Fully Exploiting the PILS Effect for High Performance Joint imaging: Benefits of Coil Arrays with S/I Sensitivity

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Target audience: Imaging scientists interested in accelerated imaging and clinician scientists interested in high performance joint imaging.

Introduction: Large phased arrays coils are arranged in multiple rows normally to enable parallel imaging acceleration in more than one dimension. As image resolution is paramount in joint imaging, phased array coils are utilized for a more conventional purpose, improved SNR. However, radial imaging has been shown to improve dramatically with larger phased arrays coils due to the PILS effect[1]. We hypothesize that the asymmetry of a single row coil allows the PILS effect to only be partially exploited in 3D radial imaging. We utilize a means to estimate aliasing's contribution to noise-like variance and demonstrate the significant benefits of reducing aliasing with a 16-channel, 3 row knee coil relative to- a conventional 8-channel single row knee coil.

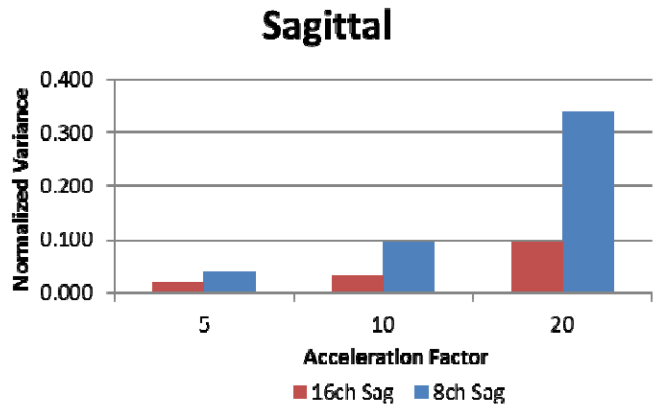

Table 1 The magnitude of artifact due to aliased, undersampling artifacts and the rate at which it grows with acceleration factor is lower for the 16 channel coil with S/I sensitivity.

Methods: For a single channel coil, the number of acquired radial lines necessary to fully sample a spherical volume increases as the image matrix size, N_r, squared. Specifically $N_{TR} = \pi N_r^2$ (Eq. 1) where N_{TR} = number of radial lines. However, the PILS effect states that individual coils in phased array systems are sensitive to a smaller subvolume of the entire image[1]. Thus N_r is effectively reduced, which in turn decreases the actual number of radial lines that need to be acquired. A typical 8-channel knee coil is arranged entirely in a single row about the physical z-axis. While the effective image matrix for each coil is reduced in the transverse plane, there is no differential S/I sensitivity and thus no reduction of the image matrix in that dimension. Therefore we compared an 8-channel single row knee coil (GE/Invivo Precision) to a 16-channel knee coil (GE NeoCoil, Pewaukee,WI) split in 3 rows of 5,6 and 5 elements to determine if the increased sensitivity in the S/I direction improved performance over a single row coil design. A 0.33 mm isotropic, 8 minute scan was utilized to challenge imaging performance with a theoretical undersampling factor of 5 (Eq. 1) on a GE 750 3T scanner. Scans were also repeated with increasing acceleration (5,10,20) to increase undersampling artifact while signal averaging was increased to keep the same level of stochastic noise. Any increase in the variance over ROIs of comparisons of the same region is thus due to undersampling.

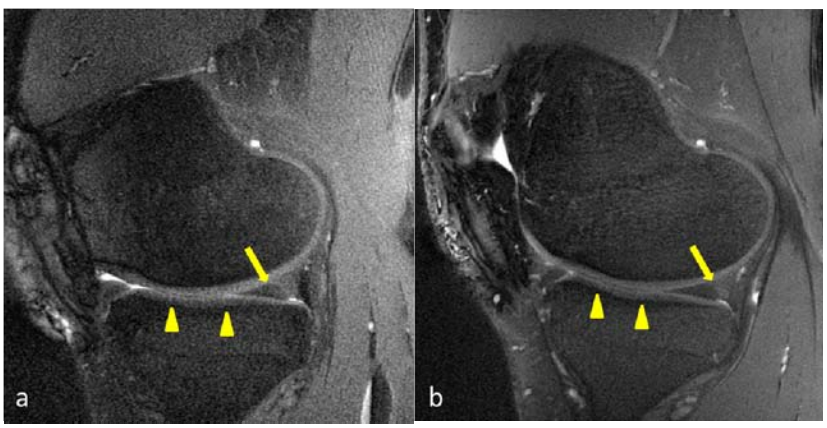

FIGURE 1. Improving performance using coils with S/I sensitivity. Note improved bone-cartilage interface (small arrows, meniscus (large arrow) and muscle depiction in (b) due to reduced noise-like aliasing energy.

Results: Table 1 shows a comparison of variance due to tissue and surface coil variation and undersampling over an ROI as undersampling is increased while stochastic noise is held constant. The study shows that the 16-channel coil has some headroom to accelerate through undersampling while artifacts due to undersampling rapidly escalate with the 8-channel coil. While comparing exactly the same anatomy is difficult due to differences in the knee flexion created by each coil, the 16 channel coil significantly reduces noise-like artifacts due to undersampling that improve depiction of the meniscus, bone-cartilage interfaces, and muscle, as shown in Fig 1. In Fig. 2, the 16 channel coil performs remarkably well at this challenging resolution in depicting the patella cartilage, removing mottling in bone, and is especially evident in the posterior vasculature. Performance improvement at challenging resolutions with 16 channel coils is much higher than one could expect when using a Cartesian sequence.

Conclusion: Providing S/I sensitivity through the addition of coil elements in rows in the S/I dimension allows commercial coils to fully exploit the PILS effect in high performance 3D radial joint imaging.

References 1. Griswold MA et al, MRM, 2000, 44:602-609.

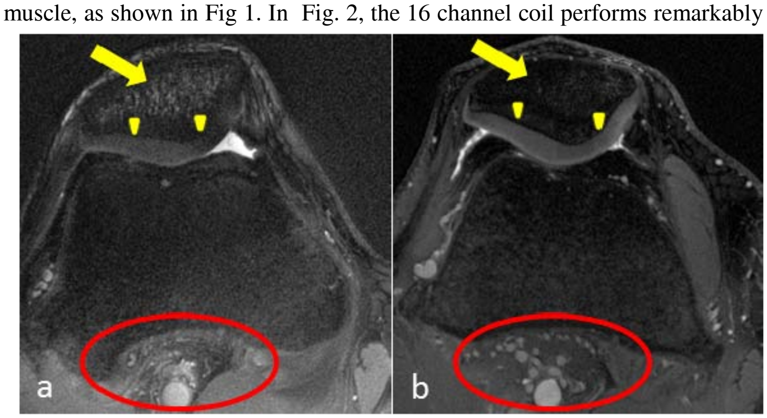

FIGURE 2 Improved performance demonstrated in the axial plane with 0.33mm isotropic resolution. Cartilage SNR is degraded in the 8-channel image due to under sampling compared to the16-channel image (arrowheads). Aliasing in the patella bone in (a) ,which could be confused with bone marrow edema, is also eliminated in (b)(large arrows).