Double Loop-Asymmetric Saddle Coil Arrays Optimized for Spine and Torso Imaging

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Introduction: Of different surface coil topologies: loop, saddle, asymmetric saddle (Asaddle) [1,2], saddle train [3], higher order lobed coils [4], etc., loop coil is, in most the cases, the simplest and most efficient one for MRI. Therefore, loop coils are usually the choice for construction of large channel count arrays [5]. So far, to our best knowledge, all the loop arrays are single layer structure. Multi-layer coil configurations [4,6], for particular application like cardiac imaging, demonstrated good SNR and parallel imaging (PI) capability, however, its complicated multi-layer circuit layout makes it difficult to become a building element to replace each individual loop coil in an array. In this abstract, we propose a double asymmetric-saddle (DAS) coil configuration, shown in Fig.1, which inherits the advantages of loop coil and also the quadrature nature of a loop-saddle pair. In other words, an asymmetric saddle coil can behave very much like a loop coil and has similar efficiency for MRI as a loop coil. The quadrature nature between the pair of asymmetric saddle coils offers two major advantages. First, it allows the two asymmetric saddle coils to significantly overlap. Second, it can achieve simultaneous minimization of both mutual inductance and correlated noise between the two asymmetric saddle coils. Significant SNR improvement has been observed for a DAS coil package over a single loop coil of similar size.

Methods: Preliminary studies for the properties of asymmetric saddle coils were conducted at 1.5T frequency. A pair of identical asymmetric saddle coils, as shown in Fig.1, and a pair of identical loop coils (not shown) were constructed and tuned to 64MHz. Here the values for D1, D2, D3 and D4 for the two asymmetric saddle coils are 10cm, 1cm, 2.5cm and 5cm, respectively. The length (L) of the asymmetric saddle coils was 15cm. The size of the loop coil was 10cm x 15cm. Isolation values between the two coil elements of each pair were measured, using a network analyzer (S12), when the coils were first in air (i.e., unloaded) and then loaded with a physiological phantom. Images of the same physiological phantom were also obtained for an asymmetric saddle coil and a loop coil, respectively, on a GE Excite 1.5T MRI scanner, see Figs. 2 and 3.

Results and Discussions: The unloaded isolation value was about 30dB between the two asymmetric saddle coils and between the two loop coils. This shows that the mutual inductance between the two coils of each pair was well minimized when they were unloaded. On the other hand, under the loaded condition the isolation value for the two asymmetric saddle coils (29dB) was significantly better than that for the two loop coils (15dB). The significant drop of the loaded isolation of the two loop coils from its unloaded value was mainly due to the electric coupling between them through the conducting solution of the phantom [7]. The electric coupling is the source of correlated noise for MRI. These clearly indicate that the electric coupling/correlated noise between the two asymmetric saddle coils was significantly lower than that between the two loop coils. Figs. 2 shows the SNR profiles (for a single asymmetric saddle coil and a single loop coil), obtained at 7cm deep from the phantom surface, of the axial images at the middle of the asymmetric saddle and loop coils in the right-left (R-L) direction. The origin of the horizontal axis was defined as the geometric centers of the large wing of the asymmetric saddle coil and also the loop coil as well. The shift of the center of SNR profiles from the coil geometric center was due to the dielectric/wavelength effect on the phantom images at 1.5T. In Figs. 3, the SNR profiles, obtained from the same axial images, were plotted along the line passing through the geometric centers of the two coils in the anterior-posterior (A-P) direction. From Figs. 2 and 3, we can see that the performance of the asymmetric saddle coil is very similar to that of the loop coil. The efficiency of the asymmetric saddle coil will approach to that of the loop coil if the ratio of D3/D1 is further reduced. Based on this DAS building element, a double loop-asymmetric saddle (DLAS) coil configuration [8], as shown in Fig. 4, was designed. In this DLAS design, the two loop coils were arranged on the left and right sides of the middle two asymmetric saddle coils to form a building block. A 3T array coil with multiple DLAS blocks was constructed and tested against a commercially available 3T 8-channel quadrature cervical-thoracic-lumber (CTL) coil on a GE Excite 3T scanner. Higher SNR for spine imaging was observed for the DLAS array coil, as shown in Figs. 5-7. Fig.7 shows the SNR improvement (ΔSNR in percentage) of the DLAS array coil over the CTL coil for three healthy human volunteers (V1, V2, V3) of different sizes. The DLAS array coil could also achieve a reduction factor of 3 for parallel torso imaging, see Fig. 8.

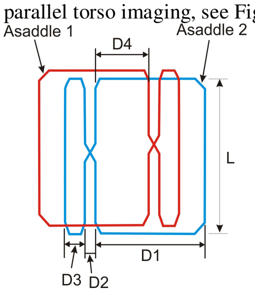

Fig.1. The DAS pair.

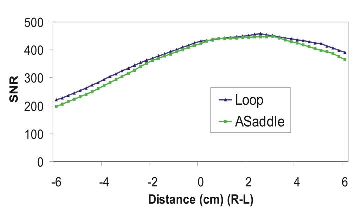

Fig.2. SNR profiles in the R-L direction.

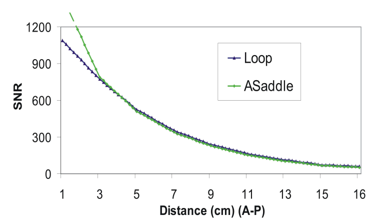

Fig.3. SNR profiles in the A-P direction.

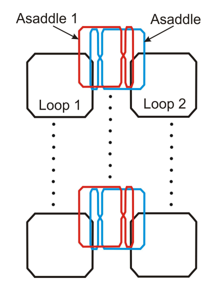

Fig.4. The DLAS array coil.

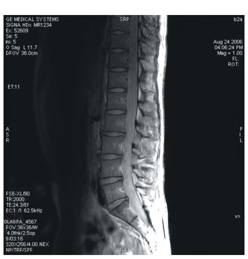
Fig.5. From the DLAS array coil.


Fig.6. From the CTL coil.

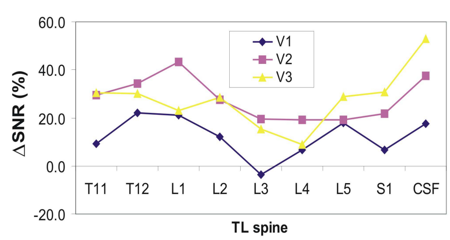

Fig.7. SNR improvement for TL spine imaging.


Fig.8. ASSET with R=3, PE: L/R.

Conclusions: The DLAS coil design, with two asymmetric saddle coils at the middle of each building block, has demonstrated to be able to outperform the quadrature CTL coil for spine imaging and provide good parallel imaging capability as well. The DAS building element has the potential of improving SNR and can be used to replace loop coil for future array design.

References:

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