A 21-channel High Performance Combo Head-Neck-Spine-Cardiac Coil for 3D Parallel Imaging Applications

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Synopsis: The quest for MRI systems with larger number of receiving arrays [1] allows the design of a multi-functional RF coils to distribute sufficient channels/coil elements at each region of interest (ROI) and provide performance that can meet or exceed that of a dedicated regional RF coil. In this paper we present a 21-channel combo head-neck-spine-cardiac coil that has been proven to be able to provide higher SNR and better coverage than does an 8-channel brain coil, an 8-channel Cervical-Thoracic-Lumber (CTL) coil, and an 8-channel cardiac coil for head, neck/c-spine, and aortic arch imaging.

Introduction: Lately developed multi-purpose array coil systems, for example, a 16-channel neurovascular coil [2], utilize a large number of phased array coil elements to provide improved SNR over an extended field-of-view (FOV) and parallel imaging [3,4] capability as well. Until now, the design of the most of neurovascular coils is still the traditional three-section version: head, anterior torso and posterior torso sections. The drawback of the three-section design is the signal drop-off between the head and torso regions, which causes shading at neck region. As the number of coil elements increases for each of the head and torso regions, the size of each coil element decreases correspondingly. This makes the shading problem at the neck region even more severe. Furthermore, the three-section design does not facilitate parallel imaging in the superior-inferior (SI) direction in the head region and in the torso region. In this paper, we present a new four-section, 21-channel combo head-neck-spine-cardiac coil which makes 3-dimensional (3D) parallel imaging feasible for all the three major imaging modes, i.e., head, neck/c-spine and full FOV vascular modes.

Methods and Materials: The 21-channel combo coil, as shown in Fig. 1, consists of four sections: brain, neck, anterior torso and posterior torso sections. Six shaped loop coils are distributed along the outer circumference of the head coil former for each of the brain and neck sections. Two saddle coils are also placed under the neck to enhance the performance for the neck and c-spine imaging. The anterior torso coil, which is a detachable and adjustable piece, has four loop coils: two of them are arranged at the middle in the superior-inferior direction while the other two are placed on the left and right sides of the middle two coils. A similar coil configuration is also used for the posterior torso coil. Both geometric overlap and preamplifier decoupling are used to isolate the adjacent coil elements. The isolation for the next nearest neighbor coils and the coils facing each other is solely depended on preamplifier decoupling. This 21-channel combo coil can be designed primarily for a 16- or 8-channel MRI scanner, which has at least eight DC (PIN diode) control lines. For each imaging mode, a certain number of the twenty-one coils are selected through multiplexing/switching using the DC control lines. For head mode, 12-14 coils from the brain and neck sections are selected; for neck/c-spine mode, 12-15 neck and torso channels are used; and for full FOV vascular mode, 16 channel from all the four sections are properly chosen to achieve the best SNR and uniformity for the vascular imaging from the circle of Willis to the aortic arch. Phantom and volunteer images were obtained using the 21-channel combo coil on a GE Signa 1.5T 8-channel MRI scanner. For phantom imaging, two consecutive scans were performed for each of the three imaging modes. In each scan six to eight coil elements were selected. A final image was obtained by using the sum of square method for the images (12-16 images) acquired in the two consecutive scans. In order to scan volunteers on the 8-channel MRI system the 12-16 channels for each of the three imaging modes were properly combined into 8 channels, which results in a lost of 15-20% of the overall SNR. Some commercially available regional RF coils, for examples, a quadrature (QD) head coil, an 8-channel brain coil, an 8-channel CTL coil and an 8-channel cardiac coil, were used to compare against the 21-channel combo coil.

Results and Discussions: Figure 2 shows the SNR comparison for head region for the 21-channel combo coil, a QD head coil and an 8-channel brain coil. The SNR values were obtained along the center line of a sagittal image of a cylindrical phantom (16 cm ID and 26 cm long). The SNR of the 21-channel combo coil, at the middle of head region, is significantly higher (> 60%) than that of the QD head coil and also considerably higher (> 20%) than that of the 8-channel brain coil. ASSET imaging with a reduction factor of 2 was performed on a healthy volunteer for T_2-weighted axial and 3D TOF angiographic images as shown in Figs. 3 and 4, respectively. Phase encoding was in the left-right direction.

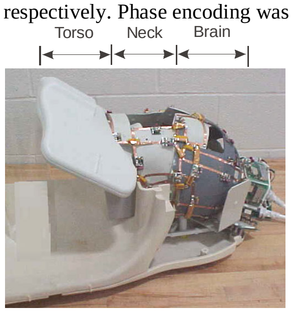

Fig. 1 The 21-channel combo coil.

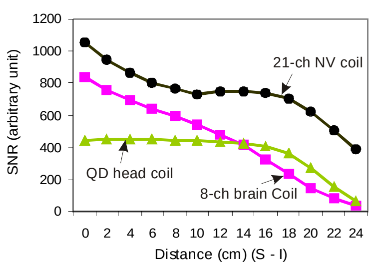

Fig. 2. SNR comparison.

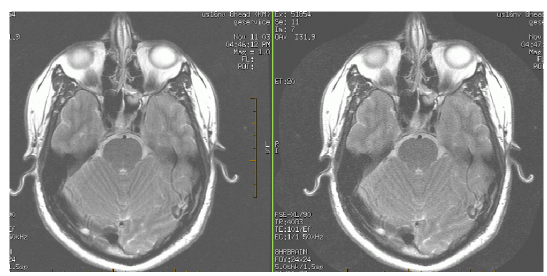

Fig. 3. Full (left) and ASSET with R=2 (right) axial head images.

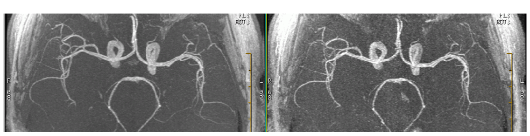

Fig. 4. Full (left) and ASSET with R=2 (right) 3D TOF images.

Conclusions: The 21-channel combo coil has shown to be able to outperform dedicated regional RF coils for head, neck/c-spine and aortic arch imaging. The four-section design for the 21-channel combo coil makes parallel imaging feasible in all the three dimensions and for all the three imaging modes. The high performance potential of the 21-channel combo coil will be fully realized when it is used on a MRI scanner equipped with sixteen or higher number of receivers.

References:

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