N O T E

Improved MR Imaging Using a Surface Coil Designed for the Cervical Spine Part I Properties of the Cervical Coil Determined on the Basis of Iso-intensity Curves

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Basic properties of the cervical coil developed for commercial imaging system were studied by measuring maximum and minimum intensities of the cervical coil using a 5-inch surface coil as a control on the basis of which the percent iso-intensity curves were defined. The coil was also evaluated by MR-imaging of human subjects. The results indicate that percent iso-intensity curves at given distances from the surface coil obtained using the present coil always have a higher percent value than obtained using conventional surface coil and that the present coil possesses the property of being able to obtain appropriate signals effectively from deeper neck region than conventional surface coil.

Matching the appropriate sensitivity range of the present coil to the region of anatomical interest was also emphasized in this paper.

Index terms Cervical spine, magnetic resonance study, iso-intensity curve, surface coil, MR imaging

Introduction

Evidences are being accumulated that MRI is a useful method of examining diseases involving the cervical disks and vertebrae the same as in the case of other imaging modalities, such as the standard radiography, conventional myelography and computed tomography (CT) myelography[1,2]. Comparative studies of these devices demonstrated that MR imaging offers accuracy and sensitivity similar to that of other methods[2,3] as well as advantage superiority of being a noninvasive method. In order to obtain the sufficient spatial resolution in the region of interest (ROI) when it is remote from the surface coil, it has been claimed that using a surface coil specifically designed for the features of cervical spine improves the signal-to-noise ratio (SNR). In our own clinical experience the abnormal contour of cervical and thoracic spines with degenerative disks and vertebrae encountered in elderly subjects sometimes make it difficult to obtain the best quality images. Such situations have led us to develop a surface coil specifically designed to obtain the best quality of images of cervical spine in such elderly subjects. In this article we report the basic properties of cervical coils for MR imaging. A comparative study was performed to demonstrate the profiles of percent iso-intensity curves obtained using the present coil and a reference coil (5-inch general purpose coil) (5-inch GP). Relationships between the profiles of the iso-intensity curves and the contours of the cervical spines were also investigated. Sensitivity profiles clearly demonstrated advantages of the newly developed coil for neck studing of the elderly over the 5-inch GP coil.

Methods and Materials

The surface coil used as a receiver in this study consisted of deoxidized copper tube (8 mm in diameter) wrapped in pieces of syliconized piping for insulation and in polyacetal resin at the portion of the box. The design parameters of the electronic characteristics

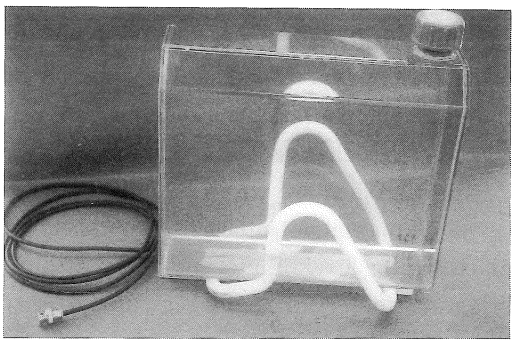

Fig. 1
Experimental apparatus consisting of a cervical coil having "saddle"-like configuration and a phantom containing water. Iso-intensity curve were made as described in "Methods".

on loaded are an impedance of 55 ohms, a resonant frequency of 63.86 MHz and a Q of 220. The surface coil having a "saddle" like configuration measured 29 cm long and 18 cm wide (Fig.1).

To investigate basic properties of the present coil a profile of percent iso-intensity

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curves was compared with that the 5-inch GP. The iso-intensity curves were obtained experimentally using a water-containing phantom (acryl acid resin: width 12 cm; length 30 cm; height 25 cm) which was placed precisely on the surface coils. MRI was performed using GE(Milwaukee, Wisconsin) 1.5 tesla (T) SIGNA MR imager. The method of MR imaging employed was the spin-echo technique with a short echo time (TE) of 20 msec and a repetition time (TR) of 1000 msec (4 excitations) with five-millimeter thick sections. Pixel size was 1.0 mm and a 256×128 matrix was employed. The field of view (FOV) was 24 cm. Images of the phantom thus obtained were used for making the profile of the percent iso-intensity curves by the following method. A maximum intensity, representing the greatest brightness, was measured. When the width on the window is set at 1, maximum intensity is obtained by matching the level of intensity at the greatest brightness observed at the region nearest to the surface coil. The 10 percent values of the difference between maximum and minimum (background intensity) intensity were calculated.

Setting the level at a certain intensity, a contour of the region with brightness was drown. The percent iso-intensity curves with various levels were obtained in this way. Features of the cervical spines at the neutral cervical position were investigated in relation to the percent iso-intensity. Positions of each cervical vertebra (the lowest point of the posterior line of the vertebral body on short TE/TR sagittal image) in the FOV were measured (fig. 2).

The points of the cervical vertebra in each case thus obtained were plotted on a graph to outline the contours of the certebral columns. Fourty-three subjects (22 men and 21 women with an age range of 35 to 90 years) with myelopathy and/or radiculopathy were studied in this investigation. The two different coils mentioned above were used as receivers. Twenty of the 43 subjects were

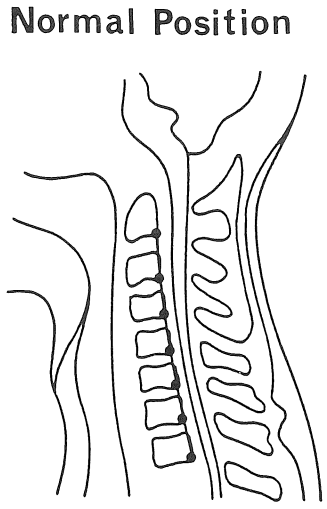

Fig. 2
The position of each cervical vertebra was plotted on the graph and the contour of cervical spine was outlined by measuring the lowest points of the posterior line of the vertebral bodies (closed circles) on the sagittal image in the FOV.

examined using the present coil. The remaining 23 subjects were exmined using the 5-inch GP coil as a control. Spin-echo pulse sequences with a short TR/TE (400 msec/20 msec) were used in clinical study.

Other parameters were the same as those described previously for the phantom study.

All subjects were examined by means of sagittal images. The contours of all cervical spines were superimposed on the profile of the percent iso-intensity curves and the range of the intensity in which the cervical columns were located was read.

Results

Intensity of the present coil and the 5-inch GP

Maximum intensity obtained using the present coil was 1117, whereas it was 1427 in case of the 5-inch GP coil. The maximum intensity of the former was significantly lower than that of the latter. Since the minimum intensity measured in this study was 1024, the 10 percent values of the differences were 9.2 and 44.3, respectively. When the iso-intensity curves obtained using the two coils were compared, the present coil at the given distance had a higher percent value than obtained using the 5-inch GP (Fig. 3). The slope of intensity plotted against distance was less steep in case of the present coil than in the letter. Moreover, the intensities at the distances more than 8 cm from the surface of the present coil revealed higher values than those obtained by 5-inch GP (Fig. 4).

Contours of Cervical Spines

The contours of the cervical spines obtained using the two different coils are shown in Fig. 5. There were no sex differences between them. However, cervical spines exmined using the present coil were generally located about 1 cm farther from the bottom of the coil than those examined using the 5-inch GP coil. This was apparently caused by the patient's neck being put on a sponge pad placed on the coil. As far as the profiles of the percent iso-intensity curves are concerned, the cervical spines examined using the present coil were located in the range of 50% to 80% iso-intensity, whereas cervical spines examined using the 5-inch GP coil were located in the 10% to 30% range.

Discussion

Several types of surface coil have been

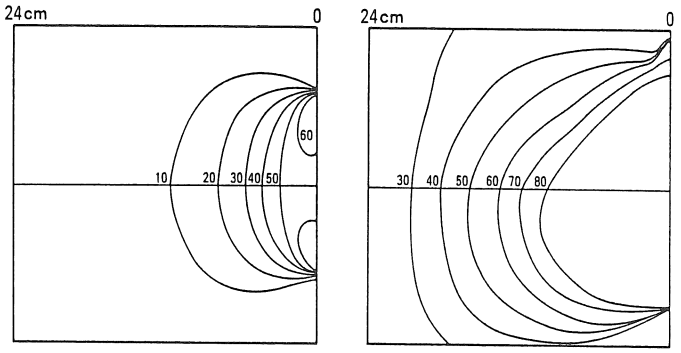

Fig. 3
Profiles of percent iso-intensity curves obtained using two difference coils (5-inch GP coil for reference and a cervical coil). The FOV was 24 cm×24 cm. The method is described in the text.

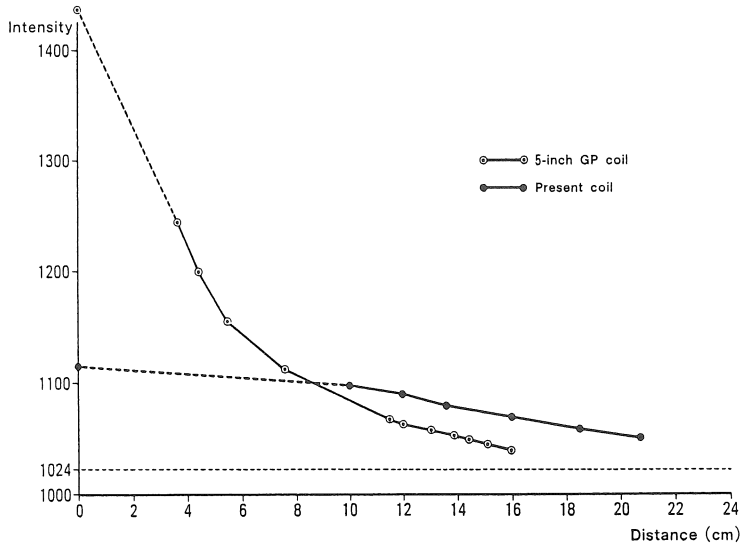

Fig. 4
Decay curves of intensity obtained using two different coils. Values have been plotted against distance. Intensity values were measured at the midline of the FOV as shown in Figure 2. The present cervical coil had a slope less steep than that in the case of the reference coil.

developed for cervical spine imaging. Few reports, hewever, have concerned basic studies describing about the properties of the cervical coil. The properties of the present coil included the finding that the intensity decreases at a much less steep slope than in the case of the 5-inch GP flat coil used as a reference, although maximum intensity is significantly lower in the present coil. It appeared that a certain range of the area imaged in the case of the present coil was revealed the greater values of iso-intensity curves than in the case of the 5-inch GP.

Cervical spines measured using the 5-inch GP cervical spines were located mostly in 30% to 10% region of the iso-intensity curves. These iso-intensity values correspond to distances of 6 cm and 12 cm from the surface of the coil, respectively. Supposing that this intensity range is suitable for obtaining the best cervical imaging results, these intensites could be obtained roughly from distances of 0 cm to 16.0 cm using the present coil. Mereover, the intesities at the distances more than 8 cm from the surface of the present coil revealed higher values than those obtained by 5-inch GP as mentioned previously. Hence, when performing MR imaging with use of the present coil, the best cervical imaging results would also be obtained in the above described region, and the present coil thus possesses the property of being able to obtain signals effectively deeper region than conventional surface coil. It also appears that MR imaging of the cervical spine using the present coil can offer useful information con-

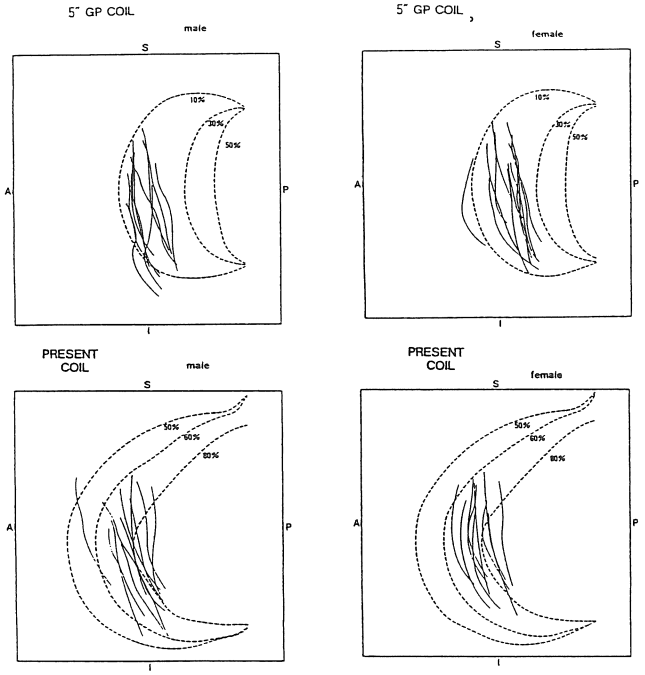

Fig. 5
Relationship between the profiles of percent iso-intensity curve and localization of the cervical spine. The cervical spines obtained from the reference coil (5-inch GP coil) fell roughly ithin the 30% to 10% range of the iso-intensity curves, whereas the cervical spines obtained using the present coil fell within the range of 80% to 50% of the iso-intensity curves.

cerning the anatomical and pathological features of cervical regions even in the case of persons with abnormal cervical spine contours and that it may also be applicable to dynamic studies of flexion and extension.

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