# MULTI-PLANAR ASSESSMENT OF THE ELBOW JOINT USING ISOTROPIC RESOLUTION VIPR-ATR IMAGING

**L. Hernandez[1], J. L. Klaers[1], W. F. Block[1,2], and R. Kijowski[3]**
[1]Medical Physics, University of Wisconsin, School of Medicine & Public Health, Madison, WI, United States, [2]Biomedical Engineering, University of Wisconsin, Madison, WI, United States, [3]Radiology, University of Wisconsin, School of Medicine & Public Health, Madison, WI, United States

Purpose: Evaluating the elbow joint with magnetic resonance (MR) imaging is difficult due to the thin morphology and complex anatomy of the articular cartilage, ligaments, and tendons. At our institution, we have developed a rapid MR technique called VIPR-ATR for obtaining three-dimensional fat-suppressed images of the elbow joint with steady-state free-precession (SSFP) tissue contrast and high isotropic resolution (1). VIPR–ATR uses a dual half echo radial k–space trajectory called vastly undersampled isotropic projection reconstruction (VIPR) which allows for almost continuous acquisition of data and provides twice the resolution achievable with a Cartesian trajectory during the constrained repetition time. VIPR–ATR uses two different alternating length repetition times (ATR) and radiofrequency phase cycling to create a null for off–resonance fat signal during the SSFP acquisition (2). This study was performed to compare VIPR-ATR with currently used two-dimensional and three-dimensional MR sequences for evaluating the elbow joint.

Methods: The elbow joints of 5 asymptomatic volunteers were imaged using a 3.0T Discovery MR750 scanner (GE Healthcare, Waukesha WI) and an 8-channel phased-array extremity coil. All MR exams acquired the following sequences in the coronal plane: 1) fat-saturated proton density-weighted fast spin-echo (PD-FSE) with 0.4 x 0.6 x 3.0 mm voxel size and 4.1 minute scan time, 2) fat-saturated T2-weighted FSE (T2-FSE) with 0.4 x 0.6 x 3.0 mm voxel size and 4.3 minute scan time, 3) fat-saturated spoiled gradient recalled-echo (SPGR) with 0.4 x 0.6 x 1.5 mm voxel size and 6.4 minute scan time, 4) fat-saturated FSE-Cube with 0.6 x 0.6 x 0.6 mm voxel size and 7.1 minute scan time, and 5) VIPR-ATR with 0.4 x 0.4 x 0.4 mm voxel size and 5 minute scan time. VIPR-ATR images were reformatted with 3 slice averages in each dimension to generate 1.2 mm slices. Signal-to-noise ratio (SNR) efficiency and contrast-to-noise ratio (CNR) efficiency measurements were performed on all MR exams and were additionally normalized to voxel volume where the slice thickness of VIPR-ATR was taken as 1.2 mm. Paired t-tests were used to compare differences in normalized SNR and CNR efficiency values between sequences.

Results: VIPR-ATR produced high quality multi-planar images of the elbow joint following a single 5 minute acquisition. VIPR-ATR had significantly higher ($p<0.05$) normalized SNR efficiency for cartilage and fluid and significantly higher ($p<0.05$) normalized CNR efficiency between fluid and cartilage, tendon, bone, and muscle when compared to PD-FSE, T2-FSE, SPGR, and FSE-Cube (Figures 1-3). VIPR-ATR reformat images could be created in any plane following a single acquisition which was especially useful when evaluating the complex anatomic structures of the elbow such as the lateral collateral ligaments and biceps tendon (Figure 4).

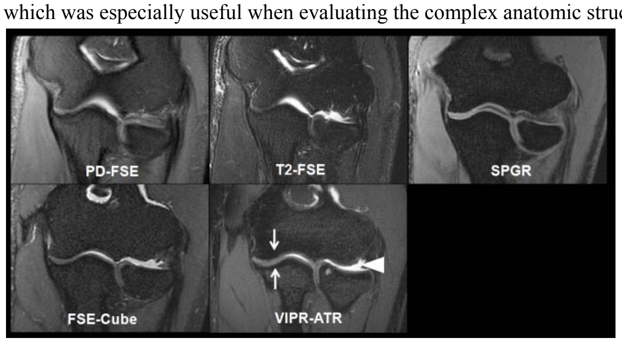


Figure 1: Comparison of sequences for elbow joint imaging. On the VIPR-ATR image, note the absence of image blurring and the excellent visualization of articular cartilage (arrows). Also note the excellent contrast between bright fluid (arrowhead) and adjacent joint structures.

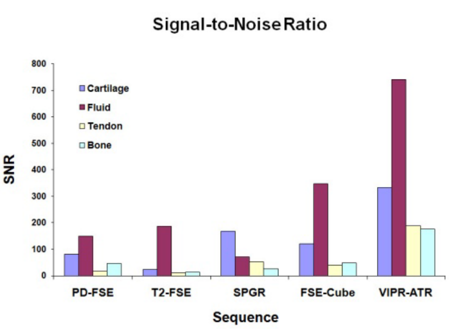


Figure 2: SNR efficiency normalized to voxel volume.

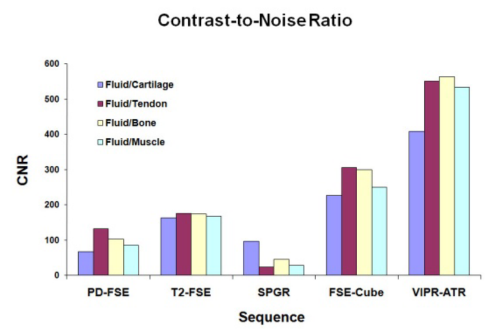


Figure 3: CNR efficiency normalized to voxel volume.

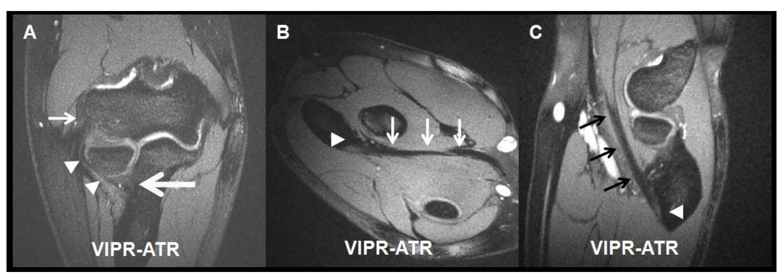


Figure 4: (A) Coronal oblique VIPR-ATR reformat image shows the full course of the ulnar band of the lateral collateral ligament as it arises from the lateral epicondyle (small arrow), courses posterior around the radial head (arrowheads), and inserts onto proximal ulna (large arrow). (B) Axial oblique and (C) sagittal oblique VIPR-ATR reformat images show the full course of the distal biceps tendon as it passes through the antecubital fossa (arrows) to insert onto the radial tuberosity (arrowheads).

Conclusions: VIPR-ATR produces high quality multi-planar images of the elbow joint with 0.4 mm isotropic resolution in 5 minutes. VIPR-ATR has high cartilage and fluid SNR efficiency and high contrast between fluid and adjacent joint structures. VIPR-ATR acquires thin continuous slices with high in-plane resolution which reduces partial volume averaging, and its ability to create reformat images in any plane is especially useful when evaluating the complex anatomic structures of the elbow joint. The ability of VIPR-ATR to acquire small voxel volumes and then reformat images in any orientation with minimal amounts of slice averaging produces 33% higher in-plane resolution with similar voxel volume in 33% less time than FSE-Cube. In addition, VIPR-ATR does not suffer from imaging blurring, and its bright fluid and highly versatile SSFP tissue contrast (3) allows good visualization of the tendons, ligaments, and osseous structures. Additional studies are needed to determine the potential applications of VIPR-ATR for evaluating the elbow joint in clinical practice and research studies.

Bibliography: (1) Klaers J, et al. ISMRM, 2010. (2) Leupold J, et al. Magn Reson in Med, 2006. (3) Kijowski R, et al. Radiology, 2009.

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