The Effect of Over/Underlap of Surface Coil Elements on AP Direction Acceleration

G. R. Duensing[1], S. Vijayakumar[1], S. B. King[2]

[1]Advanced Concept Development, Invivo Corporation, Gainesville, Florida, United States, [2]National Research Council of Canada, Winnipeg, Manitoba, Canada

Introduction: It has been reported that "underlapping" coils in an array provides lower g-factor than the conventional coils overlapped for zero mutual inductance (1). In the following, we examined the effect of overlap on g factor and parallel SNR. Three cases with very different underlap/overlap conditions were simulated.

Methods: All coils were simulated as 10 cm square loops, with all resistance originating with the sample, modeled as a rectangular volume (40 cm in the z direction X 40 cm in the left-right direction X 38 cm in the AP direction) on one side of the coils and spaced 2cm away. The phase encoding direction was taken to be perpendicular to the plane of the coil array (the AP direction). The imaging plane with g factor and SNR results is a sagittal slice (40 cm in the z direction X 38 cm in the AP direction) centered on the array in the left-right direction and originating 2 cm above the coil array. All coils were modeled by using the shifted field of one source loop modeled and simulated using Remcom FDTD software at 64 MHz. Uniform under-sampling with a reduction factor of 2 was assumed. The calculations for g factor followed the description by Pruessman et al. (2). We chose to compare the coil arrays in the following fashion. Coil sizes were identical for all cases. The number of coils used in the comparison was the number of coils that had a portion within the 40 cm FOV. Assessment of g factor and SNR was to be considered to be accurate in the central region (in the z-direction). The 40 cm sections for the three linear geometries compared are shown in Figure 1a-c.

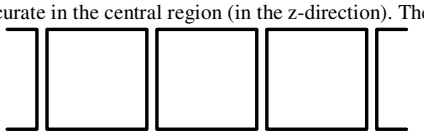

Figure 1a. 1cm underlapped loops

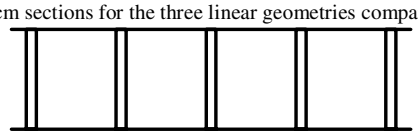

Figure 1b. 1 cm overlapped loops

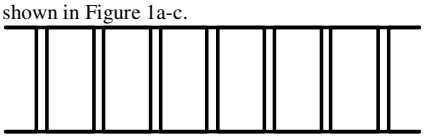

Figure 1c. 4.5 cm overlapped loops

Results: The results are summarized in Figures 2 through 5. The 9 greatly overlapped loop array (4.5 cm overlap) produced both lower g factor and higher parallel SNR than the standard underlapped loops everywhere in the assessed plane. Figure 4a, therefore shows the g factor ratio is always less than one, while Figure 4b shows that the ratio of parallel SNR is everywhere greater than one. The 5 loops overlapped by 1 cm produced similar overall results as the 5 underlappped loops.

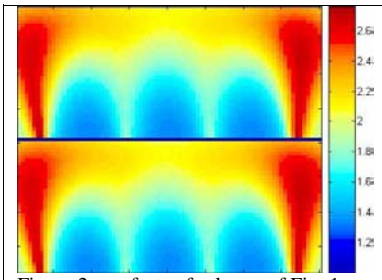

Figure 2a. g factor for loops of Fig. 1a

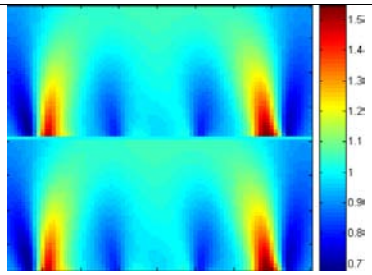

Figure 3a. Loops 1b g factor divided by loops 1a g factor

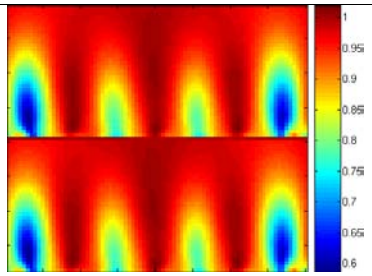

Figure 4a. Loops 1c g factor divided by loops 1a g factor

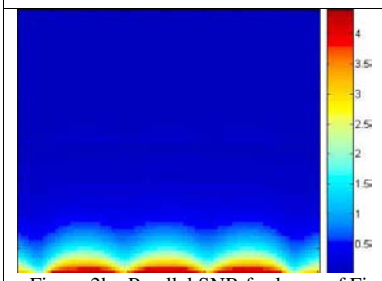

Figure 2b. Parallel SNR for loops of Fig. 1a

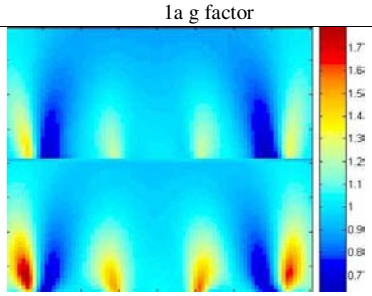

Figure 3b. Loops 1b parallel SNR divided by loops 1a parallel SNR

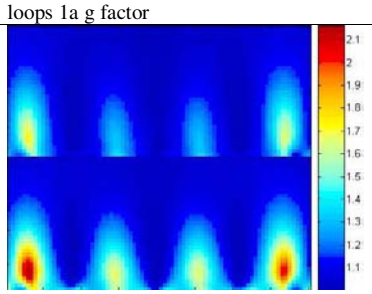

Figure 4b. Loops 1c parallel SNR divided by loops 1a parallel SNR

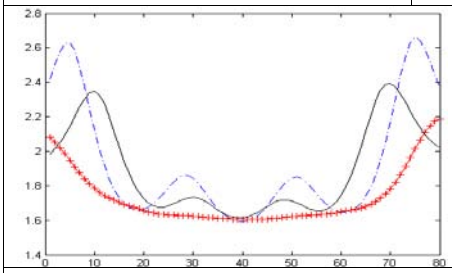

Figure 5a. g-factor profiles through a sagittal slice at a distance of about 10 cm from the coil

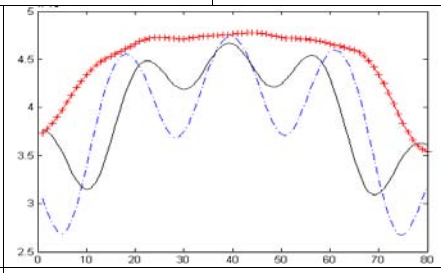

Figure 5a. Parallel SNR profiles through a sagittal slice at a distance of about 10 cm from the coil

Conclusion: Our simulations lead to a conclusion that large overlap provides the best results in terms of parallel SNR, for AP speed-up, albeit while utilizing more channels. At a depth of 10 cm (typical spinal cord depth) the parallel SNR was better by as much as 20% in the areas above the underlapped loop gaps as seen from Figure 5b. It should be noted that the large overlaps, which provided the best results, create a difficult practical situation, since the coils will tend to be highly coupled, however the twisted array demonstrated by King (3) may offer a partial solution by creating large overlaps but maintaining adequate isolation between channels.

Reference: (1) de Zwart et al, MRM 2002 Jun; 47(6):1218-27. (2) Pruessman et al. MRM 42:952-962 (1999). (3) S.B. King, Proc. ISMRM p.675 (2005)