Ocular Pursuit Movement Assessment by Magnetic Resonance Imaging

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ABSTRACT
We describe a new technique for generating cinematic magnetic resonance images. This method produces more physiological imaging of extraocular muscles than our previous method. In addition, this technique provides more comfort for the study subject and results in less head movement artifact.

INTRODUCTION
We have recently described a technique in which movement of the extraocular muscles is viewed by sequential summation of individual magnetic resonance imaging (MRI) scans. However, the cinematic or cine images produced by this procedure represent a composite of static images rather than the actual imaging of muscle motility as it is occurring. We now wish to report a new MRI technique which permits the cinematic imaging of the muscles in a continuous fashion during pursuit movements.

TECHNIQUE
Patients were requested to track a moving point of light which was projected into the bore of the MRI magnet by a red laser pointer (Figure). The oscillation of the mirror which redirected the laser beam was controlled by a WaveTek (Indianapolis, Ind) generator. The WaveTek produces a variety of waveforms (eg, sinusoidal) which can be customized for the particular ocular pursuit movement being investigated. We used a sawtooth waveform for our current study. The output from the WaveTek was sent through an amplifier which was used to drive a General Scanning G330 motor. The amplitude and duration of the waveforms could be varied to obtain an appropriate sweep speed and deflection for any implementation. This apparatus was positioned outside the magnet room and the laser pointer output beam was reflected through the radio frequency (RF) window in front of the MRI operation console. The sweep rate was 1 Hz during our current study. A parallel output from the WaveTek was taken through a resistor network which decreased the voltage and fed into the electrocardiogram leads for cardiac gating by the Signa 0.5T MRI scanner (GE, Milwaukee, Wis). By using the cardiac gating package, it is possible to trigger the MRI scanner to begin image acquisition using the steeply rising phase of the sawtooth signal. This arrangement permits a coordination of the scanning with the movement of the target. In this way, as the laser pointer’s light swept from left to right, the subject tracked it in a slow pursuit movement while moving back to the starting point in a fast saccade as the pointer reset to the start of the sweep.

As indicated above, the MRI imaging was performed on a Signa 0.5 T clinical scanner using a cardiac gating package. A custom-built anterior neck coil was used as the receiver coil. Other studies have used the SPGR 3D slab for reformating.1 In this instance, however, cardiac gating SPGR was used with only a single slice location and numerous time points after triggering.

With use of cardiac gating sequence, the MRI scanner produces images which are different in time, but not spatial location. Thus, after triggering, the MRI scanner generates an image after every 100 milliseconds producing a series of images spaced temporally which coincide with the different gaze positions indicated by the laser beam. With a usual matrix size of 128 phase-encoding steps, it is necessary to collect 128 repetitions (128 seconds). The
volunteers and patients who have participated in these exams have not complained about tracking the object for this length of time, especially when compared to the steady fixation required by our earlier studies. Tracking a moving object generates a more physiological image than the cinematic images we obtained by our previous sequential scanning technique.1,2

DISCUSSION
Cine imaging of eye movements has provided an improved understanding of extraocular muscle dynamics.2 To produce a more physiologic imaging, we have devised a technique which utilizes an adaptation of the method used to generate cardiac MRI studies.

This new method images the eye movements while the patient is tracking a moving target, rather than adding together the sequential static views of the earlier method to create the appearance of movement. This new technique has a much faster acquisition time than the previous cine procedure and, therefore, is less difficult for the subject to perform. This increased patient comfort has significantly reduced the head movements which produced artifacts in our initial technique. A disadvantage of this new cine method is the increased cost of the targeting system, compared to the simple preplaced markers in the bore of the magnet which we used in our earlier technique.1

REFERENCES