B) Phase image (C) field map and (D) susceptibility map.