# Trial of safe working procedure against occupational SMF exposure - evaluation of its effectiveness in occupational SMF exposure levels and work performances among 3 T MRI system users -

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## Introduction

Occupational exposure to the static magnetic field (SMF) is an arising problem in operators of magnetic resonance imaging (MRI) system. It has been well established that human body movements in the stray field from MRI system induces the electric current inside the body and this magnetically induced current causes the temporal sensational changes such as vertigo, headache, nausea and metallic taste etc… to MR workers[1]. Although the individual motion control is recommended for MR workers to prevent these temporal effects[1], more feasible safe working procedure is required to achieve the compliance monitoring. The present study performed the trial of the safe working procedure among 3 T MRI system users and investigated its effectiveness in occupational exposure SMF levels and their work performances.

## Material and Methods

All experiments were conducted under approval of the ethics committee at the National Institute of Occupational Safety and Health, Japan (Kawasaki, Japan: No. H23017) and National Center for Geriatrics and Gerontrogy (Ohbu, Japan: No. 530). Measurements were taken using three cameras (GE60, Library, Tokyo, Japan) and a three-axis Hall magnetometer (THM1176-HF, Metrolab, Geneva, Switzerland) at 3 T MRI system room (Siemens, National Center for Geriatrics and Gerontology, Ohbu, Japan). The study population of the present study is six RTs of 4 males and 2 females and average height was 169.3±8.1 cm. During the safety activity, 30 cm of the approach restricted area was set from the end of 3 T MRI system instead of the individual motion control as recommended by the exposure guidelines[1] (Fig 1). Subjects were asked to perform the mock motion of head MR examination with or without this safe working procedure. The 3-axis hall sensor was attached to the subject's head to measure the exposed SMF at head position. The measurements of magnetic fields were carried out based on the technique as described in our previous research[2]. The data acquisition conditions were as follows; resolution: 0.5–3 mT, bandwidth: DC-1 kHz, sampling rate: 100 Hz. Three cameras in the MRI room recorded the motions during mock examinations.

Capture of subjects' movements were taken at 70 cm (W) X 170 cm (L) X 180 cm (H) of capture area which is located at the vicinity of MRI system (Fig.1) with the flame rate of 30 fps. Reflection-type capture marker was attached on the subject's head and it was placed approximately 3 cm upper to magnetometer. The work performances such as subjects' velocity, sojourn time, and moving distance were analyzed using the motion capture system (Move-tr/3D, Library, Tokyo, Japan).

## Results

The maximum exposed SMFs was 172-849 mT (Average: 492±170 mT, N=18 from 6 subjects) at usual mock head MR examination and 548-92 mT (Average: 365±137 mT, N=17 from 6 subjects) when safe working procedure was performed. Each experimental session contains three times of the trial from the subject (3 trials/session/subject). The average of the maximum value was decreased in 25 % by this action (*t*-test, $p<0.01$).

Table 1 shows the results of motion analysis of MR workers in this experiment. Motion analysis of capture marker (in this case, this means motion capture of the subject's head motion) was carried out only when subjects were located closer than 100 cm distance from MRI system. The minimum approach distance from MR scanner (X-axis) was expanded from 10.2 cm to 18.9 cm under the performance of the safety activity with statistical significance (*t*-test, $p<0.05$, Table 1). No differences in maximum approach distance of X-axis, approach distance of Y and Z-axis, moving distance were observed. And the implementation of this safe working procedure had no effect on subjects' velocity, suggesting that this method do not disturb work performances although sojourn time in MRI room become a slightly shorter under this trial (*t*-test, $p<0.01$, Table 1)

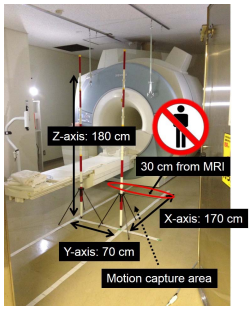

Fig. 1 Experimental setup.

## Discussion and Conclusion

Concerns regarding occupational exposures to MR workers have become a recent focus and International Commission on Non-Ionizing Protection (ICNIRP) released the guideline that mainly targets to the controls of occupational SMF exposure in MR workers on January 2014[1]. This guideline recommends the individual motion control to prevent hazardous effects, however, alternative method is required for compliance monitoring. And motion analysis of MR workers are essential information for numerical calculation of induced currents or to assess the reference level of ICNIRP 2014 guideline. This kind of survey has been carried out by several groups[3], however, the motion capture itself has not been implemented adequately. Our results suggest that this simple safe working procedure is applicative for MR workers to reduce occupational SMF exposure without remarkable changes in work performances. And the quantification of MR workers' motions by motion capture provides the useful information for electromagnetic field dosimetry.

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**References:**

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Table 1 Results of the motion analysis during mock head MR examination.

| | | X-axis (cm) | Y-axis (cm) | Z-axis (cm) | Moving distance (cm) | Velocity (cm/s) | Sojourn time (s) |
|---|---|---|---|---|---|---|---|
| Head MRI without safe working procedure (N=11 from 6 subjects) | Min | 10.2 | -26.0 | 136.7 | 57.1 | 0 | 21.1 |
| | Max | 100.0 | 57.7 | 178.7 | 628.1 | 151.3 | 36.1 |
| | Ave | - | - | - | - | 114.2 | 28.1 |
| Head MRI with safe working procedure (N=16 from 6 subjects) | Min | 18.9 | -25.8 | 131.1 | 45.2 | 0 | 19.9 |
| | Max | 100.0 | 49.8 | 181.4 | 723.4 | 149.0 | 33.9 |
| | Ave | - | - | - | - | 15.1 | 24.9 |