



Magnetic Resonance Imaging / Formation image de résonance magnétique

## Association Between Measures of Vertebral Endplate Morphology and Lumbar Intervertebral Disc Degeneration

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### Abstract

**Purpose:** The aim of this study was to evaluate the association between vertebral endplate morphology and the degree of lumbar intervertebral disc degeneration via magnetic resonance imaging (MRI).

**Methods:** In total, 150 patients who met the inclusion criteria and were 20–60 years of age were retrospectively evaluated. Patients were evaluated for the presence of intervertebral disc degeneration or herniation, and the degree of degeneration was assessed at all lumbar levels. Vertebral endplate morphology was evaluated based on the endplate sagittal diameter, endplate sagittal concave angle (ECA), and endplate sagittal concave depth (ECD) on sagittal MRI. The association between intervertebral disc degeneration or herniation and endplate morphological measurements was analysed.

**Results:** In MRI, superior endplates (*ie*, inferior endplates of the superior vertebra) were concave and inferior endplates (*ie*, superior endplates of the inferior vertebra) were flat at all disc levels. A decrease in ECD and an increase in ECA were detected at all lumbar levels as disc degeneration increased ( $P < .05$ ). At the L4-L5 and L5-S1 levels, a decrease in ECD and an increase in ECA were detected in the group with herniated lumbar discs ( $P < .05$ ). There was no association between lumbar disc degeneration or herniation and endplate sagittal diameter at lumbar intervertebral levels ( $P > .05$ ). At all levels, ECD of women was significantly lesser than that of men and ECA of women was significantly greater than that of men ( $P < .05$ ).

**Conclusions:** There is an association between vertebral endplate morphology and lumbar intervertebral disc degeneration. Vertebral endplates at the degenerated disc level become flat; the severity of this flattening is correlated with the degree of disc degeneration.

### Résumé

**But :** Cette étude avait pour but d'évaluer l'association entre la morphologie des plateaux vertébraux et le degré de dégénérescence des disques intervertébraux lombaires au moyen de l'imagerie par résonance magnétique (IRM).

**Méthodes :** Un total de 150 patients âgés de 20 à 60 ans qui répondaient aux critères d'inclusion ont fait l'objet d'une évaluation rétrospective pour détecter la présence de dégénérescence ou d'herniation des disques intervertébraux. Le degré de dégénérescence a été évalué au niveau de chaque vertèbre lombaire. La morphologie des plateaux vertébraux a été déterminée à partir du diamètre sagittal, de l'angle concave sagittal et de la profondeur concave sagittale des plateaux sur des images obtenues dans le plan sagittal. La relation entre la dégénérescence ou l'herniation des disques intervertébraux et les mesures de la morphologie des plateaux vertébraux a ensuite été analysée.

**Résultats :** Les images montraient des plateaux supérieurs (soit les plateaux inférieurs des vertèbres supérieures) concaves et des plateaux inférieurs (soit les plateaux supérieurs des vertèbres inférieures) plats au niveau de chaque disque lombaire. Une diminution de la profondeur concave sagittale et une augmentation de l'angle concave sagittal ont été détectées dans tous les disques lombaires lorsque la dégénérescence augmente ( $P < 0,05$ ). Au niveau des disques situés entre les vertèbres L4 et L5 ainsi que L5 et S1, une diminution de la profondeur concave sagittale et une augmentation de l'angle concave sagittal ont été détectées chez les patients présentant des hernies discales lombaires ( $P < 0,05$ ). Aucune relation n'a été démontrée entre la dégénérescence ou l'herniation des disques lombaires et le diamètre sagittal des plateaux vertébraux au niveau des disques intervertébraux ( $P > 0,05$ ). Pour tous les segments, la profondeur concave sagittale était nettement moins élevée chez les femmes que chez les hommes, et l'angle concave sagittal était nettement plus élevé chez les femmes que chez les hommes ( $P < 0,05$ ).

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**Conclusions :** Il existe une relation entre la morphologie des plateaux vertébraux et la dégénérescence des disques intervertébraux lombaires. Les plateaux vertébraux s'aplatissent en cas de dégénérescence, et il existe une corrélation entre le degré d'aplatissement et le degré de dégénérescence des disques.

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Lower back pain is one of the most frequently observed symptoms in the human musculoskeletal system. The frequency of lower back pain increases with age and its frequency in the adult population is reported to vary between 60%–90% [1]. Lumbar intervertebral disc degeneration is considered to be a significant risk factor for lower back pain [2]. In a recent study conducted by Cheung et al [3], it was reported that there is a close relationship between the level of lower back pain and degree of disc degeneration.

The intervertebral disc comprises a centrally located nucleus pulposus encircled by the annulus fibrosus, which is attached to cartilaginous endplates [4,5]. Intervertebral discs provide flexibility to the spine and transmit and distribute large loads. Changes in the tissue properties of the disc, such as dehydration, stiffening of the annulus fibrosus, and reorganization of the nucleus, alter the mechanism of load transfer in the vertebra [4,6,7]. The endplates as a physical shield separate discs from the vertebral bone and prevent the highly hydrated nucleus from bulging or penetrating into adjacent vertebral bodies. The endplate is a mechanical interface between the vertebral body and disc. It not only absorbs the considerable hydrostatic pressure that results from mechanical loading of the spine but also, together with the disc, helps evenly distribute the compressive load across the vertebral body [1,5,8].

Conventional radiography alone is inadequate to evaluate the shape of the vertebral endplate. Magnetic resonance imaging (MRI) is the best method for evaluating degenerative disc disease, providing primary diagnosis, as well as grading disc degeneration [2,9,10].

Numerous studies have analysed the frequency of intervertebral disc degeneration on MRI and the relationship between intervertebral disc degeneration and bone marrow change in the vertebral endplate. Despite this, the concave morphology of the vertebral endplate and how it changes with disc degeneration remain unclear.

The purpose of this study was to investigate the relationship between the morphology of the vertebral endplate and degree of intervertebral disc degeneration using MRI.

## Materials and Methods

### *Patients*

This retrospective study included 150 patients (75 men and 75 women) 20–60 years of age. The mean age was  $42.3 \pm 11.5$  years. All the patients who presented at our hospital complaining of lower back pain or leg pain and

underwent MRI from June 2015 to December 2015 were recruited. Patients with previous lumbar spinal surgery, evidence of lumbar tumours on MRI, congenital anomalies, discovertebral infection, lumbar vertebral fracture, current radiotherapy, and spinal deformities such as spondylolisthesis and scoliosis were excluded from the study. The present study was approved by the Institutional Review Board of Ankara Numune Education and Research Hospital.

### *Imaging Parameters*

MR images were obtained with a 1.5 T unit (Optima, GE Medical System, Milwaukee, WI, USA). Sagittal T1-weighted fast-spin echo (FSE) (repetition time [TR]/echo time [TE] = 460–680 ms/8–10 ms, matrix =  $320 \times 224$ ; field of view [FOV] =  $28 \times 28$  cm, slice thickness = 4 mm), sagittal T2-weighted FSE (TR/TE = 2700–3000 ms/100–105 ms, matrix =  $352 \times 224$ , FOV =  $28 \times 28$  cm, slice thickness = 4 mm), and axial T2-weighted FSE (TR/TE = 4400–5000 ms/80–100 ms, matrix =  $256 \times 192$ , FOV =  $18 \times 18$  cm, slice thickness = 4 mm) sequences were used in the imaging protocol.

### *Image Analysis*

A single radiologist retrospectively evaluated MR images of the patients using our ClearCanvas Picture Archiving and Communication System (Version 6.2; ClearCanvas Inc, Toronto, ON).

### *Disc Degeneration or Herniation*

The severity of intervertebral disc degeneration was graded for all lumbar intervertebral levels. The evaluation was performed using T2-weighted midsagittal images employing the 5-grade classification introduced by Pfirrmann et al [11] (Table 1). Grade 5 degeneration in the Pfirrmann classification was excluded from the study because of collapsed disc space.

Disc herniation was defined as the extension of disc material beyond its endplate. A herniated disc was subclassified as protruded and extruded [2,12]. Lumbar disc herniation was confirmed on sagittal and axial T2-weighted images in the patients.

### *Vertebral Endplate Morphology*

Anatomical landmarks, including anterior (A) and posterior (P) rims of the endplate and the concave apex (Ca) points

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