Development of a compact whole hand MRI system for diagnosis of rheumatoid arthritis using a 0.3 T permanent magnet.

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INTRODUCTION

Whole hand MR imaging is essential for early detection and drug therapy assessments of rheumatoid arthritis (RA) (1,2). However, hand MRI examination using a whole body MRI system is not cost effective and often painful for RA patients. To overcome this problem, we have developed a compact MRI system using a 0.21 T and 16 cm gap permanent magnet (2). Because better image quality could be obtained if we use a higher magnetic field, a high-field permanent magnet for whole hand MRI is desired. In this study, we have developed a compact whole hand MRI system using a 0.3 T permanent magnet.

MATERIALS AND METHODS

For whole hand imaging, the field of view (FOV) should include the wrist and the distal end of phalanx. Therefore, the target homogeneous volume was determined to be a 22 cm × 22 cm × 8 cm diameter ellipsoidal volume. Figure 1 shows the compact whole hand MRI system was developed in this study. The entire system was installed in a 1.5 m × 2 m space. The specification of the permanent magnet is: magnetic field strength: 0.3 T, gap width: 13 cm, homogeneity: less than 50 ppm over 22 cm × 22 cm × 8 cm diameter ellipsoidal volume, weight 600 kg. The transverse gradient coils were designed using the target-field approach (4) and the axial (z) gradient coil was designed using the genetic algorithm. The maximum field gradients were 18 mT / m, 18 mT/m, 28 mT/m for Gx, Gy and Gz, when a 10 A constatnt current power supply was used. A 14 turn solenoid coil (oval aperture (7 cm width × 13 cm height) and 22 cm length) was developed for whole hand imaging (3). To image a whole hand without an RF shielded room, a locally RF shielded probe was developed (3).

RESULTS AND DISCUSSIONS

Figure 2 shows a 2D cross section selected from a 3D image datasets of a 54 years old male subject acquired with a gradient echo sequence (TR/TE/FA = 40 ms/5 ms/ 60 deg, matrix size: 512 × 256 × 32, voxel size: 0.4 mm × 0.8 mm × 1.6 mm, acquisition time = 5 min 30 sec). Anatomical structures of the whole hand are clearly visualized within 6 min. Figure 3 shows a fat suppressed 2D cross section of the same subject acquired with a STIR-3D-FSE sequence (TR/TE/TI = 1000 ms/80 ms/110 ms, ETL = 16, image matrix: 256 × 320 × 32, voxel size: 0.8 mm × 0.8 mm × 1.6 mm, acquisition time: 10 min 30 sec). Figure 4 shows a 3D maximum intensity projection image reconstructed from the fat-suppressed 3D image dataset. Bone marrow fat signal is well suppressed and long T_2 tissues such as joint fluid, blood, etc. are clearly visualized. The T_1-weighted images of the male subject have demonstrated 1.6 times signal to noise ratio compared with those obtained with the 0.21 T MRI system previously reported (2). These results have demonstrated that our system has a potential to be used for a whole hand examinations with reduced time or higher spatial resolution images in the same acquisition time.

CONCLUSION

A compact whole hand MRI system was developed using a 0.3 T permanent magnet. The 0.3 T system has 1.6 times SNR advantage over the 0.21 T system previously reported. Therefore, we conclude that our system can be used for evaluating RA with reduced measurement time or higher spatial resolution in the same examination time.

FIG. 1

FIG.2

FIG.3

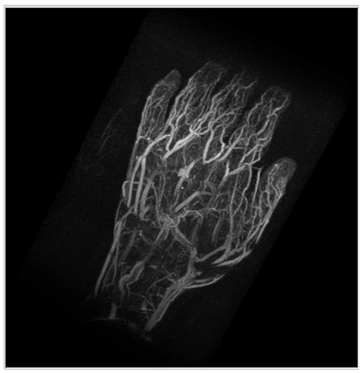

FIG.4

References

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