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Technical Report

Modic changes: prevalence, distribution patterns, and association with age in white men

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Abstract

BACKGROUND CONTEXT: Suspected as a cause of back pain, Modic changes (MCs) have received increasing attention in spine research and care. Yet, epidemiologic knowledge of MCs based on the general population, which may provide an important clinical reference, is limited.

PURPOSE: To investigate the prevalence and distribution patterns of MCs in the lumbosacral spine and their associations with age in a large population-based sample of men.

STUDY DESIGN: An epidemiologic investigation of lumbar magnetic resonance images (MRIs).

PATIENT SAMPLE: This study was based on the Twin Spine Study database, comprising a sample of male twins shown to be largely representative of the base Finnish population. Lumbar spine MRIs (1.5 Tesla Magnetom; Siemens AG, Erlangen, Germany) of 561 subjects (mean age, 49.8 years; range, 35–70 years) were included in the present study.

METHODS: For each spine, all 11 end plates (L1–S1) in the lumbar region were evaluated using both T1- and T2-weighted images to identify MCs, which were classified into Type 1, 2, 3, and mixed types. Furthermore, the number and location of MCs were recorded, as well as the anteroposterior (AP) and transverse sizes, to explore the prevalence and distribution pattern of MCs in the lumbar region and associations with age.

RESULTS: Modic changes were identified in 55.6% (312) of individuals and 13.5% (830) of end plates studied. Among these MCs, 64.2% (533) were Type 2, 16.0% (133) were Type 1, 18.1% (150) were Mixed Type 1/2, and the remaining 1.6% (13) were noted as Type 3 or Mixed Type 2/3. Modic changes were more common in the lower (74.5%) than in the upper lumbar region (25.5%), and 77.9% (642) of MCs presented in pairs at opposing end plates of a disc. Moreover, the specific type of MCs on opposing end plates was usually concordant. The presence of MCs in the lumbar region was associated with age (odds ratio=1.05–1.08 for each additional year of age, depending on type of MCs, $p<.001$). In addition, greater age was associated with a greater number of end plates affected and MCs of larger size ($p<.001$).

CONCLUSIONS: Modic changes are common MRI findings in the lumbar spines of middle-aged white men, with Type 2 MCs predominating. Mainly present in the lower lumbar region, MCs tend to affect both end plates adjacent to a disc simultaneously, and they commonly involve the entire AP diameter of the vertebral end plate. The presence and size of MCs are clearly related to age, suggesting that aging or associated factors may play an essential role in the pathogenesis of MCs.

Keywords: Lumbar spine; Magnetic resonance imaging; End plate; Modic changes; Epidemiology

Introduction

Modic changes (MCs) are signal variations of the vertebral end plate and the adjacent subchondral vertebral marrow seen on magnetic resonance images (MRIs) [1,2]. According to the patterns of signal changes on T1- and

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T2-weighted images, traditionally MCs have been classified into three types [1,3]. Type 1 MCs show decreased signal intensity on T1-weighted images and increased signal intensity on T2-weighted images. Type 2 MCs demonstrate increased signal intensity on both T1- and T2-weighted images, whereas Type 3 MCs reflect decreased signal intensity on both T1- and T2-weighted images. The presence of different types of MCs together within an end plate was later regarded as mixed MCs, such as Mixed Type 1/2 and Mixed Type 2/3 [4–6].

Despite over 20 years of study, much about MCs remains either controversial or unknown. Assumed to be degenerative features of the vertebral end plate and marrow, MCs have long been suspected as a cause of low back pain [2], although this remains controversial [4,7–10]. Because of limited cases of biopsy, the pathologic nature of MCs largely remains unclear [2,11]. Even the prevalence of MCs and the predominant type are uncertain. For example, the prevalence rates reported in the scientific literature widely range from 0.5% [12] to 62% [13]. Among the factors underlying the inconsistencies are variations in age and race of the subjects, back pain status [7,14], and occupation [9]. To date, there are only two reports on MCs in the general population, which come from the same cohort [8,15]. The role age may play in the pathogenesis of MCs, and the distribution pattern of MCs, has not yet been explored in the general population.

A systematic study of MCs in the lumbosacral region in the general population would provide fundamental epidemiologic insights of MCs and an important reference for clinical observations. The purpose of the present study was to investigate the prevalence and distribution pattern of MCs and their associations with age using a large population-based sample. Evidence suggests that MCs are closely related to disc [16,17]. Thus, we refer to end plates containing MCs relative to the intervertebral disc and differentiate them as cranial and caudal to the adjacent disc.

Materials and methods

Subjects

This study used the lumbar MRI of the Twin Spine Study cohort [18], which consists of 300 pairs of male monozygotic and dizygotic twin pairs (N=600). Subjects were recruited from the population-based Finnish Twin Cohort, containing virtually all Finnish sex-matched twin pairs born before 1958 and alive in 1975, which has been shown to be representative of the general Finnish population [19]. Initially, monozygotic twins were recruited and compared with the larger twin cohort on a variety of factors and were found to be largely representative of the Finnish Twin Cohort, which is representative of the Finnish population. Later, dizygotic twins were recruited using identical methods [18].

Each subject underwent a structured interview and an MRI examination of the lumbar spine revealing that 28 subjects had previously undergone lumbar spinal surgery. These subjects were not included in the present study. Lumbar MRIs of another 11 subjects were missing in the Twin Spine database, leaving 561 subjects for the present study (mean age, 49.8±7.6 years). The study was approved by the Health Research Ethics Board at the University of Alberta.

MRI data acquisition

The lumbar MRIs were acquired with either a 1.5 Tesla Magnetom SP 4000 scanner or Magnetom Vision scanner (Siemens AG, Erlangen, Germany), using a surface coil. With the Magnetom SP 4000 scanner, sagittal T1-weighted images were obtained using repetition/echo times of 650/22 milliseconds and T2-weighted images using 2,600/90. With the Magnetom Vision scanner, the repetition/echo times were 650/12 in T1-weighted and 2,600/80 in T2-weighted sagittal images. For both scanners, the acquisition matrix was 192×256 for T1 and 256×256 for T2, with a field of view of 260 mm (pixel size, 1.02 mm). The slice thickness and interslice gap were 4 and 0.4 mm for sagittal images and 3 and 0.3 mm for axial slices. Each subject was lying supine for 30 to 45 minutes immediately before MRI scanning. For each imaged lumbar spine, there were seven sagittal slices of T1-weighted images and 11 sagittal slices of T2-weighted images.

Image evaluation

Magnetic resonance image evaluations were performed on a PC workstation using either Osiris (version 3.1; University Hospitals of Geneva, Geneva, Switzerland) or a custom-designed image analysis software, *Spine Examiner* (SpEx, version 2.73; University of Alberta, Edmonton, Canada). Osiris is able to simultaneously display multiple T1- and T2-weighted images for comparison, and SpEx allows further quantification of needed measurements. All evaluations were performed by one of the authors (YW), an orthopedic surgeon who was experienced in the measurement of MCs. The assessments were blinded to clinical history and any previous measurements. All T1- and T2-weighted sagittal images were evaluated.

Classification of MCs

The traditional Modic classification was used in the first step of the evaluation [3]. The mixed type MCs were noted if different types of MCs were present within an end plate. To differentiate MCs from artifacts and signal variations resulting from other vertebral marrow abnormalites, only signal changes of vertebral bone marrow that extend from the end plate and involve two or more adjacent sagittal slices were classified as MCs. Very small regions of signal changes commonly appearing in the corners of a vertebral