Multi Nuclear Volume Coil for1H and 23Na in the Human Knee

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INTRODUCTION: Sodium MRI is currently being used in human patellar articular cartilage imaging, clearly distinguishing areas of glycosaminoglycan (GAG) depletion from areas of healthy cartilage [(1)]. Previous designs using four ring bird cages [(2)] have shown deficiencies in axial coverage for the sodium section and poor uniformity in the split proton sections of that design. We propose the use of two separate concentric birdcages with slightly different diameters and similar axial field of view in order to avoid the problem of resonant coupling that would cause field interactions between the two coils. By using low pass topology for the higher frequency coil and high pass topology for the lower frequency coil the coil interactions are avoided resulting in better coil performance.

METHODS AND MATERIALS: Two concentric birdcages were employed on a whole body Discovery MR750 3T scanner (GE Healthcare, Waukesha, WI). By using a low pass topology for the outer 1H proton section (128MHz) and a high pass topology for the inner 23Na Sodium section (34MHz) as shown in Figure 1. , we have achieved operation of volume coils at both nuclei without the use of lossy traps, active diode disable circuits or other decoupling methods that reduce coil Q. We have completely avoided resonant mode coupling since the higher order modes of the high pass 23Na Sodium coil will be below 34MHz and the higher order modes of the low pass 1H proton coil will be above 128MHz. Both coils are circularly polarized quadrature operation using lumped element lattice baluns on the high pass 23Na Sodium section and a dual cable trap balun on the 1H low pass section. By mechanically combining the two coils concentrically, the proton coil had little effect on the sodium coil. However the sodium coil had a proximity effect and shifted the proton frequency up about 5%, this was easily retuned down to the proper proton frequency. The two coil sections were rotated 22.5° from each other to minimize rung interaction. Sodium images which were obtained using a fast gradient-spoiled sequence with the 3D cones k-space trajectory, TR/TE 35/0.6 ms, 70° flip angle, 28 NEX, 1.25x1.25x4mm3, 21:33 scan time [(3,4)] .

RESULTS: We imaged two healthy volunteers. The sodium coil produced images (fig.2) with signal to noise (SNR) of nearly double the results of the four ring birdcage, mainly due to higher Q from the heavy copper tube construction of the sodium coil. The proton section also showed an improvement in uniformity and coverage over the split proton sections of the four ring birdcage. When the two coils were combined some loss in Q and tuning shift was observed in the proton section, but the sodium coil was not significantly affected by the addition of the proton coil. More detailed performance comparison will be presented in another abstract by the authors.

DISCUSSION: This method holds great potential in other applications including C13 Hyperpolarized Carbon and 1H Proton. It could also be used as a whole body volume coil for 23Na Sodium and 1H proton. In general a low pass 1H proton coil can be combined with any other nuclei of lower gamma without risk of significant coupling. In addition is should be possible to combine coil arrays for C13, 23Na or other nuclei with a low pass 1H proton coil. In addition, this coil arrangement should also support the use of combined multiple nuclei interleaved imaging or even multiple nuclei simultaneous imaging.

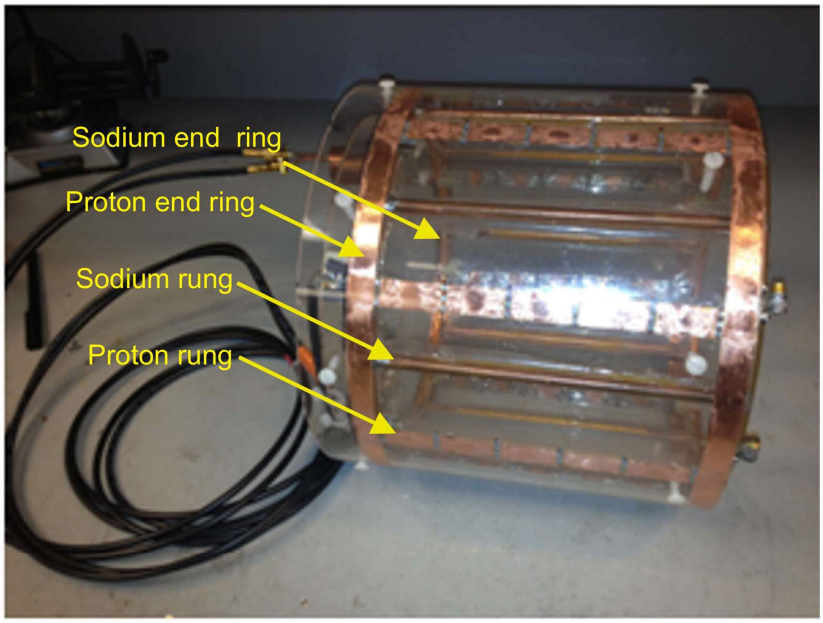

Figure 1. Combined concentric 1H/23Na birdcages

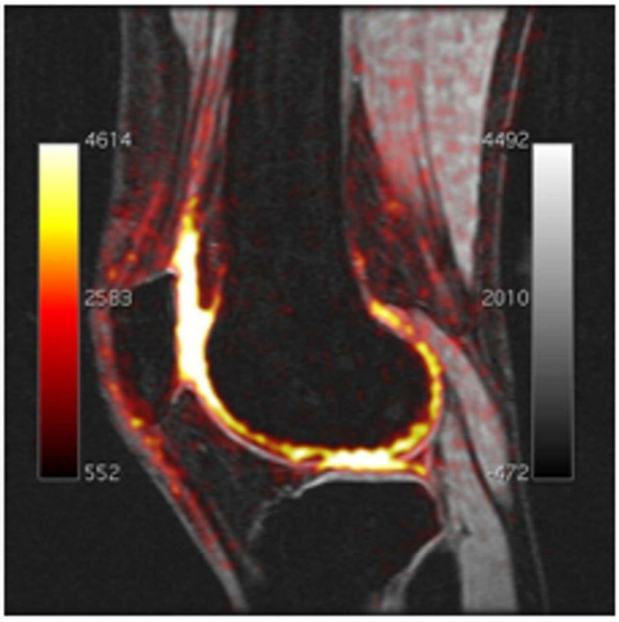

Figure 2. Sodium Image overlaid on DESS Low Proton Image

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