Review article:  
Kinematic evaluation of the spine: a kinetic magnetic resonance imaging study

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ABSTRACT

Kinetic magnetic resonance images (kMRIs) of 587 lumbar and 459 cervical spines of symptomatic patients in axially loaded, upright neutral (0°), flexion (40°), and extension (-20°) positions were evaluated. Imaging took 10 to 12 minutes to complete in each position. Cervical kinematics were significantly affected by intervertebral disc degeneration, cervical cord compression, and sagittal alignment of the cervical spine. kMRI was effective in diagnosing lumbar disc herniations that are often missed using conventional MRI. kMRI is effective for diagnosing, evaluating, and managing degenerative disease or injury within the spine.

Key words: biomechanics; cervical vertebrae; intervertebral disk; lumbar vertebrae; magnetic resonance imaging

INTRODUCTION

Spinal degeneration is increasingly common as a result of population ageing. Degeneration typically begins in the intervertebral disc during the second decade of life in men and the third decade in women. It then appears posteriorly in the facet joints, causing altered mechanical function of the disc and ultimately spinal instability and clinical symptoms.

Magnetic resonance imaging (MRI) provides the greatest range of information and accurate delineation of soft-tissue (e.g. intervertebral discs, spinal ligaments, and neural elements) and osseous structures (e.g. facets and uncovertebral joints), enabling detection of subtle abnormalities with great sensitivity. However, it can obtain only non-weight-bearing, static images. Spinal disorders, especially cervical and lumbar stenosis, are posture-dependent. To overcome this limitation, radiographic and cineradiographic studies of spinal kinematics have been reported. We evaluated spinal kinematics of patients in a weight-bearing position with dynamic motion of the spine using kinetic MRI (kMRI).

MATERIALS AND METHODS

From February 2006 to May 2007, kMRIs of 587 lumbar and 459 cervical spines of symptomatic patients in axially loaded, upright neutral (0°), flexion
Segmental angular motion (the angle between the motion of one vertebrae over another), and sagittal segmental translational motion (the anteroposterior AP diameter (disc level and pedicle level), sagittal disc beyond the intervertebral space), spinal canal endplate), disc bulge/herniation (the extension of the inferior border of the 2 adjacent vertebrae).

The lumbar spine data included global lordosis (Cobb’s method and posterior tangent method), segmental lordosis (Cobb’s method), lumbar gravity line (vertical line drawn from the centre of L3 and its intersection with the sacral base), lumbar spine vertical height (the perpendicular distance between 2 horizontal lines drawn through the anterosuperior corners of L1 and S1), vertebral height, spondylolysis, disc height, disc bulge/herniation, spinal canal AP diameter, sagittal segmental translational motion, and sagittal segmental angular motion.

**RESULTS**

A comprehensive grading system for intervertebral disc degeneration was used for analysing the spinal kinematics. We classified neutral-position T2-weighted sagittal images of all intervertebral discs into 3 to 5 grades and reported the results of kMRI of the spine.

In normal cervical spines, most of the total angular mobility was attributed to C4/5 and C5/6, but mobility was significantly reduced in these segments in patients with severe disc degeneration. Cervical segmental mobility was significantly reduced in segments with severe cord compression, compared to those with no cord compression. It was hypothesised that the spinal cord was protected from dynamic mechanical cord compression by restricting segmental motion, and these mechanisms were closely related to the intervertebral discs. Changes in sagittal alignment of the cervical spine affected the kinematics and progress of cervical intervertebral disc degeneration.

kMRI also improved the detection of lumbar disc herniations. The degree of such herniation increased significantly in flexion and extension images, compared to neutral images.

**DISCUSSION**

The spine is subjected to great compressive forces during activities of daily living. Mechanical loading of the spine (due to axial compression and dynamic motion) induces mechanical stresses on the intervertebral discs, and this is an important factor in the aetiology of intervertebral disc degeneration. Therefore, it is important to evaluate spinal disorders under mechanical loading. For this purpose, kMRI is effective for diagnosing, evaluating, and managing degenerative disease or injury within the spine.
In our study, some patients needed pain control prior to kMRI because of severe discogenic or radicular pain in upright, weight-bearing positions. It was difficult for them to maintain their position for more than 30 minutes. Patients with severe myelopathy should avoid dynamic motion or superfluous loading. Neurogenic evaluation and observation prior to and during kMRI may be necessary.

REFERENCES