Positional/Kinematic MRI of the Spine

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Positional and kinematic MRI are relatively new techniques that are being more widely used. Positional MRI refers to performing the examination with the patient in the upright position. A kinematic MRI is also an exam performed in the upright position.

However, the spinal region in question can be placed in flexion, extension, lateral bending, or whatever position may be provocative for the patient. This does not have to be just for the spine; other body regions can be assessed in different positions as well. This discussion will focus on the spine.

Positional MRI is often referred to as stand-up, upright or weight-bearing MRI. Kinematic MRI is often referred to as dynamic or dynamic-kinetic MRI. The Fonar Company claims to have introduced "the world’s only whole-body MRI scanner with the ability to perform position imaging" in 1996 (www.fonar.com/history.htm).

While upright scanners have been around for approximately 10 years, they have not been widely available until recently. Many areas of the country still may not have access to these types of scanners, but it is my experience, in Southern California, that they have become more common. These upright-MRI magnets are open and located on the sides of the patient, as opposed to the front and back of the patient, as is the case with most open-MRI magnets. This allows the patient to be scanned in a recumbent, seated or standing position. While in the seated or standing position, it is then possible to add flexion/extension or any position that may be provocative to the patient.

Two main potential uses for upright scanners are: 1) Clinically, they may be useful as a diagnostic tool; and 2) Academically, they may be used for research of the spine. Let’s first look at the clinical application of upright scanners. Why would you, as a doctor, order these types of examinations? According to Gilbert, et al., the pros for performing these types of studies include the following:

- Potential to detect occult stenosis, occult disc protrusion, or occult instability in the spine by placing the spine in a weight-bearing position.
- Potential to detect occult nerve-root impingement by putting the patient’s spine in the position that causes pain, or in a position that narrows the spinal canal and neural foramen (such as spinal
extension).

- Potential to handle large or claustrophobic patients, or patients who need to be scanned in an upright position because of congestive heart failure, severe chronic obstructive pulmonary disease, or severe spinal kyphosis.

This summarizes nicely the current rationale for performing these types of studies. The upright scanners allow for imaging positional-dependent disease processes of the spine. Oftentimes, the clinical information for a patient does not match up well with the imaging findings on conventional MRI, during which the patient is usually in the supine position. According to Weishaupt, et al.,\textsuperscript{2} upright/dynamic-kinetic MR imaging more frequently demonstrates minor forms of neural compromise than conventional MR imaging. The positional-dependent disease processes referred to earlier are usually degenerative arthritis. So, the upright scanner allows visualization of the degenerative spine in an upright, load-bearing position and further allows visualization of how the degenerative process affects the motion of the spinal segments individually and as a whole.

Now, you may be asking yourself, \textit{Can’t we do that somewhat already with plain film?} The answer is yes, we can, but what we can’t do on the plain-film study is actually visualize how these degenerative changes are affecting the adjacent neurological structures. This added information can apparently change the treatment of patients for some surgeons. The main objective of a study performed by Hiwatashi, et al.,\textsuperscript{3} was to see whether treatment decisions for spinal stenosis were influenced by having axial-loaded MRI of the lumbar spine verses conventional non-axial-loaded MRI. They specifically were looking at the treatment decisions of three experienced neurosurgeons. The results clearly showed an influence of treatment decisions. Five out of 20 patients were changed from conservative management to surgical decompression when the additional information from the axial-loaded MRI was provided. Now, keep in mind, they did not study whether this resulted in a positive or negative outcome for the patient. I found the study very interesting because of the additional information that positional and kinematic studies provide, because it affects treatment decisions and ultimately, patient outcomes.

While I did not come across any articles addressing these issues for the chiropractic community, I did find articles discussing the clinical usefulness of these studies for surgeons. This certainly seems an area ripe for further investigation. In a study by Jinkins, et al.,\textsuperscript{4} some of the cervical posterior disc herniations became less severe in the flexed position. Some surgeons place the spine in a flexed position when performing operations for disc herniations. It would seem reasonable to consider that some of the poor outcomes
following surgery may have been related to this. Kinematic MRI also may play a role in the post-operative spine. These can be done to evaluate intersegmental fusions for stability.\textsuperscript{4} Cord mobility can be assessed as well, looking for post-operative cord tethering.\textsuperscript{4}

I have discussed the pros of upright scanning; now let’s look at some cons, as proposed by Gilbert, et al.\textsuperscript{1}:

- Scan time may be two to three times longer than with a high-field system.
- Longer scan times in a low-field or mid-field magnet make open systems more prone to image degradation by patient movement than in a high-field scanner.
- Placing the patient in the position that causes pain may, in fact, cause the patient to have more movement secondary to the pain, thus resulting in further image degradation.

As you can see, the main concern with performing these upright images is with image quality. An alternative method of simulating this upright position has been developed. According to Hiwatashi, et al.,\textsuperscript{3} the device consists of a harness/jacket connected with straps to a footplate. By tightening the straps, an axial load can be applied to the patient in the supine position. This allows an axial load to be applied to the lumbar spine, but does not allow for flexion/extension or other kinematic studies. This may be offset, according to the authors of this study, by the fact that this system would not have as much of a problem with image quality. I would add as a potential con the cost of the studies in today’s market of cost-consciousness.

Upright Scanner Research

Now let’s take a brief look at some of the research that upright scanners have been used for. The first study looked at the length of the spinal canal and the dural sac cross-sectional area. According to Hirasawa, et al.,\textsuperscript{6} the length of the spinal canal changes from flexion to extension. It lengthens in flexion and shortens in extension. The spinal cord itself acts as like an accordion by physically lengthening in flexion and shortening in extension to match this change in spinal canal length. This is supported by a second study done by Kuwazawa, et al.\textsuperscript{7} They demonstrated a significant change in the AP diameter of the cervical cord in neutral, flexion and extension. In general, the AP diameter of the cervical cord increased on extension and decreased with flexion. Also in the study by Hirasawa, et al.,\textsuperscript{6} they demonstrated a significant posture-dependent difference in the dural sac cross-sectional area in the lumbar spine in asymptomatic individuals. The dural sac cross-sectional area increased in the upright position verses the supine position. This is thought to be due to the increased hydrostatic pressure of the cerebrospinal fluid.
In a third study, by Vitaz, et al., the actual changes that occur in the cervical spinal canal diameter on flexion and extension were documented. The greatest canal size was seen in flexion with a significant decrease in extension of the cervical spine. And Karadimas, et al., studied the effects of the degenerative process on the lumbar segmental motion. This study demonstrated changes in motion at degenerative levels that were more significant as the severity of degeneration increased. The study also demonstrated significant changes in the motion of healthy discs adjacent to areas of degeneration.

This is by no means a comprehensive list of all the studies that have used upright scanners. However, in evaluating the studies presented, it is clear that upright scanners are certainly assisting our understanding of the spinal column and adjacent neurological structures, as well as how these relationships change with position and disease processes. This information seems to be very pertinent to the present chiropractic community. In the future, it could be used to help develop/refine our manipulative techniques to improve patient outcomes by expanding our pool of knowledge.

References


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