The SENSE CTL Coil for 3T 8-Channel MRI Systems

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Introduction

The traditional Cervical-Thoracic-Lumbar (CTL) Spine coil consists of several quadrature coil pairs. Each quadrature coil pair consists of a loop coil and a saddle coil. The loop and saddle coil are either analogically combined in the coil or digitally combined in the system. The CTL coil with the quadrature structure made for 1.5T or lower field MRI systems has optimized SNR in the center area where the spine is located. But when it is used in 3T or higher field systems it has asymmetrical sensitivity in the left-right (LR) direction. The images acquired by the coil have obvious LR shading. This phenomenon was reported as early as in 1988 by H. Merkle [1] and in 1989 by P. H. Wardenier [2] and is known as Local Intensity Shift Artifact (LISA). The distribution of the circular polarized electromagnetic field with high radio frequency generated by nuclei spins inside the human body is affected by the dielectric and conductivity of the tissue. The coil with a symmetrical structure has a tilted and shifted sensitivity map. The tilting and shifting direction is related to the direction of the main magnetic field of the system. The CTL coil with the quadrature structure doesn't have SENSE imaging capability in LR direction. The coil has very high G factor for phase encoding in LR direction because the loop and saddle coil of each quadrature pair have a large common coverage in LR direction.

The present CTL coil is designed for 3T or higher field systems with eight receive channels. It uses three parallel loop coils in LR direction for each coil section. The coil with this 3-loop structure generates a wide and uniform sensitivity area in LR direction to cover the spine region. The new structure provides SENSE imaging capability in LR phase encoding direction in additional to the head-foot (HF) direction. The coil with a neck bridge also has SENSE imaging capability in the anterior-posterior (AP) direction for the cervical spine scan.

Method

The present coil (see Fig.1) consists of 14 loop elements (see Fig.1). There are 12 loop elements on the posterior former and 2 loop elements on the removable anterior neck bridge. The loop elements on the posterior former are aligned into four sections in HF direction. Each section has three parallel loop elements laid in LR direction. The loop elements of the first section are conformal to the shape of the neck. Adjacent loop coils have overlap in order to get best isolation and also get best SNR. Normally for the cervical spine scan (C mode) eight coil elements of the first and second sections and the neck bridge are selected to receive signals. For the thoracic spine scan (T mode) six coil elements of the second and third sections are selected. For the lumbar spine scan (L mode) six coil elements of the third and fourth are selected. The DC currents from the system control the multiplexer inside the coil to connect selected coil elements to the receive channels of the system for each scan mode. The maximum FOV for each scan mode is 40cm.

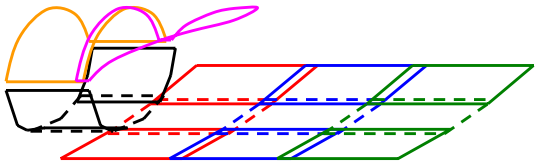

Fig.1 The new CTL with 14 loop elements

In order to increase the penetration of thoracic and lumbar spine an anterior torso piece with two loop elements inside can be added to the new coil. The anterior torso piece can also provide SENSE imaging capability in AP direction for the thoracic and lumbar spine scan.

Results

The new CTL coil and the traditional quadrature CTL coil have been tested in the 3T system. Fig.2 and Fig.3 are the axial and coronal lumbar spine images acquired by the new CTL coil and the traditional CTL coil. The images show that the new CTL coil with 3-loop structure has better signal uniformity in LR direction. Even though the sensitivity of each loop coil is tilted and shifted but the sensitivity combined from three loop coils is uniform in LR direction. It doesn't have LR shading problem. Because the uniform sensitivity area is very wide it doesn't matter which direction the sensitivity is shifted to. That means it doesn't matter which direction the main field of the system is. Since the sensitivity of the quadrature CTL coil is tilted and shifted the coil doesn't has the best SNR in the center. The 3-loop CTL coil has almost the same SNR as the quadrature CTL coil in the center.

Fig.4 shows axial G factor maps of the new CTL coil for R=2. For the C mode, the average G value is 1.20 and the maximum is 1.64 for AP phase encoding, and is about 1.29 in the lower area where C-spine is located for LR phase encoding. For T or L mode, the G value of the lower area (below 12 cm) where the spine is located is lower than 1.6.

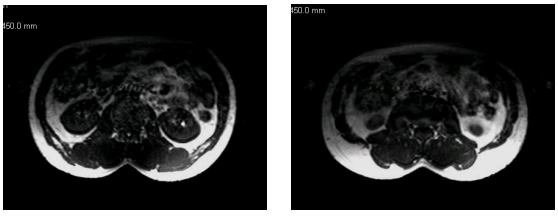

Fig. 2 The axial spine images of the new CTL coil (left) and the traditional CTL coil (right)

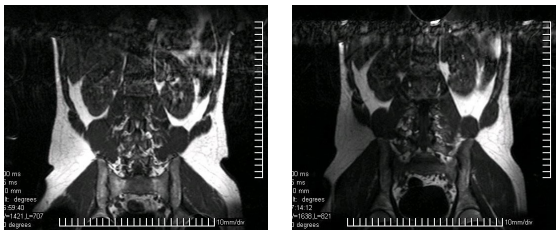

Fig. 3 The coronal spine images of the new CTL coil (left) and the traditional CTL coil (right)

Conclusion

The new CTL coil with 3-loop structure is suitable for 3T or higher filed systems. It doesn't have LR shading problem and is a SENSE compatible coil.

References

[1] Merkle, H. et al., SMRM Book of abstracts, 114, 1988.
[2] Wardenier, P., SMRM Book of abstracts, 1175, 1989.
[3] Pruessmann KP, Weiger M, Scheidegger MB, and Boesiger P, Magn Resn Med 42:952-962, 1999.

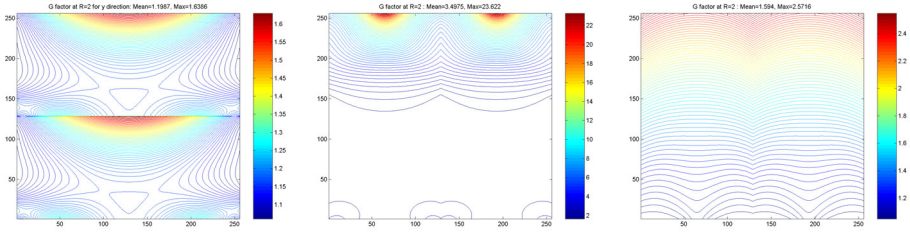

Fig. 4 The G factor maps of the new CTL coil in C mode (left and center) and T/ L mode (right)