European Journal of Radiology 98 (2018) 193–199

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Research article

Do modic changes, disc degeneration, translation and angular motion affect facet osteoarthritis of the lumbar spine

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ARTICLE INFO

Keywords:
Modic changes
Facet osteoarthritis
Disc degeneration
Lumbar spine
Multi-positional MRI

ABSTRACT

The objective of the study is to identified the correlation between Modic changes (MCs), disc degeneration, motions (translation and angulation) and facet osteoarthritis in lumbar spine. 425 patients who underwent multi-positional lumbar MRI were reviewed. A total of 2250 lumbar spinal segments in neutral position were evaluated for MCs, disc degeneration grading, translation and angulation motion, and facet osteoarthritis. The chi-square test, Kruskal-Wallis, Mann-Whitney *U* test, Pearson's correlation and linear regression were used to test for statistically significant difference between parameters. MCs type 2 showed the most translational motion. The presence of MCs was significantly correlated with advanced disc degeneration (grade 4–5, Odds ratio 6.29, 95% CI 4.48–8.83) and the presence of facet osteoarthritis (Odds ratio 9.50, 95% CI 6.18–14.62). The presence of facet osteoarthritis had significantly more translation motion than non-osteoarthritis facet ($p = 0.04$). The facet osteoarthritis grade was positively correlated with disc degeneration grade ($r = 0.309$, p-value < 0.001). The facet osteoarthritis correlated with the presence of MCs and more translation motion. The severity of facet osteoarthritis was correlated with the advanced disc degeneration. The MCs, translation motion, and disc degeneration were the significant parameters which affected lumbar facet osteoarthritis.

1. Introduction

Modic changes (MCs) are detected on MRI as bone marrow changes within the vertebral body and endplate [1]. Modic type 1 is represented with decreased signal intensity on T1-weighted MRI and increased signal intensity on T2-weighted MRI. Modic type 2 has increased signal intensity on T1-weighted MRI and isointense or slightly increased signal intensity on T2-weighted MRI, while Modic type 3 has a decreased signal intensity on both T1 and T2-weighted MRI. MCs are detected not only during disc degeneration but also in an early infection process and some immunological diseases [1–3]. The infection etiology of Modic change type 1 was reported in chronic low back pain patient treated with antibiotics [4,5]. These studies found significant improvement in back pain related outcome in antibiotic treatment group compared to the placebo group. Dudli et al. proposed that the development of MCs is dependent on (a) structural disruption of disc or endplate, (b) inflammatory potential of the disc, and (c) the capacity of bone marrow to respond to higher stimuli. Different types of MCs might represent different stages of the same pathological process [6].

Most of the studies concerning lumbar spine focused on the relationship between MCs and low back pain [7–9]. In a multi-positional MRI study, Hayashi et al. showed that patients with MCs in the lumbar spine had significantly more disc degeneration and translational motion than patients without MCs this suggests that MCs might play a role in the stability of lumbar spine [10]. Lumbar spine facet joint osteoarthritis has been shown to have a significant associations with disc degeneration, aging, and anterior translational instability [11,12]. To the best of our knowledge, there is no report on the relationship between lumbar MCs and facet joint osteoarthritis. The objective of this study were to (a) evaluate the relationship between lumbar MCs and lumbar facet joint osteoarthritis using multi-positional MRI and (b) To identify the relationship between lumbar facet osteoarthritis and lumbar disc degeneration grading, translation motion, and angular motion.

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https://doi.org/10.1016/j.ejrad.2017.11.023
Received 7 August 2017; Received in revised form 31 October 2017; Accepted 29 November 2017

2. Methods

2.1. Patient population

Four hundred and twenty-five patients (284 men and 141 women, mean age of 48.89 ± 10.1 range from 23 to 71 years) with lower back pain who underwent multi-positional MRI from February 2016 to August 2016 were evaluated. The inclusion criteria were (a) lower back pain with or without neurological symptoms (b) quality of multi-positional MRI image good enough for evaluation of MCs, disc degeneration, and facet osteoarthritis. The exclusion criteria were (a) congenital lumbar spine pathology, (b) trauma at the lumbar spine, (c) lumbar spinal tumors, (d) lumbar spinal infection, (e) autoimmune diseases such as rheumatoid arthritis, and (f) previous surgery at lumbar spine. A total of 2125 lumbar intervertebral disc segment from L1-2 to L5-S1 were evaluated.

2.2. Multi-positional magnetic resonance imaging

Multi-positional MRI of the lumbar spine was performed using 0.6 T MRI scanner (Upright Multi-Position, Fornar Corp., New York, NY). The MR unit uses a horizontal orientation of two opposing magnetic doughnuts, allowing patients to be scanned in the weight-bearing position. The image protocol included T1- and T2-weighted sagittal fast spin-echo images that were obtained using a flexible surface coil with the patient seated in upright weight-bearing neutral, flexion, and extension positions.

2.3. MCs assessment

MCs were classified into 3 types (1–3) using sagittal multi-positional MRI image. Type 1 MCs was defined as the presence of hypointense signal on T1-weighted and hyperintense signal on T2-weighted MRI. Type 2 MCs had hyperintense signal on T1-weighted and iso- or hyperintense signal on T2-weighted image, and Type 3 MCs had hypointense signal on both T1 and T2-weighted images [1,13] (Fig. 1).

2.4. Assessment of degenerative disc change

Pfirrmann grading system was used to classified degenerative disc degeneration base on T2-weighted MRI [14].

2.5. Assessment of facet osteoarthritis

The facet osteoarthritis was divided into 4 grades using T1-weighted MRI[11,12]. Grade 1 was normal, grade 2 was mild osteoarthritis (joint space narrowing or mild osteophyte), grade 3 was moderate osteoarthritis (sclerosis or moderate osteophyte), and grade 4 was severe osteoarthritis (marked osteophyte) (Fig. 2).

2.6. Assessment of translation and angulation motion

Translational motion was determined as horizontal plane motion of the cephalad vertebra on its caudad vertebra from flexion to extension. Angular motion was defined as the difference of the intervertebral angle between two vertebrae from flexion to extension. The translation and angular motion were analyzed by MRAnalyzer3 (TrueMRI Corp., Bellflower, CA, Fig. 3A and B)

2.7. Statistical analysis

The Kruskal-Wallis test was used to analyze of disc degeneration, translation motion, angulation motion, and facet osteoarthritis among three types of MCS, and used to analyze of translational motion and angular motion among four grades of facet arthritis. The Mann-Whitney *U* test was used for post-hoc analysis of the statistically significant difference parameters from the Kruskal-Wallis test. The *p*-value of less than 0.0125 was considered statistically significant according to Bonferroni's inequality correction. Correlation between the disc degeneration and the facet osteoarthritis was analyzed using Pearson correlation and simple linear regression analysis. Chi-square was used to analyzed odds ratio (ORs) and 95% confidence interval (95%CI) in order to detect the association between presence of MCs, disc degeneration, and facet osteoarthritis. Disc degeneration was defined as mild (grade 1–3) or severe (grade 4–5). Facet osteoarthritis was defined as none (grade 1) or present (grade 2–4).

Inter-observer agreement between the two spine surgeons, and intra-observer agreement by one reader were analyzed in 30 patients using kappa statistics. The intra- and inter-observer agreement for the presence of MCs, disc degeneration grading, and facet osteoarthritis were analyzed. The kappa value was assessed as follow: 0–0.2 indicated slight agreement, 0.21–0.4 fair agreement, 0.41–0.6 moderate agreement, 0.61–0.8 substantial agreement, and 0.81–1 excellent agreement [15]. All statistical analyses were performed in SPSS (Version 23.0, International Business Machines, Chicago, IL, USA).

3. Results

3.1. Modic changes

Modic changes were detected in 105 patients (24.7%). One-hundred fifty-seven (7.4%) lumbar segments from 2125 segments had MCs. 79 MCs were present at L5-S1, 44 at L4-5, 23 at L3-4, 7 at L2-3, and 4 at L1-2. Type 2 MCs was the most common (66.24%, n = 104 segments) followed by type 1 (24.2%, n = 38 segments).

The kappa values for MCs were 0.758 for intra-observer and 0.724 for inter-observer.

3.2. Disc degeneration and MCs

Only L4-5 and L5-S1 spinal segment showed a statistically significant difference between the presence of MCs and disc degeneration (Table 1). The chi-square test showed that there was a statistically significant association between the presence of MCs and severe disc degeneration (ORs = 6.29, 95% CI 4.48-8.83, Table 2). Results of disc degeneration among the types of MCs are shown in Fig. 4. There was a statistically significant difference between lumbar segments with and without MCs. However, there was no statistically significant difference regarding the type of MCs.

The kappa values for disc degeneration grading were 0.727 for intra-observer and 0.712 for inter-observer.

3.3. Facet osteoarthritis and MCs

There were no statistically significant differences between grades of facet arthritis and the presence of MCs at all lumbar spinal segments (Table 1). The chi-square test showed that there was a statistically significant association between the presence of MCs and facet osteoarthritis (ORs = 9.50, 95% CI 6.18–14.62, Table2). There were also no statistically significant differences in grading of facet osteoarthritis among three types of MCs (Fig. 5).

The kappa values for facet osteoarthritis grading were 0.715 for intra-observer and 0.682 for inter-observer.

3.4. Motions analysis among MCS and facet osteoarthritis

The translational motion and angular motion value among three types of MCS and four grades of facet arthritis are shown in Table 3. MCs type 2 showed the most translation motion, whereas MCs type 1 showed the most angulation motion. The Kruskal-Wallis test showed statistically significant difference in translational motion among MCs (*p*-value 0.014). The post-hoc analysis showed MCs type 2 had