Development of a compact MRI for early diagnosis and follow up of rheumatoid arthritis

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Introduction

It is widely accepted that MRI of hand is very useful for early diagnosis of Rheumatoid Arthritis (RA). However, hand is not suitable for whole body MRI scanners, because patients have a lot of difficulties to place their hands at the center of the magnets and gradients. To solve this problem, MRI systems with which patients can comfortably have hand MR examinations, are desired. We have already reported a compact hand scanner with installation space of about 6 m^2 and total weight of 1,500 kg [1,2]. In the present study, we have optimized a permanent magnet, gradient coil set, and pulse sequences for a hand and achieved about 2 m^2 installation space (without a shield room), about 600 kg total weight, and examination time of less than 16 minutes, which have enabled the MRI to be used even in a small clinic for early diagnosis and follow up of RA.

Materials and Methods

Figure 1 shows an overview of the compact whole hand scanner. The specification of the permanent magnet is ; field strength: 0.21 T, gap space: 16 cm, homogeneity: 34.6 ppm over a 20 cm × 12 cm diameter ellipsoidal volume, and weight: 520 Kg. The planar gradient coil set (Fig.2) was optimized for the ellipsoidal region using the target-field approach[3,4] and a genetic algorithm[5].

Healthy volunteers were imaged using the hand scanner. Coronal 3D gradient echo T_1-weighted and STIR-3DFSE images were obtained with an image matrix of 512 × 256 or 256 × 256 and 20.5 cm square FOV. In addition, high-resolution coronal 3D gradient echo images were obtained with a 256×256 image matrix and 12.8cm square FOV.

Results and Discussion

Figure 3 shows a coronal 2D image of a hand selected from a 3D image dataset (voxel size 0.4 mm × 0.8 mm × 4 mm) acquired with a 3DGE sequence (TR/TE= 50/9 ms, FA 60deg, NEX 2, acquisition time: 7min). Figure 4 shows a coronal 2D fat-suppressed T_2 weighted image selected from a 3D image dataset (voxel size: 0.8mm×0.8mm×8mm) acquired with a STIR-3DFSE sequence (TR/TI/TE= 1000/100/40 ms, ETL=8, NEX 2, acquisition time: 9min). As shown in these figures, detailed anatomical structures and inflammatory region (shown by the arrow) are clearly observed. Figure 5 shows a coronal high resolution 2D image selected from a 3D image dataset (voxel size 0.5 mm × 0.5 mm × 2 mm) acquired with a 3DGE sequence (TR/TE= 50/8ms, FA 60deg, NEX 2, acquisition time: 14min). In this figure carpal bone trabeculation, joints and cartilages are clearly observed. This result suggested that our whole hand scanner can be used also for follow-up of RA.

In conclusion, a compact whole hand MRI has been developed using a magnet and gradient coil set of which homogeneous regions were optimized for a hand. This system was approved by the ethical committee of our university hospital and is scheduled to be used for a clinical test in our university hospital.

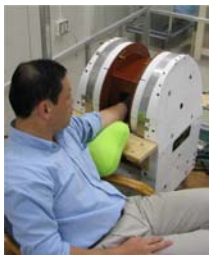

Fig.1 System overview

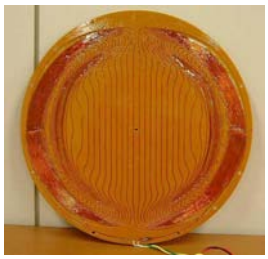

Fig.2 planar gradient coil

Fig.3 Coronal T1W image

Fig.4 Coronal STIR image

Fig.5 High resolution image

References

[1] T. Kurimoto, T. Furuya, S. Tomiha, T. Shirai, Y. Matsuda, T. Haishi, S. Utsuzawa, K. Kose, H. Yoshioka, Compact Hand MRI Systems using Permanent Magnets, 12th ISMRM Proc p1638, 2004.

[2] H. Yosioka, S. Ito, S. Handa, S. Tomiha, K. Kose, T. Haishi, A. Tsutsumi, T. Sumida, "Low field compact magnetic resonance imaging system for the hand and wrist in rheumatoid arthritis", accepted for publication.

[3] Turner R. A target field approach to optimal coil design. J Phys D: Appl Phys 1986;19:147-151.

[4] Jianming Jin: Electromagnetic analysis and design in magnetic resonance imaging, (CRC Press, 1998).

[5] S. Handa, F. Okada, K. Kose, "Effects of magnetic circuits on magnetic field gradients produced by planar gradient coils", 13th ISMRM Proc p851, 2005.