4D DYNAMIC MR IMAGING OF THE WRIST AT 1.5 AND 3T: FIRST RESULTS FROM A FEASIBILITY STUDY

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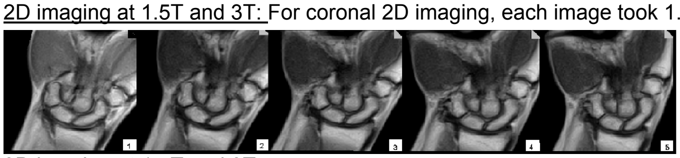
Introduction:
Kinematic evaluation and detection of kinematic abnormalities of the wrist play an important role in the diagnosis, staging and management of wrist pathology. Altered kinematics can lead to unbalanced joint loading and ultimately, osteoarthritis. Dynamic abnormalities of carpal motion, however, are often missed on static imaging. With the exception of fluoroscopy, which requires exposure to ionizing radiation, there are no clinically available noninvasive methods for evaluating carpal kinematics in vivo. We sought to test the feasibility of fast MR imaging techniques to obtain 2D and 3D data of the wrist in motion in healthy volunteers, and to test its clinical face validity with what is known about carpal kinematics.

Materials and Methods:

Image acquisition: Three volunteers (male, age range 24-37 years) were scanned on 1.5T (AVANTO; Siemens, Erlangen, Germany) and 3T (VERIO; Siemens, Erlangen, Germany) MR systems. Volunteers were positioned supine with wrist over head ("superman position") in an 8 channel Siemens head coil with a visual guide marked at 10 degree intervals. Active-movement technique (AMT) and incremental, passive-positional technique (IPPT)[1] were used to obtain functional MRI data of the wrist. AMT 2D imaging: mid coronal HASTE (Half-Fourier Acquisition Single Shot Turbo Spin Echo)images (3T/1.5T:FOV 100 mm, slice thickness 5 mm, TR/TE 1200/20 ms, 128x128 matrix) acquired during smooth, uninterrupted radial and ulnar deviation; these images were combined to form a cine-loop at the scanner. IPPT 3D imaging: For coronal plane motion, coronal HASTE sequence acquired images at 20 and 10 degrees ulnar deviation, neutral and 10 degrees radial deviation (1.5T: TR/TE=1500/41ms, 128x128 matrix, resolution = 0.8x0.8x0.8 mm^3, 32 slices/position; 3T: TR/TE=1000/44, 128x128 matrix, 0.8x0.8x0.8 mm^3, 56 slices/position). For sagittal plane motion, sagittal HASTE sequence acquired images at neutral, 10, 20 and 30 degrees dorsiflexion (1.5T: TR/TE=1500/41ms,128x128 matrix, 0.8x0.8x1mm^3, 72 slices/position; 3T: TR/TE=1000/44, 128x128 matrix, 0.8x0.8x1mm^3, 64 slices/position). To ensure consistent and reproducible motion, volunteers used the visual positioning guide. Post processing: Siemens Syngo Multi Modality Leonardo Workplace (version VE23A) created 3D data sets that were post processed using the Translucent 2_2005 Siemens algorithm and reconstructed in 4D InSpace. The result was recorded as an .AVI file and transmitted to the clinical workstation for viewing.

Results:

2D imaging at 1.5T and 3T: For coronal 2D imaging, each image took 1.2 seconds to acquire; 40 images were obtained in 48 seconds.



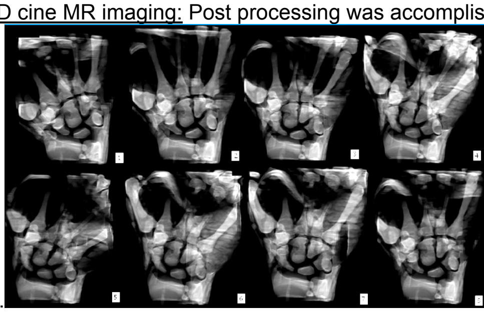
Selected Coronal Dynamic 2D Images, 3T: Carpal motion, most obvious at the level of the scaphoid (which lengthens as a result of scaphoid extension), can be appreciated as the wrist moves from radial (1, far left) to ulnar (5, far right) deviation.

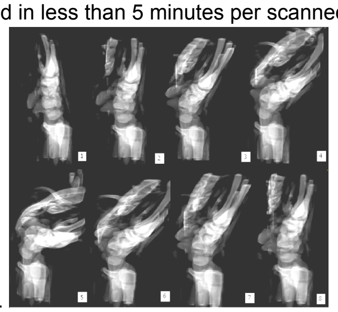
3D imaging at 1.5T and 3T:

Plane of motion	MR field strength	No. slices per position	Taq per position	No. positions	Taq* for all positions
Coronal plane	3.0 T	56	29"	9	4'45"
Coronal plane	1.5 T	32	22"	9	3'42'
Sagittal plane	3.0 T	64	39"	9	6'15"
Sagittal plane	1.5 T	72	1'6"	9	10'18"

* Each position was separated by a 3 second interscan pause to allow for positioning

4D cine MR imaging: Post processing was accomplished in less than 5 minutes per scanned volunteer.

A. 

B. 

Static Coronal (fig. A) and Sagittal (fig. B) 3D Images, 3T: Coordinated carpal motion can be appreciated on these selected 3D images of the wrist as it moves from: Fig. A: radial to ulnar deviation (top row) and ulnar to radial deviation (bottom row). Fig. B: neutral to dorsiflexion (top row) and from dorsiflexion to neutral (bottom row). Despite multiplanar motion of the individual bones, the coordinated work between individual bones and soft tissue stabilizers allows synchronous motion while maintaining overall joint stability.

Conclusions:

The wrist is an ideal model for MR based motion studies given its small size and relatively small radius of motion which can occur within the confines of commercially available coils designed for closed MR systems. However, it is also a structurally and kinematically complex and poorly understood joint. Routinely available sequences, such as HASTE, allow MRI data to be acquired within shorter scan times at both1.5 and 3.0T so that they have adequate temporal resolution to allow for real time dynamic in vivo imaging under physiologic conditions. The MRI data can be quickly processed into cine loops viewed at clinical workstations where their face validity can be tested against and was confirmed by what is known about carpal kinematics. We show that it is feasible to obtain these data at little time cost suggesting that this technique may prove to be an important addition to routine clinical static imaging to provide kinematic information to the clinician. This technique has the potential to be used in both research and clinical applications including the further study of in vivo carpal motion in normal and diseased states, and the evaluation of results after corrective surgery aimed at altering or restoring normal carpal kinematics. [1]Shellock, Frank G. "Functional assessment of the joints using kinematic magnetic resonance imaging." *Seminars in Musculoskeletal Radiology* 7, no. 4 (December 2003): 249-276.