

## Fluid-suppressed $^{23}\text{Na}$ MRI of Knee Joint at 7T

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**Introduction** Loss of glycosaminoglycans (GAG) is a signature of early osteoarthritis (OA). Sodium MRI has been shown to correlate linearly with GAG concentration in cartilage [1]. However, sensitivity constraints do not allow one to demarcate cartilage tissue completely, and signal contributions from fluids often occur. The aim of this study is to use inversion-recovery (IR) and quadrupolar contrast (quadrupolar filter by nutation – QFN) methods to null the signal of fluids and thereby enhance the quantifiability of sodium concentrations. While the IR method nulls the signal of fluids simply based on the long  $T_1$  times of fluids compared to those of cartilage sodium, the QFN method provides this demarcation based on the dependence of the signal intensity on the quadrupolar interaction. Since no residual quadrupolar interaction is present in fluids, those signals are suppressed well.

**Methods:** 3D sodium images of whole knee joint were acquired on five healthy volunteers after the IRB approval with the following parameters: TE/TR=0.25/100 ms, 10,000 radial projections, pulse durations 0.2-1ms, inversion-recovery delay 28 ms, FOV=192mm, 3mm isotropic resolution. A quadrature  $^{23}\text{Na}$  knee coil (Rapid MR International, LLC, OH) was used. The images were reconstructed offline using a non-uniform fast Fourier Transform algorithm [2].

### Results and Discussion:

- **Fluids are suppressed extremely well in QFN and NaIR:** the artery signal is suppressed by 91% and 96%, respectively. At the edges of the FOV the artery signals are less well suppressed in QFN, likely as a result of  $B_1$  inhomogeneities.
- The femoral and posterior cartilage signals are at 30-40% of the NaSP signals. A large part of this loss arises from the reduction of the signal from fluids (compare with the NaIR signals with similar SNR).
- An SNR of 15 or better can be achieved in the QFN experiment within 15 min.
- The posterior cartilage signal is slightly smaller than the femoral cartilage signal, likely as a result of orientation effects (compare with NaIR).
- The cartilage-to-fluid signal (cartilage-to-artery) ratio increases by a factor 5.1 in the QFN and 7.8 in the NaIR.

**A comparison between the IR and a short TR experiment also reveals that fluid suppression is better in the IR experiment (Fig. 2).**

**Conclusion** The IR and QFN methods suppress fluids extremely well as compared to single-pulse  $^{23}\text{Na}$  MRI. Suppressing the signal from synovial fluid will allow one to better quantify the sodium concentrations in cartilage, and thus to enhance the quantifiability of the fixed charge density via  $^{23}\text{Na}$  MRI.

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### References

1. Bashir et al MRM, 41 (1999) 857-65; Shapiro et al JMR 142 (2000) 24-31.
2. L. Greengard et al, Comm. App. Math. Comp. Sci. 1 (2006) 121–131; S. Inati et al ISMRM (2006) 2953.

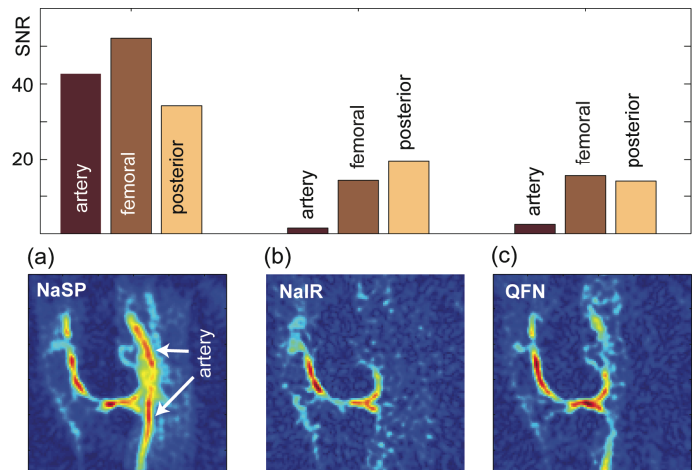


Figure 1: Comparison between (a) NaSP, (b) NaIR and (c) QFN in vivo at 7T (sagittal knee views) with 3mm resolution and 15 min acquisition time. The popliteal artery signals are suppressed very well in NaIR and QFN. The femoral and posterior cartilage signals are quantified here.

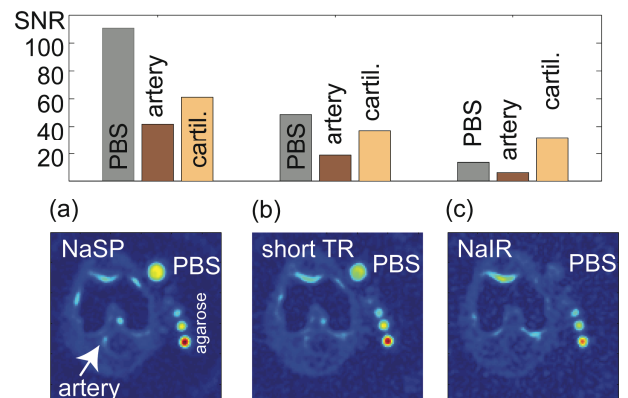


Figure 2: In vivo 7T  $^{23}\text{Na}$  MRI (axial knee views) showing the suppression of both external (PBS) and internal fluids (popliteal artery) by NaIR. (a) Single pulse (b) short TR single pulse, and (c) NaIR sequence.