Compact hand MRI systems using permanent magnets

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Abstract

Two compact MRI systems were developed for hand imaging. The first system used a 0.21 T, 25 cm vertical-gap permanent magnet and the second system used a 0.20 T, 16 cm horizontal-gap permanent magnet. These magnets were installed in compact electromagnetic shield rooms (3.8 and 1.8 m^2) and combined with compact MRI consoles. The total installation spaces were about 6 and 4 m^2. MR images of hands acquired for several athletes and volunteers demonstrated usefulness of the systems.

Introduction

It is widely accepted that MRI of hand is very useful for early detection of Rheumatoid Arthritis. However, hand is a difficult part for imaging with whole body MRI, because patients are required to extend their arms to place their hands at the center of the magnets, or motion artifacts frequently appear if patients' hands are imaged on their chests. To solve this problem, MRI systems with which patients can comfortably have hand MR examinations, are desired. We have thus developed two compact MRI systems using permanent magnets which can be used for hand imaging.

Materials and methods

Two permanent magnets were used for the MRI systems. The specification of the first one was: magnetic field; 0.21 T, gap; 25 cm (vertical), homogeneity: 25 ppm over 15 cm dsv, weight; 1,350 kg. That of the second one was: magnetic field; 0.20 T, gap; 16 cm (horizontal), homogeneity: 40 ppm over 10 cm dsv, weight; 200 kg. These magnets were installed in compact electromagnetic shield rooms (1.6 m (W) x 2.0 m (H) x 2.4 m (D) and 1.0 m (W) x 1.8 m (H) x 1.8 m (D)) and combined with compact MRI consoles. For uniform RF excitation over a hand, two solenoid RF coils with oval apertures were developed for each system. The total installation spaces were about 6 and 4 m^2, respectively. Figures 1 and 2 show system overviews.

Hands of five Shorinji Kempo (a kind of martial arts) players who had hand or wrist injuries were imaged using a T_1 weighted 3DSE sequence (TR/TE: 200ms/26ms or 200ms/16ms, matrix: 256 x 128 x 16 or 128 x 128 x 16, FOV: 20.48 cm x 20.48 cm x 6.4 cm or 10.24 cm x 10.24 cm x 6.4 cm, acquisition time ~7 min.) and a 3D STIR sequence (TR/TE/TI: 1000ms/26ms/70ms or 1000ms/16ms/70ms, matrix: 256 x 128 x 8 or 128 x 128 x 8, FOV: 20.48 cm x 20.48 cm x 6.4 cm or 10.24 cm x 10.24 cm x 6.4 cm, acquisition time ~17 min.).

Results and discussion

Figures 3 and 4 show T_1 weighted images acquired with the two systems. In Fig.3, acquired with the larger system, bone anatomy was clearly visualized and the patient was diagnosed as osteoarthritis. For five injured players, however, no bright portion was detected in STIR images. We think this is because the injuries of the players were not acute and the inflammations were not active.

As far as we have experienced, there was no pain for the subjects during the MR examinations. Thus such a small MRI can be a useful and comfortable diagnostic tool for hand injuries and Rheumatoid Arthritis.

Conclusions

We have developed two compact MRI systems for hand. Several injuries were successfully detected within a reasonable imaging time. We are now planning to apply these systems to early detection of Rheumatoid Arthritis.

Fig.1 The larger system overview.

Fig.2 The smaller system overview.

Fig.3 Osteoarthritis (18M)

Fig.4 Control (22M)