Localized MR Imaging Technique by Using Locally-Linear Gradient Field*

Y.J. Yang, J.K. Lee, S.T. Jeong**, Z.H. Cho**, C.H. Oh

Department of Applied Electronics, Korea University
*** Department of Information and Communications Engineering, KAIST*

부분적 경사자계를 이용한 국부자기공명 영상촬영기법*

양윤정, 이종권, 정성택**, 조장희**, 오창현

고려대학교 자연과학대학 응용전자공학과
** 한국과학기술원 서울분원 정보 및 통신공학과

ABSTRACT

A new localized imaging technique of reduced imaging time using a locally-linear gradient is proposed. Since most fast MR imaging methods need the whole *k*-space data corresponding to the whole imaging area, there are limitations in reducing the minimum imaging time. The imaging method proposed in this paper uses a specially-made gradient coil generating a local ramp-shape field and uniform field outside of the imaging area. Conventional imaging sequences can be used without any RF/gradient pulse sequence modifications. The proposed localized imaging technique has been implemented on a 2.0 Tesla whole-body system at KAIST and the imaging results show the utility of the proposed technique.

INTRODUCTION

Most fast MR imaging methods can be classified by the method to obtain the *k*-space (spatial-frequency space) data as (i) methods using fast gradient switching such as the echo-planar method (1, 2) and (ii) methods with fast RF excitation such as FLASH (3). However, since these methods need the whole *k*-space data corresponding to the whole imaging area, there are limitations in reducing the minimum imaging time. This limitation can be overcome by somehow reducing the imaging region by spatial localization schemes such as ISIS or stimulated echoes (4, 5). However, these methods need extra RF and gradient pulses for the localization of a volume, causing complexity and instability or signal reduction.

METHOD

The imaging method proposed in this paper uses a specially-made gradient coil with a local ramp-shape field and uniform field outside of the imaging area. Conventional imaging sequences such as multislice or gradient-echo imaging can be used without any RF/gradient pulse sequence modifications except the change in the number of encoding steps and the field of view.

The field pattern for the special gradient coil is shown in Fig. 1. For the imaging region of $|x| \le x_0$, it has a usual linear gradient field pattern. However, the field pattern outside of the area shows a flat constant distribution. If we apply the encoding gradient using this gradient, the area for $x < -x_0$ or $x > x_0$ is mapped into one frequency component. Then these areas will be squeezed to small lines in the final image. If the subject covers the area $|x| \le x_{max}$, the minimum imaging time of the area $|x| \le x_0$ with the identical resolution can be

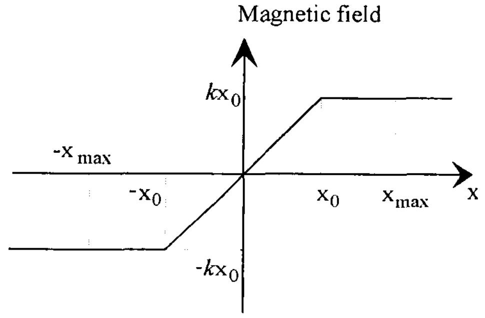

Fig. 1. The locally-linear field pattern for the proposed imaging method.

* : A part of this work has been presented at the third annual meeting of the Society of Magnetic Resonance (1995) in Nice, France.

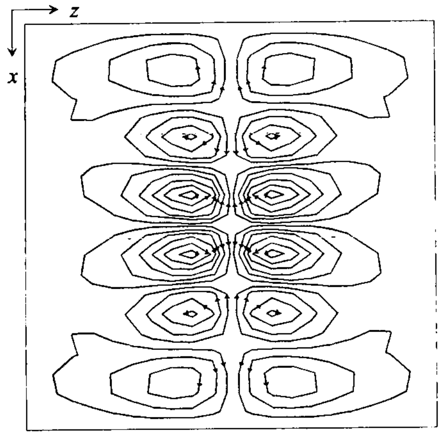

Fig. 2. The wire arrangement to produce the specified locally-linear magnetic field. The imaging volume is assumed to be located 10cm above the center of the coil.

reduced by the ratio of $\frac{x_0}{x_{\max}}$. Alternatively, if we use more encoding steps with an identical field of view, we can obtain the images with better resolution.

We have designed and implemented a surface gradient coil(SGC) with the field pattern specified as in Fig. 1 by using the target field approach. Seven-point target field intensities were specified for the positions of x=0, ±1, ±5, ±10cm along the x axis. The gradient is assumed to be linear for -3cm≤x≤3cm. The position of the gradient coil is assumed to be at y=-10cm. Figure 2 shows the wire arrangement of the designed gradient coil.

In Fig. 3, the B_z map for -10cm≤x≤10cm, -3cm≤z≤3cm, y=0cm is shown. A nice locally-linear gradient field is shown as expected. Figure 4 compares it with a usual linear gradient field and the ideal local x gradient. It shows an almost ideal local gradient field pattern for x≤10cm except a slight distortion along the lines at z=±3cm.

RESULTS AND DISCUSSION

A locally-linear gradient coil has been constructed as designed in Fig. 2. and applied to localized fast (reduced encoding number) scanning on the 2.0 Tesla MRI system at KAIST. One of the results is shown in Fig. 5. Figure 5 (a) shows a 64×64 image obtained with a FOV of 128mm. Since the number of the encoding steps is not enough, fold-overs in the horizontal direction are seen in Fig. 5(a). Figure 5 (b) shows a 64×64 image obtained by using the proposed

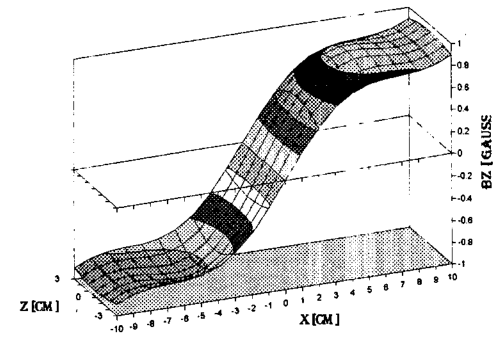

Fig. 3. B_z for -10cm≤x≤10cm, -3cm≤z≤3cm, and y=0cm for the coil designed as in Fig. 2. It shows a nice locally-linear field pattern.

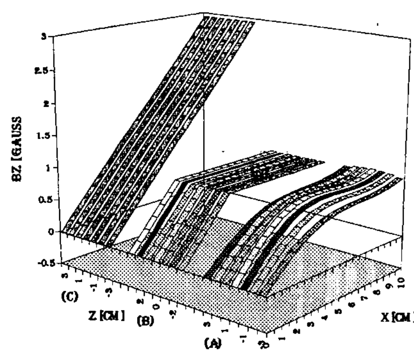

Fig. 4. The magnetic field map for -3cm≤z≤3cm obtained from the wire arrangement in Fig. 2. (a) One obtained from the designed coil, (b) Ideal field map, and (c) A linear gradient field.

locally-linear gradient. Only 64 encoding steps were applied in the x direction. As shown, this image has the same resolution as Fig. 5 (a) without any overlap in the horizontal direction from fold-over.

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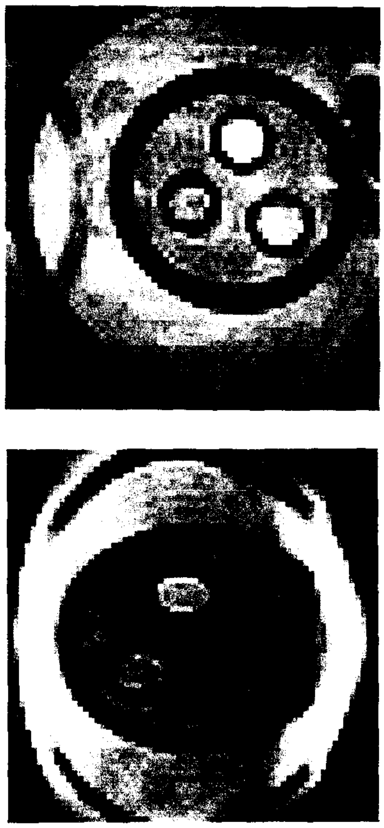

(a)

(b)

Fig. 5. Comparison of images obtained by using the conventional *x* gradient, and by using the proposed locally-linear gradient.
(a) Image from the conventional x gradient coil. (FOV : 128mm, 64 encoding steps)
(b) Image from the proposed locally-linear gradient coil. (FOV : 128mm, 64 encoding steps)

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